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A Survey of Exchange Rate Pass-Through in Asia

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Exchange rate pass-through (ERPT) refers to the transmission of exchange-rate changes into import (export) prices of goods in the destination-market currency as well as into aggregate domestic prices. This paper examines the analytical and empirical literature on ERPT with particular reference to Asia. It is generally believed that Asian economies are potentially susceptible to ERPT into domestic inflation since they are highly trade-dependent. Particular attention is paid to production sharing—a key characteristic of Asian trade—and its implications for ERPT.

Introduction

Exchange rate pass-through (ERPT) refers to the transmission of exchange-rate changes into import (export) prices of goods in the destination-market currency as well as into aggregate domestic prices. ERPT is said to be partial or incomplete if the import price changes by less than the percentage change in the exchange rate. Incomplete pass-through may arise, for instance, because firms engage in pricing-to-market (PTM), which effectively implies that firms with market power in a segmented market are able to sell the same product at different prices in different markets (Dornbusch 1987, Krugman 1987; also see the surveys by Goldberg and Knetter 1997 and Menon 1995).

The issue of ERPT is particularly important because of its policy implications for small and open economies. If ERPT is partial, the use of exchange-rate-based adjustments to improve the trade balance may be less effective—an issue that has been of some concern in the case of the persistent US trade deficit despite secular declines in the US dollar.[1] Conversely, a partial ERPT implies that small, open economies may be less concerned about the potential inflationary consequences of exchange-rate fluctuations. The degree of ERPT also has implications for the transmission of shocks in countries characterised by high levels of intra-regional trade (see Betts and Devereux 2001).

ERPT is commonly analysed at two levels. One set of studies deals with the transmission of exchange-rate changes into import and export prices. This level of transmission is referred to as the 'first stage pass-through'. Within this category, the literature has examined ERPT at both the aggregate level (for aggregate exports and imports) and at disaggregated levels (using industry or product specific import/export price data). The second set of studies examines ERPT into aggregate domestic prices as measured by consumer, producer or wholesale-price

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1 There may be other real sector consequences of exchange-rate changes via, for instance, balance-sheet effects.

indices. This level of transmission is referred to as the 'second stage pass-through'. The second-stage ERPT is typically lower than that of the first stage. This is because aggregate price indices usually include non-tradable goods, which may be impacted by domestic taxes, and also because wholesalers and retailers in the importing country may absorb some of the exchange-rate change.

The bulk of the ERPT literature to date has been focused on the US and other industrial countries. However, given the extent of openness of Asian economies to international trade, the extent of ERPT into import/export prices and the factors determining the ERPT are key areas of policy interest to the region. This paper surveys the recent analytical and empirical literature on ERPT with particular reference to Asia, and also outlines areas of needed research in ERPT related to Asia.

The next section develops a simple framework within which to analyse ERPT and offers an overview of the determinants of ERPT. Then the paper continues to review some of the empirical literature on ERPT in Asia. Afterwards, the paper considers the issue of production sharing—a key characteristic of trade in Asia—and its implications for ERPT. In the final section, the paper offers concluding remarks on areas for future research. The Annex attached develops a simple analytical framework to help understand the impact of production sharing on ERPT.

What does the analytical literature on ERPT tell us?

A simple analytical framework

To aid the discussion of the determinants of ERPT and the analysis of the relevant empirical studies, we develop a stylised framework of ERPT and PTM. We consider two countries trading a single good Y, with country A being the importing nation and country B the exporter. Let E_B^A be the bilateral exchange rate defined as the number of units of A's currency per unit of B's.

Assuming the law of one price (LOP) holds in relative terms:

$$\frac{\Delta \ln P_Y^A}{\Delta \ln E_B^A} = \frac{\Delta \ln P_Y^B}{\Delta \ln E_B^A} + 1 \qquad (1)$$

where P_Y^A = price of Y in local currency of A; P_Y^B = price of Y in the currency of B, with all variables expressed in log form. ERPT into A's currency is given by the left hand side of equation (1). ERPT for B in its own currency is given by the first term on the right hand side of equation (1).

If $\frac{\Delta \ln P_Y^B}{\Delta \ln E_B^A} = 0$, this implies no PTM by exporters of B into B's currency-denominated prices and consequently full pass-through to A's imports. If $\frac{\Delta \ln P_Y^B}{\Delta \ln E_B^A} = -1$, this implies full PTM by exporters in country B, and consequently zero pass-through into A's imports.

Under imperfect competition, we can write P_Y^B more generally as:

$$\ln P_Y^B = \ln MC_Y^B + \ln[MKP_Y^B(E_B^A)] \qquad (2)$$

where MC = marginal costs and MKP = the exporters' mark-up, with both in logs.

The literature generally assumes that MC is constant to a change in the exchange rate (although this assumption is too strong, as noted), and MKP varies with the exchange rate. Specifically, $-1 < \frac{\Delta \ln MKP_Y^B}{\Delta \ln E_B^A} < 0$. So, the greater the PTM by exporters in country B, the more willing they are to raise mark-ups in response to a depreciation in their country's currency. In other words, as $\frac{\Delta \ln MKP_Y^B}{\Delta \ln E_B^A} \to -1$, and $\frac{\Delta \ln P_Y^B}{\Delta \ln E_B^A} \to -1$, therefore, $\frac{\Delta \ln P_Y^A}{\Delta \ln E_B^A} \to 0$.[2]

We now assume that country B imports intermediate goods from country A. In this situation, we have $\ln MC_Y^B = \ln[MC_Y^B(E_B^A)]$ and

2 Of course, if $\frac{\Delta \ln MKP_Y^B}{\Delta \ln E_B^A} < -1$, then $\frac{\Delta \ln P_Y^A}{\Delta \ln E_B^A} < 0$, that is, there is more than full ERPT.

$-1 < \frac{\Delta \ln MC_Y^B}{\Delta \ln E_B^A} <$, that is, a depreciation of country B's currency increases the costs of procuring intermediate goods from A. The more reliant B is on imported intermediate goods from A and the greater the import elasticity, the more likely that $\frac{\Delta \ln MC_Y^B}{\Delta \ln E_B^A} \to -1$. In this case, $\frac{\Delta \ln P_Y^B}{\Delta \ln E_B^A} \to -1$. This scenario—wherein country B is exporting the final good to its partner nation A while simultaneously importing intermediate goods from A—is referred to as 'production sharing'. With this pattern of trade, production sharing reduces the extent of ERPT to the importing country. We revisit the issue of production sharing more formally in the Annex. In the remainder of this section, we survey some of the recent empirical literature on ERPT in Asia.

Determinants of ERPT

There is a voluminous body of literature that has aided understanding of the factors that affect the extent of ERPT into import (export) prices as well as into aggregate price indices such as consumer price index (CPI), producer price index (PPI) or wholesale price index (WPI). The first factor considered, at the disaggregated level, is the nature of the goods or industries. If exporters do not face much competition, mark-ups or prices of the exporters may be somewhat less responsive to fluctuations in the value of the exporter's currency against the buyers. In this situation, exchange-rate changes are passed in full in terms of the buyers' currency. Conversely, if the destination market is highly competitive, firms may try to guard their market share by absorbing exchange-rate changes by accepting lower mark-ups. The willingness to accept lower domestic unit prices leads to lower levels of ERPT. In a pioneering study, Knetter (1993) found differences across industries to be critical in explaining different degrees of ERPT. For example, exports to the US markets, such as the industries of autos and alcoholic beverages, showed higher PTM and correspondingly lower ERPT as exporters try to maintain market share. More broadly, studies have consistently found that manufactured goods have lower ERPT than agricultural products (Campa and Goldberg 2005; also see Marazzi et al. 2005).

The second factor is the duration of exchange-rate changes. For instance, Meurers (2003) undertakes Blanchard-Quah decompositions to identify permanent and temporary exchange-rate changes in the US, Japan, Germany, France and Italy. The author finds that ERPT tends to be almost complete in the long run with persistent exchange-rate shocks. On the other hand, if the exchange-rate change (depreciation in the importing country, for instance) is temporary, an exporter may be more willing to accept a temporary cut in profit margins to maintain market share, given the possibility of 'hysteresis effects' *á la* Baldwin (1988), Baldwin and Krugman (1989), and Dixit (1989) (also see Froot and Klemperer 1989).

The third factor is the direction of exchange-rate changes, which could also be explained by the 'hysteresis effect'. A commonly noted example is that, in the mid 1980s, the US dollar appreciation lowered import prices, but when the US dollar subsequently depreciated, import prices in the US rose only partially. The literature suggests that the response of exporters to exchange-rate changes is often asymmetric. A weakening of the destination market's currency causes the exporter to reduce its export price and keep the importing nation's product price more or less stable, implying a lower ERPT. However, when the exporters' currency depreciates, exports become cheaper in the destination market. This may create an incentive for exporters to maintain their export prices or, in some cases, to reduce their own currency price and amplify the impact of their currency depreciation (so as to gain market share), leading to a higher ERPT (Pollard and Coughlin 2003, Madhavi 2002).

The fourth factor is the size of the exchange-rate change. When the exchange-rate change is small, firms are generally willing to absorb it and keep domestic prices unchanged due to the costs associated with changing prices. According to Krugman (1987), when a firm announces a price it has to honour its announcements. Thus, unexpected changes in costs, caused by temporary fluctuations that are not 'too large', may not be passed on as firms do not want to

lose reputation.[3] The importance of the size of exchange-rate changes on ERPT into import prices in the US has been empirically confirmed by Pollard and Coughlin (2003) and others.

The fifth factor affecting the degree of ERPT into aggregate import prices is a country's macroeconomic fundamentals. A recognised fact is the general decline in the extent of ERPT in industrial countries since the late 1980s. Following Taylor (2000), it is generally believed that ERPT rates are endogenous to a nation's monetary policy and monetary stability. The more stable a country's monetary policy and the lower its inflation are, the lower the extent of ERPT will be. This thesis has been confirmed by Gagnon and Ihrig (2004) using macro-level data for industrial countries as well as by Choudri and Hakura (2006), Frankel et al. (2005) and others. In related work, Devereux and Engel (2001) argue that if exporters set their prices in the currency of a country that has a stable monetary policy (that is, local-currency pricing as opposed to producer-currency pricing), then ERPT into import prices in local currency terms will be low for countries with low monetary and exchange rate variability.[4]

Campa and Goldberg (2005) test the importance of changes in macro economic variables and the extent of ERPT into aggregate import prices for 25 OECD nations for the period 1975–99. They found that the lower the average rate of inflation and the less variable the exchange rate are, the lower the ERPT is. However, these macro factors play a minor role in affecting ERPT as compared to the changing composition of a nation's imports away from raw materials and energy imports towards manufacturing imports. Otani et al. (2003) also highlight the importance of changing product composition as being among the main factors in explaining differing rates of ERPT over time in Japan, while Marazzi et al. (2005) stress its importance in the case of the US.[5]

In addition to the foregoing, it is generally acknowledged that ERPT tends to be greater in lower-income economies and in relatively smaller and more open ones where there is a high share of traded goods, high import content,[6] limited domestic substitutes (thus limiting the extent of 'flight from quality' *á la* Burstein et al. 2007), and high degree of integration with the global trading system.[7] These conditions inevitably make much of developing Asia potentially more vulnerable to ERPT than other parts of the world, particularly industrial countries.[8] Another factor that might affect ERPT is the presence of non-tariff barriers

3 If large exchange-rate changes lead to sharp contractions (for instance, because of balance-sheet effects following devaluation), it is less likely that there is much if any ERPT (see Burstein et al. 2002). Goldfajn and Werlang (2000) also emphasise the importance of business cycles in determining the extent of ERPT, that is, firms are more willing to pass through increases in costs during a boom. Rajan (2007) discusses macroeconomic policy management in the presence of balance-sheet effects.

4 There is a burgeoning literature on the issue of 'local currency pricing' (LCP) which is a mainstay of the New Open Economy macro economics. Closely related to the issue of LCP is the choice by firms to hedge against exchange-rate changes (see Mann 1986).

5 In addition to changing product composition, the authors also emphasise the role of competition from China as being a factor limiting the extent of ERPT into US import prices. Marazzi et al. (2005) do not find the size or direction of exchange rate movements as having been significant determinants of import price pass-through in the US. Ganapolsky and Vilan (2005) also do not find evidence of this asymmetry in the case of US import prices between 1993 and 2004.

6 However, if the country is simultaneously importing and exporting to the same country, ERPT may be lower. See the Annex for a formalisation of this possibility.

7 Using data on the cross-country (76 countries) prices of eight goods over the period 1990–2001, Frankel et al. (2005) test some of the foregoing factors. They arrive at the conclusion that while there is strong evidence that ERPT is slower and smaller in lower-income countries, there is much weaker evidence for the size effects. They also find transport and tariff barriers to have been important factors determining the extent of ERPT.

8 It is harder to say *a priori* whether Asian countries are potentially more susceptible to ERPT than Latin American countries in view of the lower monetary stability and higher inflation rates in the latter. For instance, in a 71-country study of transmission of exchange-rate changes into consumer prices between 1980 and 1988, Goldfajn and Werlang (2000) found ERPT to be highest in Latin America. Kamin and Klau (2003) found broadly similar regional differences in the extent of ERPT.

(NTBs), that is, exchange-rate changes may be prevented from being fully passed-through into import prices due to the import premium afforded to exporters (Bhagwati 1991). There is some empirical confirmation of this relationship. For instance, Menon (1996) found that quantitative restrictions lowered ERPT into prices of Australia's manufacturing imports in the 1980s.

While many of the foregoing hypotheses have been tested in industrial country contexts, little such work has been undertaken for Asia. We turn to the literature on Asia in the next section.

What does the empirical literature on ERPT in Asia tell us?

Menon (1995) provides a comprehensive survey of empirical studies on ERPT. This section extends the analysis and examines some of the recent literature on ERPT in Asia. Special attention is paid to the implications for ERPT of production-sharing-based trade, which is significant in Asia. We first discuss multi-country studies using aggregate prices and then consider studies on disaggregated or industry-specific prices.[9] The survey includes studies of ERPT of imports and exports. The latter studies attempt to measure the extent of PTM. If a change in the exchange rate is fully transmitted into export prices in the exporter's currency, there is full PTM and consequently no pass-through into the importer's prices.

Selected aggregate-level studies on ERPT in Asia

Ito et al. (2005) examine the extent of ERPT into aggregate import prices and consumer prices in eight East Asian countries over the period 1986–2004. The authors use a first-differenced model with a lag of the effective exchange rate up to four periods. They found the estimates of ERPT into import prices to be high and significant in four economies—Hong Kong (49 per cent), Indonesia (100 per cent), Japan (99 per cent) and Thailand (166 per cent, that is, more than full ERPT). The estimates of ERPT for the other three economies (Korea, Singapore and Taiwan) were insignificant. As expected, the ERPT into consumer prices was found to be lower than that into import prices. Among the countries, it was highest for Indonesia (57 per cent), followed by Thailand (26 per cent), Singapore (20 per cent), the Philippines (15 per cent) and Korea (13 per cent).

The Ito et al. (2005) analysis uses a single-equation specification with import prices as the dependent variable and the exchange rate as the independent variable, and the co-efficient on the exchange-rate variable (either the bilateral or effective exchange rate) giving the extent of pass-through. Cost conditions in the exporter's market, the price of domestic substitute goods in the importing country, and a proxy for demand shifters for imports—such as the importing country's GDP or industrial production—were added as control variables.

Unlike the single-equation specification, which assumes exchange-rate changes to be exogenous, a systems approach—such as the vector autoregression (VAR) approach—treats each variable as endogenous. VAR analysis is generally used for measuring pass-through into a country's aggregate CPI, PPI or import prices. Using VAR analysis, Ito et al. (2005) also examine the effects of exchange-rate changes, monetary-policy changes, demand shocks (proxied by the gap between actual and potential output) and supply shocks (proxied by oil-price changes) on aggregate prices (CPI and PPI) and import prices for the period 1995–2004. The estimated impulse-response functions show that the response to import prices is of the highest, followed by that to the PPI and then the CPI.[10] The authors also conducted a variance decomposition analysis to determine the importance of these four variables for domestic prices. Exchange-rate shocks account for 40 per cent of the variation in CPI for both Indonesia and Korea, but less

9 We have limited the survey of aggregate ERPT studies to those that are multi-country in nature. Single country studies (such as Ghosh and Rajan 2007a, c on India and Singapore, respectively) are not considered here due to space considerations.

10 The magnitude of response to these shocks appears to be larger for Indonesia than for the other economies.

than 20 per cent in the cases of Malaysia, Singapore and Thailand. As for import prices, exchange-rate shocks account for 50 per cent of the variation in import prices in Korea, 20 per cent in Indonesia and Thailand, and only 10 per cent in Singapore.

The low ERPT in the case of Singapore, which is a small, open economy, is somewhat of a puzzle in the first instance. Export and import-price indices (that is, export and import-price indices constructed using prices obtained from traders) are available only for Japan, Korea and Taiwan. For many of the other Asian countries, all that is available is the 'unit-value' indices, indices based on unit values constructed by dividing reported export values by export volumes. These data limitations should be kept in mind when considering ERPT studies at a product or industry level and may explain part of the puzzle noted above.[11] Apart from data questions, part of this puzzle may be explained by the high level of production sharing in Singapore's trade and domestic production as highlighted here in this section (also see the next section).[12]

Using a similar VAR approach, Kang and Wang (2003) analyse the effect of exchange-rate changes on import prices and the CPI in Japan, Singapore, Korea and Thailand for the period 1991 to 2001. The estimated impulse-response functions show that, for all four countries, the response of import prices to changes in exchange rates is higher than is the case for the CPI. Moreover, in the post-crisis period (1998–2001), import and consumer prices in Korea and Thailand appear to have responded more to exchange-rate changes than in the pre-crisis period, while there was no difference between the two periods in Japan and Singapore. This result may be explained by the fact that Japan and Singapore were not affected structurally by the crisis, as were Korea and Thailand. In fact, the variance-decomposition analysis shows that the contribution of exchange-rate shocks in explaining variations in import prices and the CPI is higher for the post-crisis period in Korea and Thailand. The authors contend that the adoption of a free floating exchange-rate regime and the consequent exchange-rate fluctuations by these two economies, as a result of the currency crisis, may have been a further reason for the amplified ERPT in the post-crisis period.[13]

McCarthy (2000) also adopts a VAR approach to measuring pass-through into aggregate import prices, the CPI and PPI for Japan and other industrial countries during 1976–98. The impulse-response functions estimated show that the response of import prices to exchange-rate changes is greater than for PPI, while it is insignificant for the CPI. The variance-decomposition analysis shows that a variation in prices due to a one per cent exchange-rate shock is about 6 per cent for import prices and PPI, but only 1.8 per cent for the CPI.

Sasaki (2002) examines the export-pricing behaviour of Japanese exporters to the US, other Asian countries and the EU, by estimating PTM elasticity and using monthly bilateral export-price data for the period 1990–95. PTM was found to be the highest for Japan's exports to the US and lowest for exports to other Asian countries. It is estimated that Japanese exporters to the US market absorb about 50 per cent of the yen–dollar exchange-rate changes in their own currency denominated export prices, while, for the EU and other Asian countries, the PTM elasticities are 0.24 and 0.32, respectively. In all likelihood, this result is due to the larger size and high level of competition in the US market where exporters attempt to maintain their market share and are prepared to accept lower

11 We thank an anonymous referee for this insight.

12 Abeysinghe and Tan (1998) examined the relationship between export and import prices in Singapore and found a high degree of correlation and co-integration among export prices of final goods and import prices of intermediate goods for major commodity categories between 1980 and 1993.

13 On the other hand, it has been suggested that the greater the degree of exchange-rate flexibility, the lower will be ERPT as firms will be less willing to pass on exchange-rate changes to their customers when there is a chance that they will be subsequently reversed. The role of exchange-rate regimes on ERPT is clearly an issue in need of further research (see Steel and King 2004).

mark-ups.[14] Another reason for the lower ERPT of Japanese exports (that is, high PTM) to the US might be the large-scale dollar invoicing of Japanese exports to the US (about 84 per cent of Japan's exports to the US are invoiced in the US dollars).[15]

Webber (1999) examines the nexus between bilateral exchange rates with the US dollar and import prices in nine countries in the Asian Pacific region—Korea, Pakistan, the Philippines, Malaysia, Singapore, Japan, Australia and New Zealand. Using the Johansen co-integration approach, the author found a stable, linear relationship between import prices and exchange rates for seven of the nine countries over the period 1978–94, though the ERPT estimates vary between countries. ERPT was highest for the lowest income countries (Pakistan, 109 per cent and the Philippines, 89.6 per cent), while ERPT was partial for the other six countries, ranging from 25 to 50 per cent.[16] Notwithstanding macro-level differences between countries, the author surmises that the different ranges of ERPT for the countries were due to the different ranges of goods. This conclusion emphasises the need for studies using more disaggregated data (that is, at industry or product level). The next part surveys disaggregated-level analysis of ERPT in Asia.[17]

Selected disaggregated-level studies of ERPT in Asia

Japan In one of the earlier works on ERPT at the disaggregated level (SITC 4-digit), involving an Asian country, Marston (1990) examines the pricing behaviour of Japanese exporters. The author estimates PTM elasticity for 17 products in the transportation and electrical machinery industry between 1980 and 1987. The impact of trade-weighted, real effective exchange-rate changes on export-domestic price margins was found to be significant. Estimated PTM elasticity for selected products were: 0.52 for small passenger cars; 1.03 for tyres and tubes; 0.41 for trucks; 0.51 for colour TVs; 0.95 for tape recorders and 0.28 for microwave ovens. These estimates suggest that Japanese exporters only partially pass through exchange-rate changes into foreign prices of their exports, apart from tyres and tubes.

Takagi and Yoshida (2001) estimate the ERPT for Japanese exports and imports with selected East Asian trading partners—Indonesia, Malaysia, the Philippines, Singapore and Thailand—as well as for Germany and the US. The authors estimate ERPT using monthly export and import unit-value series obtained from the Japanese customs data spanning 1988–99 for 20 products (11 exports and nine imports) at the SITC 9-digit level of industrial commodities. Using panel data and applying a fixed effects model for these categories aggregated together, as well as for the countries combined, the estimated ERPT for Japanese exports into the destination-market currency is almost complete (97 per cent), while the ERPT into Japanese imports is almost non-existent (only 1 per cent). On a bilateral country basis, for the individual commodity groupings, the ERPT for Japanese exports was found to be complete or very high in the majority of the cases (that is, low degree of PTM).[18] The ERPT for Japanese imports was either absent or far

14 The paper also examines the impact of unexpected exchange-rate changes on export prices.

15 See Sato (1999) for a discussion of currency invoicing of Japanese trade and the dominance of the US dollar in East Asian intra-regional trade. Also see Giovannini (1988) and Fukuda and Ji (1994) for formalisation of the impact of currency invoicing on the extent of ERPT.

16 The estimates of ERPT for the other countries were as follows: Korea, 40.3 per cent; Australia, 26.3 per cent; Japan, 44.8 per cent; and New Zealand, 35.9 per cent. The estimated ERPT for Singapore was 77.1 per cent, much higher than most other estimates for the city-state.

17 We survey four papers each on Japan and Korea, and two papers each on Hong Kong, Southeast Asia and India. To our knowledge, there are no papers that have examined ERPT in China using disaggregated data.

18 The exceptions are electricity boards to the US and microscopes to Germany, with the ERPT rates 30 per cent and 42 per cent, respectively.

from complete.[19] This result suggests that importers attempt to maintain price stability in yen terms while pricing their exports in Japanese markets; in contrast, Japanese exporters also maintain their unit prices stable in yen terms.

The authors go on to examine the impact of the East Asian financial crisis on pricing behaviour by comparing ERPT estimates during the pre-crisis period (1988–97) with the entire sample period. They find little difference in ERPT before and after the crisis for most products and for most countries, except for some imports to Malaysia. For these Asian countries, Japan is their dominant trade partner. In other words, exporters in these countries tend to preserve or increase their market share by actively PTM. This may explain the low Japanese import ERPT (also see Sato 1999, 2003).

Otani et al. (2003) estimate ERPT into Japanese import prices, using monthly data for the period 1978–2002. Using the IMF's nominal effective exchange rate (NEER) for Japan and employing a seemingly unrelated regression (SUR)-estimation approach, the authors find ERPT elasticity into aggregate prices for the entire time period to be complete. This appears to be at odds with the Takagi and Yoshida (2001) results noted above, which examine ERPT for a shorter and more recent period (1988–99). Once Otani et al. (2003) decomposed the time period into two subsamples—1978 to 1989 and 1990 to 2001—they found a decline in the ERPT in the 1990s at both the aggregate level as well as for most product categories.[20] The fact that the decline in ERPT occurred both in aggregate and disaggregate data implies that the changing composition of Japan's imports is unlikely to be a key factor in explaining the declining ERPT in aggregate prices. An interesting hypothesis put forward by the authors for their finding is the rapid appreciation of the yen in the mid 1980s, which led to a rise in Japanese FDI and overseas production by Japanese firms. The subsequent increase in intra-firm trade and re-imports may have led to firms absorbing price changes and transferring the impact on margins between firms, thus reducing the extent of ERPT. The impact of FDI and multinational corporations (MNCs) on ERPT is clearly an issue in need of further research.[21]

Korea We turn from Japan to the only other Asian OECD member, Korea. Athukorala (1991) is a pioneering study on ERPT for selected Korean manufacturing exports. His study focused on textiles, clothing and footwear, metal products and machinery, and transport equipment over the period 1980–89. Using a polynomial distributed lag model, the author found ERPT into foreign prices for the nominal effective exchange rate (NEER) to be around 28 per cent.

Adopting a similar approach, Yang and Hwang (1994) estimate ERPT of changes in the real sectoral exchange rate to Korean export prices in six manufacturing sectors for the period 1976–90. ERPT estimates range between 18 per cent and 60 per cent (textiles, 18 per cent; chemicals, 19 per cent; machinery, 25 per cent; metal products, 41 per cent; mineral products, 46 per cent; and wood, 60 per cent).

Lee (1997) estimates ERPT of industry-specific real exchange-rate changes into prices of 24 Korean imports from OECD countries over the period 1980–90. The ERPT estimates range between 43 per cent for iron and steel and 92 per cent for leather and fur; the average pass-through elasticity for all manufacturing imports was 0.38. The author also found that the more concentrated the industries, the smaller the ERPT.

19 The exceptions are wooden seats (75 per cent) and wooden furniture (47 per cent) from the US, appliance parts from Germany (53 per cent) and wooden furniture from Singapore (93 per cent).

20 These results are robust to variations in estimation techniques and data series. The ERPT coefficients for eight disaggregated commodities vary, which are highest for fuels (1.46), followed by materials (1.11), metals (0.92), food (0.79), chemicals (0.78), machinery (0.76) and others (0.81).

21 Menon (1996) examines how MNCs affected the ERPT of import prices of Australia's manufactured imports over the period 1981–92. The author found that MNCs' operations (as proxied by the foreign control of imports) had a negative effect on pass-through. Sato (1999) briefly highlights the importance of Japanese multinationals and their role in pricing and trade invoicing with regard to Japan's trade with the rest of East Asia.

Lee (1995) estimates the response of Korean manufactured-export prices to nominal effective exchange-rate changes for 16 industries, including autos, television sets, refrigerators, silk fabrics, car tyres, and integrated circuits over the period 1980–90. The PTM estimates are 65 per cent for automobiles, 53 per cent for CTV and 112 per cent for tyres, indicating that Korean firms engage in active pricing strategies when exporting (other than tyres).

Hong Kong While most of the country-specific studies in Asia have been concentrated on Japan and Korea, there are a few studies on other economies. For instance, Parsley (2003) estimates ERPT into import prices for Hong Kong for 21 disaggregated SITC 5-digit imports from Hong Kong's top-eight, non-mainland China trading partners (Germany, the Netherlands, France, the UK, Taiwan, Japan, Singapore and Australia) over the period 1992–2000. The results indicate a high degree of ERPT, of between 80 and 95 per cent for changes in the nominal exchange rate and 70 to 85 per cent for the real exchange rate.[22]

Parsley (2004) estimates the ERPT for Hong Kong's exports (and re-exports) to its top-nine, non-mainland China export partners (Canada, Germany, Netherlands, France, UK, Taiwan, Japan, Singapore and the US) for the same time period for 29 commodities at the disaggregated SITC 5-digit level. He found a lack of evidence of PTM in Hong Kong's exports, suggesting high ERPT into foreign prices by Hong Kong exporters.

Southeast Asia Parsons and Sato (2005) estimate the ERPT for four Southeast Asian countrie —Indonesia, Thailand, Malaysia and the Philippines—for 27 export commodities at the HS 6-digit level of disaggregation and to 13 destination (export) markets for the period 1999–2004.[23] Using a pooled regression model for each good, they did not find any ERPT for the majority of the goods across all the countries. With export prices denominated in the exporter's currency, their findings of insignificant exchange-rate coefficients confirms the notion that small, open economies are predominantly price takers in world markets, but it could also reflect the fact that these economies invoice their exports in the US dollars.

Sasaki (2005) examines the effects of changes in the US dollar and Japanese yen on import prices at both the aggregate level and for individual goods for selected Asian economies (Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand) for the period 1973–2000.[24] At the aggregate level, changes in the US dollar appear to have been passed through to the import prices of the Asian countries, while there is little evidence of ERPT of Japanese yen changes into import prices for the Southeast Asian economies.[25] However, at the disaggregated commodity level there is significant ERPT for other Asian economies for imports from Japan, such as colour photo paper and golf balls.[26] From a policy perspective, we recommend that Asian

22 The country-specific ERPT estimates for the nominal exchange rate were: 136 per cent for Germany, 24 per cent for UK, 97 per cent for Taiwan, 86 per cent for Japan, 158 per cent for Singapore and 5 per cent for Australia. ERPT estimates for the real exchange rate were: 126 per cent for Germany, 109 per cent for the Netherlands, 113 per cent for France, 26 per cent for the UK, 52 per cent for Taiwan, 62 per cent for Japan, 128 per cent for Singapore and 2 per cent for Australia.

23 The destination markets were Australia, Canada, China, France, Germany, Hong Kong, Indonesia, Japan, Korea, Malaysia, Singapore, Thailand, the UK and the US.

24 The North Asian economies of Taiwan, Korea and Hong Kong were also included in the study.

25 From the US, ERPT into import prices of these nations were 52 per cent for Hong Kong, 28 per cent for Indonesia, 29 per cent for Korea, 19 per cent for Malaysia, 90 per cent for the Philippines, 40 per cent for Singapore, 91 per cent for Thailand, and 167 per cent for Taiwan. ERPT coefficients for imports from Japan were insignificant except for Hong Kong (0.04), Malaysia (–0.10) and Taiwan (0.06).

26 Interestingly, for the US imports from Japan, yen changes appear to have little impact on the US import prices. This suggests that Japanese exporters price their exports in the US dollars and engage in PTM to maintain their market share in a very competitive market. However, this conclusion is at odds with some of the other studies of Japanese ERPT noted previously.

countries adopt a currency basket of the Japanese yen and the US dollar as changes in both these currencies affect their import prices.[27]

India Mallick and Marques (2006) examine the extent of PTM in the case of India's exports. They estimate ERPT into export prices of 34 SITC 2-digit commodities for the period 1980–2001, using the NEER of the Indian *rupee* made up from India's top 36 trading partners. Given that the Indian economy has been going through a significant liberalisation program since 1991 (see Ahluwalia 2002, and Rajan and Sen 2002), with reductions in tariff rates, removal of capital controls and movement towards a managed floating exchange rate, the authors estimate ERPT coefficients for two sub-periods (1980–90 and 1991–2001) to detect any significant differences in pricing behaviour by Indian exporters. The average ERPT into foreign prices of India's exports in the pre-liberalisation period was 20 per cent, while for the post-liberalisation period it was 65 per cent. For the former sub-period, the authors do not find any ERPT for most commodities with the exceptions of clothing (47 per cent) and footwear (40 per cent). This suggests that, during the pre-liberalisation period, India acted predominantly as a small, price-taking country in world markets.

For the post-liberalisation period, the study found significant ERPT for most categories of products, ranging from 12 to 79 per cent. ERPT estimates for individual products were: 46 per cent for clothing, 79 per cent for cotton, 12 per cent for iron ore, 23 per cent for manufacturing metals, 19 per cent for spices, 15 per cent for tobacco, 28 per cent for transportation equipment and 49 per cent for yarn. The authors argue that liberalisation has enabled India to gain some price-making power in some of these industries because of the increasing share of manufactures in India's exports (which rose from 68 per cent of merchandise exports in 1986–87 to 76 per cent in 2001–02).[28] However, this conclusion is at odds with much of the literature examined above, which has argued that ERPT into import prices has declined over the years largely because of the changing composition of domestic trade towards manufactured goods.

ERPT and the role of production sharing

When thinking about trade in manufactured goods, especially in Asia, it is important to pay close attention to the role of cross-border 'production sharing'. This refers to the dispersion of separate production blocks of an integrated production process across different countries.[29] Thus, trade no longer just involves final goods and services but also the international exchange of parts and components (PACs).[30] The presence of production sharing suggests that it is insufficient to consider ERPT at a disaggregated commodity level (let alone at the aggregate level); it is especially important to consider ERPT at the level of the corresponding intermediate good.

As noted earlier in the previous section, the simplest form of production sharing is bilateral in nature, whereby a representative firm in country B exports the final good (Y) to country A, while simultaneously procuring the parts and components (X) from country

27 Also see Rajan (2002) and Williamson (2005) for discussions of the virtues of a currency basket regime for Asia and the references cited within.

28 In another paper, Mallick and Marques (2005) estimate the ERPT of the dollar–*rupee* exchange rate into India's import and export prices for nine SITC 1-digit commodities for the period 1980–2001. Using panel data estimation, the average ERPT for imports was about 82 per cent, and that for exports into dollar prices was 22 per cent.

29 The literature on production sharing has used an array of terms to describe this phenomenon, including 'recycling comparative advantage', 'production fragmentation', 'super-specialisation', 'vertical specialisation', and 'slicing the value chain', to name just a few.

30 Over the last decade, production-sharing-based trade has expanded at a faster rate than growth in world trade and world GDP. See Athukorala (2005), Athukorala and Yamashita (2006) and Ng and Yeats (2001, 2003) for excellent descriptions of trends and patterns of international production fragmentation across the globe and in Asia.

A.[31] In such a situation, depreciation of B's currency (ignoring PTM behaviour for the moment) raises the country's exports of good Y, but increases the imported input price of good X. Thus, changes in domestic costs following a currency change are higher with production sharing than without, resulting in the firm in country B altering its foreign-currency price of exports to a lesser extent. In other words, even without pro-active PTM strategies or local currency pricing (LCP), one would expect lower ERPT with production sharing. While this reasoning is intuitive, we present a stylised model of production sharing in the Annex to help formalise thoughts.

The issue of production sharing and ERPT is a relatively under-researched area and there is consequently scant literature related in the area. Gron and Swenson (1996) show that incomplete ERPT occurs when multinational firms are able to acquire inputs from different sources internationally, allowing them to adjust their input prices in response to exchange-rate changes.

Webber (1995) develops a partial equilibrium model of import ERPT in the presence of imported inputs. He also incorporates the role of currency invoicing. Not surprisingly, he shows that ERPT is incomplete or partial when imports are procured from another country and invoiced in a third nation's currency.

Athukorala and Menon (1994) examine ERPT for Japanese manufacturing exports that are characterised by the use of imported intermediate inputs. As Japanese exports rely heavily on imported inputs, the authors estimate ERPT by separating out the direct PTM effects and the impact of exchange-rate changes on input costs. Their results for the period 1980–92 show that ERPT is lower when the impact of exchange-rate changes on imported-input costs is taken into account. Using an autoregressive distributed modelling technique, the results show that pass-through estimates vary across industries. They are the lowest for industries characterised by heavy concentration of imported parts and components (such as textiles, electrical machinery and electronics) and the highest for categories such as chemicals where production sharing is not widespread.

Concluding observations

This paper surveys empirical evidence on the extent of exchange-rate pass-through in selected Asian economies. It is apparent that results on the degree of ERPT depend on the time horizon of the analysis. That being said, on a country-by-country basis, it appears that ERPT is the highest for Asia's developing economies, such as Thailand and Indonesia, and somewhat lower for developed economies, such as Japan. Beyond levels of economic development, an interesting area for research would be the extent to which ERPT is impacted by a nation's macroeconomic fundamentals, such as money supply growth, inflation rate and type of exchange-rate regime (see Ghosh and Rajan 2007b).

Exchange-rate regimes in Asia span a wide spectrum. Smaller Asian economies appear to prefer some form of single currency peg. This is true of Hong Kong SAR, China (currency board arrangement pegged to the US dollar), Brunei (currency board arrangement pegged to the Singapore dollar) and Bhutan and Nepal (pegged to the Indian *rupee*). In contrast, Bangladesh, Sri Lanka, and the crisis-hit economies of Indonesia, Korea, Philippines and Thailand officially operate flexible exchange-rate regimes. The flexible exchange rates in the four East Asian countries are accompanied by inflation-targeting frameworks. A number of other Asian countries, such as India, Pakistan, Singapore, Taiwan and Vietnam, have adopted a variety of intermediate regimes (currency baskets, crawling bands and adjustable pegs). On 21 July 2005, China and Malaysia officially shifted to what may be best referred to as a more mechanical version of a currency-basket regime (that is, keeping the trade-weighted exchange rate within a specified band as a goal in itself). Therefore, it is readily apparent that 'one-size does not necessarily fit all' when it comes to the choice of exchange-rate regimes

31 US–Mexico trade is a good case in point.

in Asia (Rajan 2006). For this reason, Asia provides an ideal setting within which to analyse the effects of exchange-rate regimes on ERPT.

In the final analysis, while the extent of ERPT has important macro economic implications, it is predominantly a micro economic phenomenon. This implies the need to pay more attention to ascertaining ERPT at the disaggregated level rather than at the broad macro level. At the disaggregated level, it is especially important to focus more research effort on the roles of production sharing and MNCs and their implications for ERPT. Given that the literature on ERPT and standard trade in Asia is relatively limited, it is not surprising that the empirical literature connecting fragmented trade with ERPT is virtually non-existent. For future empirical research on ERPT in the context of cross-border production sharing involving Asia, the challenge lies in the compilation of export (import) quantity and price data for both final goods and parts and components.

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Annex: ERPT in the presence of production sharing

This Annex develops a simple analytical framework of the impact of production sharing on ERPT with two-country trade involving a single firm in each country.

We assume that a representative firm B of country B has some market power in the sense that it can affect the A currency price of good Y by varying its price in its own currency. We assume country B to be a labour abundant country with a perfectly elastic labour supply, such that any increase in labour demand can be met at the given wage rate. Let the cost of parts and components X be denoted by P_x^B. This is in firm country B's currency. The production function for good Y is assumed to be of simple Cobb-Douglas form:

$$Y = aL^{\alpha} X^{\beta} \tag{3}$$

where a is a constant and both $\alpha, \beta \in (0, 1)$ and $\alpha + \beta = 1$.

The demand function faced by firm B is given as:

$$Y = b(P_Y^B)^{-1/\sigma} \tag{4}$$

where σ is a constant and the inverse of the elasticity of demand and $\sigma \in (0, 1)$.

Firm B's profit function is given by

$$\pi = P_Y^B Y - w^B L - P_X^B X \quad (5)$$

Plugging equations (3) and (4) into equation (5), we obtain optimal input demand L^* and X^*. Substituting this in the production function (in log form) we have:

$$\ln Y = \ln a + \alpha \ln L^* + \beta \ln X^* \quad (6)$$

Using equation (6) in the demand price equation

$$\ln P_Y^B = \ln c - \sigma \ln Y \quad \text{where } c = \left(\frac{1}{b}\right)^{-\sigma} \quad (7)$$

Let E_B^A be A's currency per unit of B's currency. The price of Y in A's currency is:

$$P_Y^A = E_B^A P_Y^B \quad (8)$$

or, in log form, $\ln P_Y^A = \ln E_B^A + \ln P_Y^B$.

We define ERPT as the extent of change in the bilateral exchange rate between A and B into the price of good Y denominated in A's currency. Differentiating P_Y^A with respect to the exchange rate E_B^A (i.e. equation (8) in log form), we arrive at the expression for ERPT:

$$\text{ERPT} = 1 - \sigma \frac{d \ln P_X^B}{d \ln E_B^A}\left[\frac{[\beta - \alpha\phi]}{[\beta(1-\sigma) - 1 - \phi(1-\sigma)\alpha]}\right] \quad (9)$$

where $\phi = \dfrac{(1-\sigma)\alpha}{\beta(1-\sigma) - 1}$ and $-1 < \phi < 0$.

Eq. (9) illustrates that if the price of X remains unchanged following country B's exchange rate change with A, then the second term is zero and we have complete pass-through. However, if the increased demand for X raises the price of X due to depreciation of country B's currency, it further increases costs for firm B. It can be easily shown that the second term is now negative and pass-through is incomplete. Figure 1 captures this point via a rise in the MC curve. The initial equilibrium is at point 0 where MR intersects the MC curve with the price being P_Y^B. The rise in costs following country B's currency depreciation shifts the MC curve outwards and raises the price of Y in B's currency to $1'$ (or $P_{Y\,\text{no ps}}^{/B}$).

We now introduce production sharing by assuming that the firm in Country B import parts and components X from the firm in Country A, priced at P_X^A, which B takes as given. The profit function for firm B is:

$$\pi = P_Y^B Y - w^B L - \frac{P_X^A}{E_B^A} X \quad (10)$$

Following the same sequence we arrive at the pass-through expression.

$$\text{ERPT} = 1 - \sigma \frac{d \ln P_X^A}{d \ln E_B^A}\left[\frac{[\beta - \alpha\phi]}{[\beta(1-\sigma) - 1 - \phi(1-\sigma)\alpha]}\right] + \sigma \frac{[\beta - \alpha\phi]}{[\beta(1-\sigma) - 1 - \phi(1-\sigma)\alpha]} \quad (11)$$

Given that $\alpha, \beta, \delta \in (0, 1)$ and $-1 < \phi < 0$ and $-1 < \dfrac{[\beta - \alpha\phi]}{[\beta(1-\sigma) - 1 - \phi(1-\sigma)\alpha]} < 0$.[32]

32 The ERPT expression equation (9) is

$$\text{ERPT} = 1 - \sigma \frac{d \ln P_X^B}{d \ln E_B^A}\left[\frac{[\beta - \alpha\phi]}{[\beta(1-\sigma) - 1 - \phi(1-\sigma)\alpha]}\right], \quad (A1)$$

where:

$$(1-\sigma)\alpha > 0, \quad -1 < \beta(1-\sigma) - 1 < 0. \quad (A2)$$

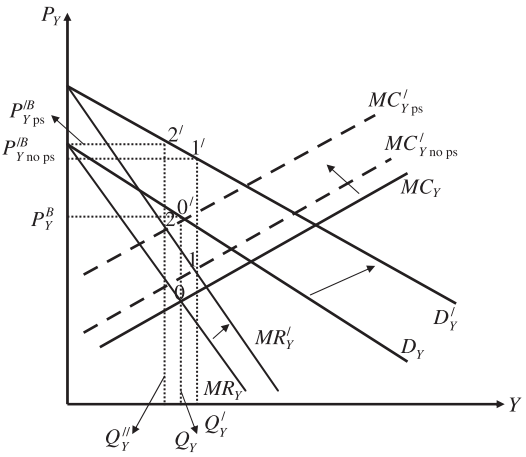
It follows from (A1) and (A2) that, since $\phi = \dfrac{(1-\sigma)\alpha}{\beta(1-\sigma) - 1}$, it must be that $-1 < \phi < 0$. Given this, we consider the second term of the pass-through expression. The numerator is

$$\beta - \alpha\sigma > 0, \quad (A3)$$

turning to the denominator

$$\phi(1-\sigma)\alpha < 0. \quad (A4)$$

Figure 1
Two-country production sharing—
Country *B*'s currency depreciates *vis-à-vis* Country *A*



	Equilibrium point	Price	Quantity
Initial	0	P^{B}_{Y}	Q_Y
Without production sharing	1	$P^{/B}_{Y\,no\,ps}$	$Q^{/}_Y$
With production sharing	2	$P^{/B}_{Y\,ps}$	$Q^{//}_Y$

Source: the Authors.

Thus, from equation (11), it is apparent that the ERPT is lower than for standard trade. The weaker currency of *B* raises exports of *Y*. This, in turn, leads to an increased demand for components *X*, thereby raising production costs of firm *B*. Moreover, country *B*'s currency depreciation makes imported components *X* more expensive. The latter effect as a result of fragmentation of the production process is captured by the third term on the right hand side of equation (11), which was absent in the situation of standard trade. This point can be intuitively grasped with the help of Figure 1 again. When *B*'s currency depreciates, the costs rise more than without production sharing, shifting the *MC* curve outwards to $MC^{/}_{Y\,ps}$. The new equilibrium for firm *B* is at 2 with the domestic currency price of *Y* being $2^{/}$ or $P^{/B}_{Y\,ps}$ compared to $P^{/B}_{Y\,no\,ps}$ without production sharing. As firm *B* absorbs more of the exchange rate change in its own price of *Y*, this leads to lower ERPT into the price of good *Y* in *A*'s currency.

As discussed earlier in the third section, effectively an exchange rate change now enters the exporter's marginal costs, an effect that would be absent with production sharing, hence leading to lower ERPT. The even higher input prices in the upstream sector imply further rises in costs for firm *B*. It follows from equation (11) that ERPT is lower for final good *Y*. With production sharing, the higher the PTM at the level of the intermediate good, the lower the ERPT is for the final good.[33]

So,
$$0 < \{-\phi(1-\sigma)\alpha + \beta(1-\sigma)\} < 1, \tag{A5}$$
that is, it is positive and lying between 0 and 1. Now, as the entire denominator, the expression is:
$$-1 < [\{-\phi(1-\sigma)\alpha + \beta(1-\sigma)\} - 1] < 0, \tag{A6}$$
and lies between 0 and –1. Thus it follows from (A3) and (A6) that the second term in the ERPT expression is negative.

33 Another form of production sharing could involve three countries, when country *B* imports the intermediate good from country *C* and then exports the final good to country *A*. This may be quite pertinent for Asia where more technologically advanced Asian countries such as Japan, Taiwan, Singapore, and Korea produce the technology-intensive inputs that are used in assembly operations in the relatively lower wage Asian countries such as China, India or Vietnam and shipped to destination markets such as the US. In such a situation, if country *B*'s currency moves in the same direction as countries *A*'s and *C*'s, the results boil down to the two-country case. However, if country *B*'s currency appreciates with respect to country *C*'s but depreciates with respect to country *A*'s, the cheaper imported input price could moderate production costs, leading to more ERPT for final good *Y*.