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PASS-THROUGH OF EXCHANGE RATE INTO DOMESTIC PRICES: THE CASE OF FOUR EAST-ASIAN COUNTRIES[1]

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ABSTRACT

The paper undertakes a comparative empirical analysis of the effects of shocks on domestic prices in four Asian countries before and after the financial crisis of 1997 in South-East Asia. We apply two different estimation methodologies, namely structural VAR and a single equation approach. The results of the two methods are consistent, although the magnitude of the elasticities of the exchange rate pass-through are different due to the inclusion of different variables, lag terms and different assumptions made in both methods. The results show that the degrees of exchange rate pass-through in these countries are different across countries and over time. In most cases, the pass-through rates are incomplete. The degree of exchange rate pass-through is highest on import prices, moderate on PPI and lowest on CPI. In some cases, the pass-through rates on CPI are even negative. The effect of the import price shock is stronger compared to that of the exchange rate shock in determining the movement of domestic prices in these countries. Trade openness has a weak correlation with the degree of exchange rate pass-through.

Keywords: *domestic prices, exchange rate pass-through, SVAR, single equation approach*

JEL classification: C22, C32, F41

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1. Introduction

One of the main issues in international macroeconomics is the relationship between exchange rate movements and price adjustments of traded goods, the so-called exchange rate pass-through. Exchange rate pass-through is defined as the percentage change in domestic/imported prices led by a one percentage change in the exchange rate between the importer and exporter currency.

According to Sahminan (2002) and An (2006), exchange rate movements transmit to domestic prices through three channels: imported consumption goods, imported intermediate goods and domestic goods priced in foreign currency prices.

A one-to-one response of domestic prices to exchange rate changes is known as a full/complete pass-through while a partial/incomplete pass-through occurs when there is a less than one-to-one response in prices as a result of exchange rate changes. In a real situation, pass-through of nominal exchange rate changes to domestic prices is incomplete. For instance, Campa & Goldberg (2001) estimate exchange rate pass-through equations for 25 OECD countries for a period between 1975 and 1999. They find that a hypothesis of complete short run pass-through can be rejected in 22 out of 25 countries. But in contrast, they are only able to reject complete long run pass-through in 9 of 25 countries. More evidence of imperfect pass-through is shown in Campa & Gonzalez (2002).

A lower degree of pass-through implies that the nominal exchange rate leads to lower expenditure switching effects of domestic monetary policy. Hence, monetary policy may deal more effectively with real shocks. Conversely, one may question the effectiveness of the monetary policy if the pass-through rate has endogenous effects on monetary stability (Campa & Goldberg, 2002). Therefore, it is very important to know and understand the determinants of the exchange rate pass-through as well as the transmission of shocks under different degrees of pass-through to the economy.

In general, the literature on exchange rate pass-through can be divided into two strands as discussed in An (2006): micro and macro level. The first strand of the literature focuses on the analysis of exchange rate pass-through into domestic prices based on the micro level such as foreign firms' pricing behavior, disaggregated product bundles/industries and market structures.

The second strand of the literature, on the other hand, studies exchange rate pass-through at the macro level. It investigates exchange rate pass-through from the monetary policy view. It estimates exchange rate pass-through into producer prices index (PPI), import price index (IMP) and consumer prices index (CPI). Our study contributes to this strand of the literature.

Although there exists a body of research on exchange rate pass-through, its primary focus is on the industrial countries. Analysis of it based on the emerging Asian economies is limited (Sahminan, 2002, Sato et.al, 2005). To fill this gap this study focuses on some emerging economies of Asia, namely Korea, Malaysia, Singapore and Thailand. To have a complete picture on exchange rate pass-through in the Asian economies we should have included other Asian countries. However this analysis was not possible due to the unavailability of data for other countries.

Korea, Malaysia, Singapore and Thailand are strongly affected by developed countries such as the US and Japan, given that the US and Japan are main trade partners. Most trade is in US dollars even among Asian countries. For instance, in 1980, 96.1% of exports and 93.2% of imports in Korea were invoiced in US dollars. This figure remained high in 2000 when 84.8% of exports and 80.4% of imports correspondingly were invoiced in US dollars. A similar trade invoicing condition pertains for Thailand. In 2000, 87% of Thai exports and 79% of Thai imports were invoiced in US dollars. This implies that the market is imperfect, where the US dollar dominates the market, according to Kamps (2006).

Another feature of the countries in the sample is that trade components feature a high proportion of intermediate goods. For instance, country specific report/data (IMF, 2004) show that more than 74% of imports into Malaysia are represented by intermediate goods. This implies that prices in these countries might be strongly affected by external shocks through imported inflation of intermediate goods.

Korea, Malaysia, Singapore and Thailand are among those countries which were hit by the financial crisis of 1997–1998, which first started in Thailand when the baht was floated on July 2, 1997. The financial crisis prompted the crisis-hit Asian countries to alter their monetary policy and exchange rate regimes. Before the crisis, these countries adopted narrow, rigid exchange rate regimes and policy authorities focused on monetary base targeting.

After the crisis, drastic actions were taken to reconstruct monetary policy implementation. Most of these countries have moved to more flexible or floating exchange rate regimes. At the same time, few countries have adopted inflation targeting regimes. Korea took the first move to implement an inflation targeting regime in April 1998, followed by Indonesia in 2000, then Thailand in May 2000 and the Philippines in January 2002[2]. Whereas Malaysia and Singapore have not adopted inflation targeting but moved to managed floating regimes.

These drastic changes in the monetary policy and regimes throw up some implications regarding the economies in these countries. By comparing the data before and after the financial crisis in three Asian countries, Osawa (2006) finds that exchange rate volatility in these countries has increased over

[2] Korea officially adopted an inflation targeting regime in April 1998 with headline CPI as inflationary target but switched to core CPI targeting from January 2000.

time. At the same time, foreign exchange reserves and interest rates in these countries have declined. These changes are due to the move in monetary policy and regimes from a rigid to a more flexible one.

Turning to economic indicators, inflation rates in these countries have declined slightly after the financial crisis or after the implementation of new monetary policy. M2 growth in these countries also declines over time. Additionally, these countries have improved their current account balance from negative to positive balances.

These countries also show an increase in trade openness over time although the degrees of trade openness in these countries are quite different. Malaysia and Singapore retain their high degrees of trade openness over time.

According to Mishkin & Savastano (2001), an inflation targeting country should let the exchange rate float. This requirement can be explained by the theory of the 'Impossibility of the Holy Trinity' where capital mobility and monetary policy independence cannot coexist with a pegged exchange rate regime. Mishkin (2004) discusses the danger of focusing strongly on limiting exchange rate movements. The first danger is that the economy faces the risk of transforming the exchange rate into a nominal anchor that takes over the inflation target. The second danger is that the impact of the exchange rate on inflation and output may be determined by the source of shocks.

Due to the above reasons, it is arguable that the adoption of an inflation targeting regime generates a cost in the form of higher exchange rate volatility. However, Edwards (2006) in his study on the relationship of exchange rate and inflation targeting shows that there is no evidence that the adoption of inflation targeting leads to higher volatility in the exchange rate.

Previous studies show that exchange rate shocks in these economies tend to pass-through into aggregate inflation at a much faster rate than in the industrial economies. Exchange rate pass-through is very rapid for emerging markets but slow for advanced economies according to Devereux and Lane (2001). How well do these statements apply to Asian countries? Does exchange rate pass-through change in these countries after moving to a more flexible exchange rate regime and inflation targeting? Are there any differences in pass-through rates among Asian countries?

This study seeks to answer the above questions and has three main objectives. First, we seek to compare the degrees of exchange rate pass-through into different domestic prices (import price, PPI and CPI) before and after the financial crisis of 1997 (or after moving to new monetary policies) in the countries in the sample.

Second, we compare the effects of exchange rate shock with other shocks on domestic prices. Previous studies show that the effect of import price is much larger than that of exchange rate shock. For instance Hahn (2003) finds that the pass-through of import price shock is largest and faster on domestic prices. It is important to investigate how large the effect of exchange rate shock is relative to other shocks. If the pass-through rate is high but the relative effect of the exchange rate is small, then

exchange rate pass-through will not have a significant and large effect on determining domestic price stability.

Third, using the same range of data through two different approaches and empirical methodologies, we seek to estimate the degrees of exchange rate pass-through in these countries. We use the structural vector autoregressive model (VAR) and single equation approaches.

The results from both methods are consistent with each other. Our findings are in line with the results of previous studies where exchange rate pass-through is incomplete both in the short-run and the long-run in most cases. The pass-through rate is the highest on import prices, moderate on PPI and lowest on CPI. Exchange rate pass-through does not decline in all countries considered in this study. Additionally we find a weak correlation between trade openness and the degree of exchange rate pass-through. In general, the effect of exchange rate shock on domestic prices is lower compared to that of import price shock.

The paper is organized as follows. In section 2, we describe the methodology and data. Section 3 discusses estimated results from SVAR and single equation approaches. Section 4 concludes.

2. Theoretical Framework

This section discusses some theoretical issues in modeling exchange rate pass-through and also the relationship between domestic prices (import price, producer price and consumer price) and exchange rate movements.

2.1. Modeling Exchange Rate Pass-through

Following the step of many previous studies in modeling exchange rate pass-through, the exchange rate pass-through equation constructed in this study is based on the concept of the law of one price (LOOP). Under the assumption of LOOP, the price of import denominated in the domestic importing country's currency (P_t^{im}) is equal to the import price denominated in the foreign exporting country's currency (P_t^{ex}) multiplied by the exchange rate of the importing country (E_t).

$$P_t^{im} = P_t^{ex}.E_t \tag{1}$$

The exporting producer sets P_t^{ex} based on the mark-up (λ_t) over marginal cost of production (C_t^*).

$$P_t^{ex} = \lambda_t.C_t^* \tag{2}$$

Substituting equation (2) to (1):

$$P_t^{im} = \lambda_t.C_t^*.E_t \tag{3}$$

where C_t^* is the exporter's production cost and λ_t is the markup. The mark-up depends on the demand pressure in the destination market. It can be represented by the real GDP of the importing country.

Equation (3) is transformed into log form (denoted in lowercase letters):

$$p_t^{im} = \alpha_1 \lambda_t + \alpha_2 c_t^* + \alpha_3 e_t \qquad (4)$$

The exchange rate pass-through is captured by the coefficient of α_3 which is the partial elasticity of import price with respect to exchange rate. Exchange rate pass-through is complete when $\alpha_3 = 1$ but zero when $\alpha_3 = 0$. In reality, exchange rate is partial or incomplete where $0 < \alpha_3 < 1$. Equation (4) is modified by including lagged terms and is estimated using single equation method (see section 3.2). Besides estimating the pass-through into import price, estimations also include pass-through into producer and consumer prices.

2.2. Sensitivity of Domestic Prices to Exchange Rate Movements

Previous studies on exchange rate pass-through show that pass-through is higher on import price than consumer price (for example Edwards (2006) and Campa & Goldberg (2006)). In general, pass-through is highest on import price, moderate on producer price and lowest on consumer price (for example, McCarthy (2000), Hahn (2003) and Ito et.al (2005)). This phenomenon can be explained by several factors. Focusing on the role of distribution margin and imported inputs on the sensitivity of domestic prices to exchange rate movements, Campa & Goldberg (2006) show that production costs are more sensitive to exchange rate and import prices as they rely on imported components, domestic suppliers and distributors on imported input. High distribution costs and low reliance on imported inputs induce low pass-through into consumer price. However, distribution margin can lead to more sensitivity in consumer price if imported inputs are used in production of nontradables.

Burstein, Eichenbaum & Rebelo (2002) seek to investigate the low inflation in consumer price compared to producer price after large devaluations. As in Campa & Goldberg (2006), they explain that pass-through into CPI is low due to distribution costs and nontradable inputs. Besides, there are inferior tradable goods which are only produced for the domestic market. These inferior goods may substitute for imported goods which leads to low pass-through into consumer price. Third, domestic consumers may switch their demand from imported goods to local tradable (inferior) goods during crisis periods or devaluations of domestic currency.

3. Data and Estimation Methods

This section of the paper describes the data used in estimation and methodology. As the financial crisis started in July 1997, the data is divided into two sub-periods: 1991M1–1997M7 (period before the crisis) and 1999M1–2007M5 (period after the crisis). We apply two different approaches: single equation approach and structural VAR estimation. In doing so, we attempt to compare the robustness of the results to two different methodologies. We estimate exchange rate pass-through into domestic prices (import price, PPI and CPI) and analyze dynamic effects of shocks on the economy in the Asian countries.

3.1. Data

All the monthly data was obtained from International Financial Statistics (IFS), IMF. This data includes oil price index, money or M1, nominal effective exchange rate, import price, producer price index (PPI), consumer price index (CPI) and industrial/manufacturing production index (IP). All series are seasonally adjusted using the Census X11 program and are transformed into logarithmic form (apart from the output gap variable). The output gap is constructed as the log difference between actual output (IP) and potential output (HP filter adjusted industrial production index[3]).

The main problem in this study is the availability of data. Most Asian countries do not have long enough series. Malaysia does not have the import price series and therefore we only apply the 6-variable VAR model (excluding the import price variable). Thailand has shorter series, starting from 1999 M1, thus the analysis is made only for the second sub-period.

All the series (in logarithmic form) are tested with the unit-root stationarity test and become stationary after the first differenced transformation, except for the output gap series. Most of the output gap series are stationary in level. We compare the results of two unit-root tests, namely the Augmented Dicky-Fuller (ADF) and Schmidt Phillips (SP) tests. All the series are divided into two sub-periods. In general, the results of the unit-root test for the first and second periods do not change much. For all time series we work with, both ADF and SP tests have agreed on the order of integration to be 1 (I(1) process).

3.2. Single Equation Approach

This section seeks to estimate the exchange rate pass-through model constructed in section 2.1. The methodology employed in this part of the paper applies LS and IV (instrumental variables)

[3] Thailand uses GDP instead of the Industrial Production index series due to the unavailability of the corresponding series.

techniques in order to estimate long run and short run exchange rate pass-through on domestic prices. There is a huge debate around the methods of estimation of long run pass-through. In theory, import prices, the exchange rate and foreign price level should have a long run Engle and Granger cointegrating relationship. However in reality and in the empirical literature this fact is not always confirmed (Campa and Goldberg, 2005).

De Brandt, Banerjee and Kozluk (2007), using time series and up-to-date panel data techniques, test for cointegration with the possibility of structural breaks and show that the long run may be restored in the estimation. The lag order and introduction of structural breaks may significantly change the results from the cointegration tests, according to De Brandt et.al, (2007). Given that some Asian countries experienced financial crisis in late 1997 we apply two different cointegration tests: Johansen trace test and Saikkonen & Lütkepohl tests for two sub-periods separately using different lag orders based on the SC, AIC, FPE and HQ information criteria. Since none of the tests outperforms the other, our conclusions are based on the results from the two tests applied. We test for cointegration between CPI (PPI, import price index), exchange rate and foreign price level as well.

If the cointegration relationship is revealed we apply error-correction model (ECM). When it is not the case we use the LS procedure suggested by Campa and Goldberg (2005). ECM is estimated using standard LS techniques in two steps. First we estimate ECM as follows:

$$\Delta \boldsymbol{p}_{k,t} = -(1-\theta_1)\boldsymbol{p}_{k,t-1} + \theta_2 \boldsymbol{s}_{k,t-1} + \sum_{j=1}^{p-1} \boldsymbol{b}_j \Delta \boldsymbol{p}_{k,t-j} + \sum_{j=0}^{q-1} \boldsymbol{a}_j \Delta \boldsymbol{s}_{k,t-j} + \sum_{j=0}^{r-1} \boldsymbol{c}_j \boldsymbol{y}_{k,t-j} + \sum_{j=0}^{z-1} \boldsymbol{d}_j \Delta \boldsymbol{p}^*_{us,t-j} + \boldsymbol{u}_t \quad (4')$$

where pk,t represents home CPI (home PPI or import price index) for country k, sk,t is the nominal effective exchange rate, yk,t is the output gap, pus,t* is the PPI of the US. All variables are expressed in logs, Δ indicates first difference. Long run pass-through is $\beta = \frac{\theta_2}{1-\theta_1}$ Coefficient $\hat{\boldsymbol{a}}_0$ is interpreted as short run exchange rate pass-through.

The lag orders of $y_{k,t}$, $\Delta p_{k,t}$, $y_{k,t}$ and $\Delta p_{us,t*}$ are determined on the basis of the AIC and SC criteria and significance of the parameters. After the final model is formulated its residual is checked again for stationarity by means of the ADF test with the lag order based on the AIC and SC information criteria. Given that the estimated residual follows a nonstandard distribution, we use critical values for the ADF cointegration tests. Inclusion of the deterministic variables trend or intercept depends on the behavior of the times series. If the variables exhibit trend behavior we include trends in the cointegrating equation, if not we don't.

The disadvantage of this model is that it does not provide the standard errors of the long run estimate directly. To calculate them we apply Bewley transformation of the ECM:

$$p_{k,t} = \beta s_{k,t-1} - \sum_{j=1}^{p-1} \frac{\hat{b}_j}{1-\theta_1} \Delta p_{k,t-1} - \sum_{j=0}^{q-1} \frac{\hat{a}_j}{1-\theta_1} \Delta s_{k,t-j} - \sum_{j=0}^{r-1} \frac{\hat{c}_j}{1-\theta_1} y_{k,t-j} - \sum_{j=0}^{z-1} \frac{\hat{d}_j}{1-\theta_1} \Delta p^*_{us,t-j} + \frac{u_t}{1-\theta_1} \quad (4'')$$

with $\hat{b}_j = \sum_{i=j+1}^{p} b_i$, $\hat{a}_j = \sum_{i=j+1}^{q} a_i$, $\hat{c}_j = \sum_{i=j+1}^{r} c_i$ $\hat{d}_j = \sum_{i=j+1}^{z} d_i$, $\hat{a}_0 = -a_0$ for $j \geq 1$

Given that $\Delta p_{k,t}$ is correlated with disturbance u_t we estimate this equation using instrumental variables (IV) estimation with instrument $p_{k,t-1}$ for $\Delta p_{k,t}$. We later drop the subscript k for simplicity.

However one should take into account that the second step is possible only if $1-\theta_1$ is significantly different from zero. Thus before continuing with the second step we test whether $1-\theta_1$ is zero. If it is the case we apply standard two step Engle Granger procedure.

If evidence of cointegration is not found we apply the method suggested by Campa and Goldberg (2005) which in our case is defined as follows:

$$\Delta p_t = c + \sum_{j=0}^{12} a_j \Delta s_{t-j} + \sum_{j=0}^{r-1} c_j y_{t-j} + \sum_{j=0}^{z-1} d_j \Delta p^*_{t-j} + u_t \quad (5)$$

The lag order of the output gap and foreign price index as before are determined on the basis of the AIC, SC information criteria and the significance of parameter estimates. Given that we have monthly data in our analysis we include exchange rate series up to lag of order 12 in order to get an approximate measure of long run pass-through. Given that this assumption is ad hoc, one should not completely rely on these estimates; they can be interpreted as benchmark estimates of long run pass-through only. Short run pass-through in the present case is a parameter which determines the contemporaneous effect of the exchange rate on price level, equal to $\hat{a}_0$ in our case.

Given that we might have an endogeneity problem in the regression we re-estimate our model using the two stages least squares method (TSLS) and use as instruments 13 lags of the exchange rate, 12 lags of output gap, 13 lags of foreign price index and 13 lags of the dependent variable. The number of lags for instruments is subject to variation (Mihailov, 2005). For comparative purposes we present obtained pass-through estimates from OLS and TSLS in Table 1.

3.3. Structural Vector Autoregression Model (SVAR)

Following the construction of the SVAR model in analyzing the effects of shocks in previous studies (Ito and Sato, 2006 and McCarthy, 2006), the SVAR model consists of seven variables:

$x_t = \left(\Delta OIL_t \quad GAP_t \quad \Delta M_t \quad \Delta NEER_t \quad \Delta IMP_t \quad \Delta PPI_t \quad \Delta CPI_t \right)$

where OIL_t stands for the oil price index, GAP_t the output gap, M_t the monetary aggregate or M1, $NEER_t$ the nominal effective exchange rate and IMP_t the import price, PPI_t producer price index and CPI_t consumer price index. Δ denotes the first differenced operator. All variables except the output gap are in logarithms and are seasonally adjusted using the Census X11 program. All series are tested with the unit-root stationarity test and become stationary after the first differenced transformation.

The analysis of exchange rate pass-through in this section takes a different approach by including different variables compared to the single equation approach that applies the concept of LOOP. It follows the setup of a standard open economy macroeconomics model which consists of the variables/equations of supply (oil price index), demand (output gap), monetary policy (M1), exchange rate and domestic prices. The setup of the model is based on the ordering of variables and restriction imposed on the structure of shocks where decomposition of the variance covariance matrix of reduced form residuals is written in a lower triangular matrix. n(n-1)/2 restrictions are imposed globally on the triangular matrix in order to identify structural shocks where some of the structural shocks do not have contemporaneous impacts on other variables.

$$\begin{pmatrix} e_t^{OIL} \\ e_t^{GAP} \\ e_t^{M} \\ e_t^{NEER} \\ e_t^{IMP} \\ e_t^{PPI} \\ e_t^{CPI} \end{pmatrix} = \begin{pmatrix} S_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & 0 & 0 & 0 \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} & 0 & 0 \\ S_{61} & S_{62} & S_{63} & S_{64} & S_{65} & S_{66} & 0 \\ S_{71} & S_{72} & S_{73} & S_{74} & S_{75} & S_{76} & S_{77} \end{pmatrix} \begin{pmatrix} \varepsilon_t^{OIL} \\ \varepsilon_t^{GAP} \\ \varepsilon_t^{M} \\ \varepsilon_t^{NEER} \\ \varepsilon_t^{IMP} \\ \varepsilon_t^{PPI} \\ \varepsilon_t^{CPI} \end{pmatrix} \quad (6)$$

The ordering of the variables determines the structure of the shocks. The first variable has influential effects on all variables below it but is not affected by these variables. The second variable only receives impact from the first variable. It does not have any impact on the first variable but it can influence all the variables below it. This rule applies to all subsequent variables. Following Ito and Sato (2006), the oil price index is ordered first, as supply or oil price shocks may affect the other variables but contemporaneously are unlikely to be affected by other shocks. The second variable is the output gap. This variable is likely to be affected by oil price shocks only and is assumed to affect all variables in the system except oil price shocks. The monetary policy variable is ordered next before the exchange rate. This variable is ordered below the exchange rate in the second model for robustness checking. The three domestic prices are ordered thus as previous studies show pass-through is highest

on import price and PPI but lowest on CPI (see discussion in section 2.2). Such ordering allows interpretation on how the price of imported inputs is transmitted into consumer final goods.

Ito & Sato (2006) use the nominal effective exchange rate to represent the exchange rate variable and argue that it is not appropriate to use the bilateral exchange rate with the US Dollar in this study as most Asian countries had de facto adopted the US Dollar. In this study, we run the baseline SVAR model using the nominal effective exchange rate series.

The advantages of applying the structural VAR in this paper are: first it solves the endogeneity problem that arises under the single equation method; second, this technique applies restrictions to identify structural shocks; and third, it enables us to investigate the effect of exchange rate and pass-through rate on the chain of domestic prices (import price, PPI and CPI) in the same system equation. For the purpose of robustness, we run the VAR model using two different ordering schemes such that:

$$x_t = \left(\Delta OIL_t \quad GAP_t \quad \Delta M_t \quad \Delta NEER_t \quad \Delta IMP_t \quad \Delta PPI_t \quad \Delta CPI_t\right), \qquad (7)$$

which is Model I in our case and

$$x_t = \left(\Delta OIL_t \quad GAP_t \quad \Delta NEER_t \quad \Delta M_t \quad \Delta IMP_t \quad \Delta PPI_t \quad \Delta CPI_t\right), \qquad (8)$$

which is Model II in the present case.

Exchange rate is assumed to influence the decision of monetary policy in Model II. The two different ordering variables of model are estimated separately for each country for both sub-periods. The number of lags is determined based on the SC, AIC and HQ information criteria. However, the final decision is made based on the results from the diagnostic tests for the residuals. The results of the first ordering are compared with the results of the second ordering.

According to Mihailov (2005), under the structural VAR estimation, the exchange rate pass-through at horizontal lag (ℓ) is obtained through the accumulated impulse response of domestic prices (P) with respect to an innovation of one standard deviation in the exchange rate (NEER) equation of the VAR. The partial derivatives can be written as:

$$\frac{\partial(d \ln P_{t\ell})}{\partial \varepsilon_{t\ell}^{NEER}}, \ \ell > 0$$

On the other hand, the exchange rate pass-through under the single equation estimation is:

$$\frac{\partial(d \ln P_{t\ell})}{\partial \ln NEER_{t\ell}}, \ \ell > 0$$

According to Mihailov (2005), there is no direct comparison of the elasticity of exchange rate pass-through between the two methods. In order to make the pass-through rates, obtained from structural VAR and the single equation estimations, comparable, transformation or normalization of the impulse response to an innovation in NEER VAR equation is made in the following way:

$$\frac{\partial(d \ln P_{t\ell}) \Big/ \partial \varepsilon_{t\ell}^{NEER}}{\partial \ln NEER_{t\ell} \Big/ \partial \varepsilon_{t\ell}^{NEER}}, \ \ell > 0$$

4. Empirical Results

This section presents empirical results from the single equation and SVAR estimations. Additionally it conducts comparative analysis on the exchange rate pass-through obtained using these two approaches.

4.1. Single Equation Estimation Results

This part of the section focuses on the comparison of exchange rate pass-through across countries and across periods. The cointegration tests (Johansen and S & L tests) show evidence of a cointegrated relation between exchange rate and domestic prices in the case of CPI in Malaysia (period I) and Thailand (period II) and PPI in Korea (period I)[4]. In these cases, the pass-through equation is estimated using the ECM method. In the cases where no cointegrated relation is found, OLS and TSLS methods are applied. The results of cointegration tests are summarized in the Appendix (Table I(a-c)). The results for exchange rate pass-through can be summarized as follows:

(1) Exchange rate pass-through on import prices

Korea and Singapore have incomplete pass-through on import prices, unlike Thailand which has complete pass-through on that in the second period. Short run exchange rate pass-through on import prices is in general lower than long run counterparts, except that of Korea in the second period. Exchange rate pass-through into import prices in Korea is very rapid in the short run.

[4] The cointegrating rank is selected using the principle where the null hypothesis cannot be rejected for the first time.

Table 1: Exchange Rate Pass-Through Rates Across Methodologies and Trade Openness

	OLS		TSLS		VAR		Average Trade openness	
Time horizontal 1 Short run	**Period I**	**Period II**	**Period I**	**Period II**	**Period I**	**Period II**	**Period I**	**Period II**
IMP								
Korea	**−0.393♣***	**−0.451♣**	**−0.387♣***	**−0.433♣***	−0.415	−0.794	0.49	0.64
Malaysia	-	-	-	-	-	-	1.48	1.82
Singapore	−0.033*	−0.388*	−0.032*	−0.384*	−0.118	−0.471	2.84	3.18
Thailand	-	**−1.15♣**	-	**−1.047♣**	-	1.266	0.69	1.12
PPI								
Korea	−0.073*	−0.10*	−0.073*	**−0.097♣** *	−0.033	−0.147	0.49	0.64
Malaysia	0.013*	−0.142*	0.026*	−0.116*	−0.192	−0.012	1.48	1.82
Singapore	0.089*	−0.262*	0.088*	−0.02*	−0.118	−0.157	2.84	3.18
Thailand	-	−0.182*	-	−0.162*	-	−0.128	0.69	1.12
CPI								
Korea	−0.06*	−0.027*	−0.06*	−0.028*	−0.057	−0.065	0.49	0.64
Malaysia	−0.012*	0.020*	−0.012*	0.025*	−0.000	0.056	1.48	1.82
Singapore	0.056*	−0.016*	0.057*	−0.02*	0.029	0.078	2.84	3.17
Thailand	-	−0.012*	-	−0.012*	-	−0.018	0.69	1.12
Time horizontal 12/ LR	**Period I**	**Period II**	**Period I**	**Period II**	**Period I**	**Period II**	**Period I**	**Period II**
IMP								
Korea	−0.497	−0.158*	−0.589	−0.169*	−0.696	−0.537	0.49	0.64
Malaysia	-	-	-	-	-	-	1.48	1.82
Singapore	−0.380	−0.833	−0.391	−0.827	−0.125	−1.478	2.84	3.18
Thailand	-	−1.61	-	−1.430	-	−1.919	0.69	1.12
PPI								
Korea	**−0.439♣**	−0.146*	**−0.439♣**	−0.136*	−0.048	−0.150	0.49	0.64
Malaysia	−0.30	−0.181	−0.29	−0.159	−0.391	−0.221	1.48	1.82
Singapore	0.070	−0.86	0.011	−0.63	−0.025	−0.696	2.84	3.18
Thailand	-	−0.358	-	−0.342	-	−0.235	0.69	1.12
CPI								
Korea	0.193*	**−0.085♣**	0.191*	**−0.090♣**	−0.040	−0.088	0.49	0.64
Malaysia	**−0.040♣**	0.055*	**−0.040♣**	0.059*	0.055	0.074	1.48	1.82
Singapore	0.099*	−0.052*	0.102*	**−0.06♣**	0.042	−0.130	2.84	3.18
Thailand	-	0.204	-	0.204	-	0.015	0.69	1.12

♣ - denotes that elasticity is significantly different from zero at 1% level

* - denotes that elasticity is significantly different from −1 at a 1% level

The following cases apply to ECM estimation as cointegration relations are found: pass-through into CPI in Malaysia (period I) and Thailand (period II); pass-through into PPI in Korea (period I)

The exchange rate pass-through values in the VAR are obtained from the normalized IRF, model I

Trade openness is defined as the total trade divided by GDP. The figures are calculated by the authors using the annual data from ADB: period I (1990-1996) and period II (1999-2006)

However import prices in Korea get adjusted in the long run so that the effect of exchange rate changes has declined over time. This is in line with the empirical findings obtained by Ito, Sasaki and Sato (2005). Comparing exchange rate pass-through elasticities across LS and TSLS we find no large difference between them. Given that we might have an endogeneity problem in the OLS estimation we rely more on the TSLS estimates. Comparing pass-through on import prices across periods in the long run, we observe it decline in Korea, but increase in Singapore. The drop in the pass-through rate in Korea may be due to the change in exchange rate regime to inflation targeting in 2000.

(2) Exchange rate pass-through on PPI

There is an overall incomplete pass-through on PPI across countries both in the short and long run. Exchange rate pass-through on PPI is lower that that on import prices. This is a quite stylized empirical fact, widely supported in the empirical literature such as McCarthy (2000) and Hahn (2003). Short run exchange rate pass-through on PPI is lower than its long run counterpart. Comparing exchange rate pass-through across periods we observe a decline in the PPI in Korea and Malaysia but a rise in Singapore.

(3) Exchange rate pass-through on CPI

Exchange rate pass-through on CPI is the lowest, and negligible compared to that on import prices and PPI. The estimates obtained are similar in magnitude to those obtained by Choudhri and Hakura (2006). As before, short run elasticities are lower than their long run estimates. Comparing long run pass-through on CPI across periods we observe it increase in Korea and Singapore, but decline in Malaysia in the second period, although by a negligible magnitude. We are not able to conduct similar analysis for Thailand due to the data availability problem.

However since most of the analysis made in this part of the paper is based on an ad hoc estimate of long run exchange rate pass-through rates these estimates should be considered with caution. Further analysis should be made by applying more sophisticated techniques

4.2. SVAR empirical results

This part of the section presents the results from SVAR estimation. First, the responses of import prices with respect to various shocks are discussed. The responses of other variables impacted by the exchange rate are also presented (IRF). Second, the relative explanatory power of shocks on domestic prices is compared using forecast error variance decompositions (FEVD). Finally, the degrees of pass-through before and after the crisis are compared.

(1) (Accumulated) Impulse response functions (IRF)

In the SVAR model, it is assumed that there are 7 shocks in the economy: oil price shocks, output gap shocks, exchange rate (NEER) shocks, import price shocks, production cost shocks (PPI) and non-oil price (CPI) shocks. The impulse response function shows the response of each variable to one positive standard deviation of each shock. The middle line represents the responses while the upper and lower dashed lines are two standard error bands. The vertical axis shows the percentage point change in the domestic price index or the percentage of pass-through and the horizontal axis shows the time (in months). However we are not going to discuss the effects of all shocks assumed; we will present here only the responses of domestic prices with respect to NEER and import price shocks.

The results of the cumulative impulse response functions are summarized in the appendix. Figures 1 and 3 show the graphs of the responses in the domestic prices (IMP, PPI and CPI) to a one percentage increase (appreciation) in nominal effective exchange rate between the two periods using models I and II. In general, the results are consistent with the results of previous studies: an appreciation in nominal exchange rate leads to a decline in domestic prices. Or equivalently, depreciation in the exchange rate causes an increase in domestic prices. This result holds in all countries between the two periods with the exceptions of Malaysia, Singapore and Thailand. In these countries, depreciation in the exchange rate leads to a decline in CPI in certain periods. This in line with the results reported in the paper by Choudhri and Hakura (2006).

In order to have a better comparison on the responses of domestic prices under exchange rate shock between the two periods, we summarize the numerical values captured when running the impulse response functions, i.e the responses of domestic prices under a 1% exchange rate shock (see Table 2). In general, the percentage changes of one standard deviation in the innovation in the NEER equations are different across countries. Import price in Thailand shows the highest response to exchange rate shock as compared to other countries. The response of domestic prices to exchange rate shock is highest on import price, moderate on PPI and lowest on CPI. The pass-through of exchange rate changes to import prices is higher in Korea and Thailand but lower in Singapore.

The cumulative impulse responses of domestic prices to import price shock are summarized in Table 2 as well. Comparing the results of Table 2, we observe that in general, the percentage changes in domestic prices led by import price shock are higher than those of exchange rate shock, with the exception of Thailand. As in the case of exchange rate shock, we observe that the effect of import price shock is highest on import prices, moderate on PPI and lowest on CPI, with the exception of Singapore. In Singapore, the effect of import price shock is highest on PPI, followed by import prices and CPI. The response of import price to a one percentage change in import price is highest in

Thailand, followed by Korea and Singapore. However, the effect of import price shock on PPI is highest in the case of Singapore, followed by Korea and Thailand.

In order to obtain exchange rate pass-through rates which are comparable with the pass-through rates estimated using the single equation method, we follow the transformation suggested by Mihailov (2005). The results are summarized in Table 1.

The results show that in most cases, exchange rate pass-through into domestic prices is incomplete, with the highest pass-through on import price, followed by PPI and CPI. Comparing the results between two sub-periods across prices, we observe that different price indices respond differently to the exchange rate changes. Additionally, changes in exchange rate pass-through in domestic prices differ across countries. This might be due to country-specific characteristics and percentage change in commodities composition of price indices over time. It is necessary to note that in general the magnitude of changes is large in Singapore and moderate in Korea and Malaysia.

(2) Forecast error variance decomposition (FEVD)

The FEVDs show the values of the percentage share of variance of the n-step forecast error of a variable that can be explained by innovation in another variable (Billmeier, 2002, p.13).

Table 3 shows the maximum effects of seven shocks on domestic prices that are obtained from the FEVD. The results show that import price shock is the main determinant of the fluctuations of import price in both periods. Exchange rate shock in its turn can explain quite well the movement of import prices especially in the case of Korea and Thailand. It can explain at most 24% and 41% of fluctuations in import prices in Korea and Thailand correspondingly (in period II).

PPI shock can mostly explain the movement of PPI in all countries for both periods, with the exception of Singapore. In Singapore, the movement of PPI is mainly determined by import price shock. Import price shock can explain at most 75% and 85% of the movement of PPI in Singapore for periods I and II correspondingly. In general, the explanatory power of import price shock on domestic prices is higher than that of exchange rate shock, with the exception of Thailand. Exchange rate has a very low effect in determining the movement of domestic prices in Malaysia and Singapore. These results hold in both periods.

Table 2: Impulse Response Functions: NEER Shock and Import Prices Shock (IMP) to Domestic Prices

Time	Period I NEER to import price				Period II NEER to import price				Period I IMP to import price				Period II IMP to import price			
	Kor	Mal	Sp	Thai	Kor	Mal	Sp	Thai	Kor	Mal	Sp	Thai	Kor	Mal	Sp	Thai
1	−0.51	-	−0.04	-	−1.35	-	−0.24	−1.38	0.63	-	0.60	-	1.90	-	1.00	1.02
4	−0.65	-	−0.02	-	−1.00	-	−0.32	−2.10	1.08	-	0.45	-	1.49	-	0.92	2.32
8	−0.68	-	-0.03	-	-0.51	-	-0.34	-2.36	0.73	-	0.40	-	1.52	-	1.11	1.98
12	−0.87	-	-0.03	-	-0.79	-	-0.34	-2.61	0.57	-	0.44	-	1.61	-	1.13	2.05
16	−0.85	-	−0.05	-	−0.73	-	−0.34	−2.96	0.63	-	0.42	-	1.57	-	1.13	2.21
20	−0.81	-	−0.04	-	−0.73	-	−0.34	−2.96	0.59	-	0.42	-	1.61	-	1.13	2.01
Time	**Period I NEER to PPI**				**Period II NEER to PPI**				**Period I IMP to PPI**				**Period II IMP to PPI**			
	Kor	**Mal**	**Sp**	**Thai**	**Kor**	**Mal**	**Sp**	**Thai**	**Kor**	**Mal**	**Sp**	**Thai**	**Kor**	**Mal**	**Sp**	**Thai**
1	−0.04	−0.29	−0.04	-	−0.25	−0.01	−0.08	−0.14	0.04	-	0.63	-	0.37	-	1.43	0.08
4	−0.09	−0.48	−0.05	-	−0.33	−0.02	−0.15	−0.16	0.25	-	0.48	-	0.33	-	1.28	0.9
8	−0.02	−0.42	−0.07	-	−0.19	−0.13	−0.18	−0.29	0.26	-	0.41	-	0.32	-	1.48	0.13
12	−0.06	−0.43	−0.06	-	−0.22	−0.21	−0.16	−0.32	0.26	-	0.44	-	0.33	-	1.45	−0.06
16	−0.08	−0.43	−0.08	-	−0.24	−0.23	−0.16	−0.36	0.29	-	0.41	-	0.32	-	1.45	0.04
20	−0.07	−0.43	−0.07	-	−0.23	−0.27	−0.15	−0.35	0.27	-	0.41	-	0.33	-	1.43	0.02
Time	**Period I NEER to CPI**				**Period II NEER to CPI**				**Period I IMP to CPI**				**Period II IMP to CPI**			
	Kor	**Mal**	**Sp**	**Thai**	**Kor**	**Mal**	**Sp**	**Thai**	**Kor**	**Mal**	**Sp**	**Thai**	**Kor**	**Mal**	**Sp**	**Thai**
1	−0.07	0.00	0.01	-	−0.11	0.05	0.04	−0.02	0.00	-	0.00	-	0.07	-	0.06	0.00
4	−0.05	0.07	−0.02	-	−0.17	0.06	−0.01	−0.03	0.00	-	0.01	-	0.06	-	0.07	0.16
8	−0.02	0.06	0.02	-	−0.12	0.07	−0.03	0.01	−0.13	-	0.00	-	0.05	-	0.09	0.12
12	−0.05	0.06	0.01	-	−0.13	0.07	−0.03	0.02	−0.16	-	0.01	-	0.07	-	0.10	0.07
16	−0.07	0.06	0.01	-	−0.14	0.06	−0.03	−0.02	−0.17	-	0.01	-	0.06	-	0.10	0.12
20	−0.09	0.06	0.01	-	−0.13	0.05	−0.03	−0.01	−0.20	-	0.01	-	0.07	-	0.10	0.11

Notes:
First half of the table: NEER to domestic prices (import prices, PPI, CPI) show the changes in domestic prices led by one percentage depreciation in exchange rate (the values are subject to multiplication by -10^{-2}).
Second half of the table: IMP to domestic prices (import prices, PPI, CPI) indicate the changes in domestic prices led by one percentage increase in import prices (the values are subject to multiplication by 10^{-2})
The values are obtained by running the impulse response functions

Table 3: Forecast Error Variance Decompositions: Maximum Effects of Shocks on Domestic Prices

Period I							
(I) Import price							
	OIL	**GAP**	**M**	**NEER**	**IMP**	**PPI**	**CPI**
Korea	0.10	0.06	0.03	0.25	0.84	0.12	0.03
Malaysia	-	-	-	-	-	-	-
Singapore	0.07	0.06	0.10	0.06	0.89	0.05	0.14
(II) PPI							
	OIL	**GAP**	**M**	**NEER**	**IMP**	**PPI**	**CPI**
Korea	0.07	0.14	0.14	0.14	0.18	0.68	0.04
Malaysia	0.01	0.09	0.02	0.10	-	0.98	0.00
Singapore	0.14	0.08	0.12	0.06	0.75	0.12	0.12
(III) CPI							
	OIL	**GAP**	**M**	**NEER**	**IMP**	**PPI**	**CPI**
Korea	0.09	0.14	0.07	0.10	0.13	0.27	0.60
Malaysia	0.10	0.06	0.01	0.05	-	0.11	0.75
Singapore	0.11	0.08	0.01	0.03	0.12	0.18	0.85
Period II							
(I) Import price							
	OIL	**GAP**	**M**	**NEER**	**IMP**	**PPI**	**CPI**
Korea	0.05	0.02	0.02	0.24	0.71	0.05	0.04
Singapore	0.02	0.03	0.09	0.07	0.91	0.01	0.00
Thailand	0.03	0.08	0.04	0.41	0.52	0.03	0.04
(II) PPI							
	OIL	**GAP**	**M**	**NEER**	**IMP**	**PPI**	**CPI**
Korea	0.02	0.01	0.01	0.19	0.36	0.62	0.05
Malaysia	0.02	0.11	0.14	0.03	-	0.96	0.02
Singapore	0.01	0.04	0.11	0.01	0.85	0.11	0.00
Thailand	0.07	0.06	0.03	0.08	0.08	0.86	0.15
(III) CPI							
	OIL	**GAP**	**M**	**NEER**	**IMP**	**PPI**	**CPI**
Korea	0.03	0.02	0.02	0.14	0.07	0.13	0.75
Malaysia	0.07	0.04	0.19	0.10	-	0.07	0.68
Singapore	0.01	0.06	0.03	0.05	0.12	0.07	0.85
Thailand	0.04	0.15	0.04	0.04	0.07	0.21	0.66

Notes:
All the values are obtained from the forecast error variance decompositions

4.3. Discussion and comparisons

In this part of the section, we check the consistency and robustness of the results by first, comparing the results of different ordering of variables in the structural VAR model; second, by comparing the results of SVAR with that of the single equation method. We also discuss the link between trade openness and the degree of exchange rate pass-through and the reasons that drive the differences in overall results across countries.

(1) Comparing results within SVAR models

For the purpose of robustness, we run again the SVAR model using two different ordering schemes, Models I and II as described in section 2.3.

Comparing the results of both orderings (see Figure 1 to 4), one can observe that the responses of domestic prices to exchange rate and import price shocks are very similar to each other in all cases. The effect of the exchange rate changes remains low in Malaysia and Singapore. The responses of domestic prices in general are higher under import price shock as compared to that of exchange rate shock. The consistency of the results implies that the results obtained from structural VAR are robust. For the double check, we compare the results of structural VAR with that of the single equation results (see the relevant section below).

(2) Comparing the results of SVAR with single equation approach

Comparison of the results obtained from SVAR and single equation approach techniques on exchange rate pass-through show that the magnitude of the exchange rate pass-through elasticities obtained from the two different methods differs to some extent. However in general the two methods exhibit similar trends on the behavior of exchange rate pass-through into domestic prices over time.

Similar results are reported in Mihailov (2005), who focuses on analysis of exchange rate pass-through in US, Germany and Japan in two sub-periods. Mihailov (2005) seeks to compare the results obtained using generalized VAR and the single equation method. He finds that the results from both methods show the same general trends in exchange rate pass-through but the precisions of the elasticities of pass-through depend crucially on the econometric method, data frequency and variable proxy employed.

As in Mihailov (2005), the dissimilarities here may be due to the different methodologies employed, number of lags and variables included in the model. In SVAR we use 7 variables: nominal effective exchange rate, money base, output gap, PPI, CPI, import price index and oil price index, with all three price indices jointly included into one model. Shocks are identified based on a certain ordering of the variables. Number of lags for regressors differs across countries and periods. Whereas, in the single equation approach we regress CPI, PPI and import prices on exchange rate, output gap and foreign price level independently. We use the same number of lags for the exchange rate variable, whereas the lags of output gap and foreign price level are subject to change.

In general the results from both methods applied are consistent with each other, although there are some dissimilarities. The exchange rate pass-through into import price is highest, moderate on PPI and lowest on CPI across methodologies applied. Behavior of pass-through rates differs across price indices and countries. As mentioned above they might be due to country-specific characteristics and the composition of the commodities in the price indices.

Results from both methods show that appreciation in exchange rate leads to an increase in CPI (in some periods) in the case of Malaysia and Singapore. This result is also found in previous studies (Choudhri and Hakura, 2006).

There are many factors which contribute to pass-through rate and the explanatory power of the effects of these factors varies across countries. In order to get more consistent estimates of pass-through rates further research is needed. Inclusion of regressors into the model should be made based on the specific characteristics of the countries.

(3) Discussion

Why is the degree of exchange rate pass-through different across countries? Does trade openness matter? Do exchange rate pass-through rates decline over time across different price indices? We attempt to compare the degree of trade openness with the degree of exchange rate pass-through across countries for both periods. Table 1 displays the summarized results. In general, the results show that there is a weak correlation between trade openness and the degree of exchange rate pass-through. Countries that have higher trade openness do not have higher exchange rate pass-through. For instance, Singapore has the highest trade openness as compared to the other three countries; however it does not have the highest degree of exchange rate pass-through.

The degrees of trade openness have increased over time in all countries. However, not all countries have experienced increase in the degree of exchange rate pass-through. For instance, long run exchange rate pass-through on PPI has declined in Malaysia and that on CPI increased, but by negligible magnitude, although trade openness has increased in this country. This result implies that trade openness is not the main factor which determines the degree of exchange rate pass-through in these countries, at least in this study.

Exchange rate pass-through rates into domestic prices exhibit different trends over time, across price indices and countries. There is no simultaneous change in pass-through rates over time across countries. This might be due to factors which are specific to the particular country. In general these changes are affected by possible change in the trade structure after the financial crisis of 1997.

So far we have analyzed the pass-through of exchange rate into domestic prices. At this stage it is natural to ask what are the main factors that drive exchange rate pass-through? What are the country-specific characteristics which lead to differences in exchange rate pass-through across countries? How big is their role in understanding this mechanism? These types of questions need to be answered. However we leave this kind of analysis for future research. Additionally our research can be extended by expanding the time period used in the analysis in the paper, given that this study only covers the latest periods of the 1990s and 2000s, excluding the crisis periods of 1997–98. For future study, one can include data from the earlier years (for example the 1970s or 1980s), when the Asian economies fluctuate more as compared to the periods before and after the crisis covered in the paper. Expansion of the time period is expected to have an effect on the magnitude of exchange rate pass-through rates. However this extension can be problematic, given the data availability problem.

5. Conclusions

In this paper, we undertook an empirical analysis of exchange rate pass-through into domestic prices for Korea, Malaysia, Singapore and Thailand. Given that these countries were hit by the financial crisis in 1997 to a different extent, we conducted analysis before and after the crisis in isolation. Several findings have been obtained, which can be summarized as follows.

First, in general, our results partially support the previous results in this area, where the degree of exchange rate pass-through is different across countries and over time. The changes in pass-through rates across countries may be due to the change in the structure of trade and monetary policy. As in the case of Singapore, the increase in exchange rate pass-through may be due to the very high degree of trade openness and low volatility in the exchange rate (as Singapore implements exchange rate targeting policy). Besides, Singapore is a manufacturing-based and non-resource producing country. This implies that Singapore may import products that have higher pass-through rates such as raw materials and fuel/ oil.

Second, the degree of exchange rate pass-through is highest on import price, moderate on PPI and lowest on CPI.

Third, pass-through into CPI remains very low in these countries. In some periods, appreciation of the exchange rate leads to an increase in CPI in Malaysia and Singapore. Due to the low pass-through into CPI and the effect of exchange rate shock on domestic prices being relatively low in these countries, the inflation rate in these countries remains stable and does not increase much over time.

Fourth, import price shocks have higher explanatory power on movement in domestic prices as compared to exchange rate shocks. The effect of exchange rate shock is very small in the case of Malaysia and Singapore, but the effects of import price shock on domestic prices are very high in all countries, especially in the case of Singapore.

Fifth, comparing the degrees of pass-through into domestic prices over time, we find that there is weak correlation between trade openness and exchange rate pass-through.

Sixth, exchange rate pass-through on CPI across periods and across countries is small in magnitude and even changes sign from positive to negative in some cases. This might be due to the pricing to market behavior of monopolistic firms, which attempt to set lower prices in the countries where they export in order to have higher competitive power relative to local firms.

Our analysis gives a clear indication that exchange rate pass-through into domestic prices is country specific, given that it is different across countries. However, country-specific characteristics are not revealed in this paper and this is left for future research.

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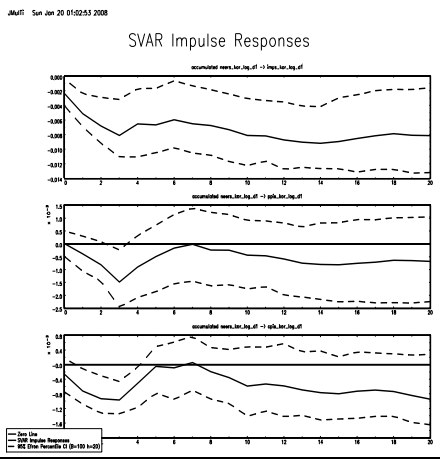
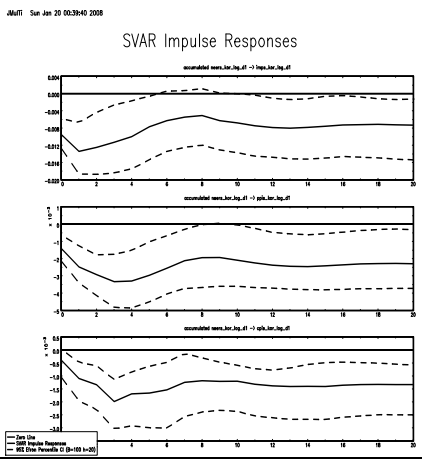
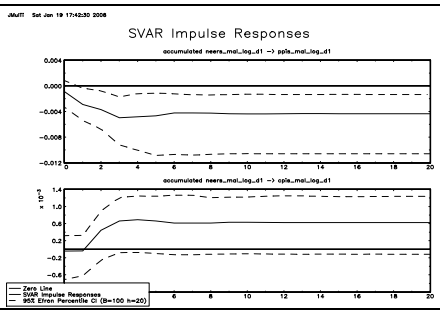
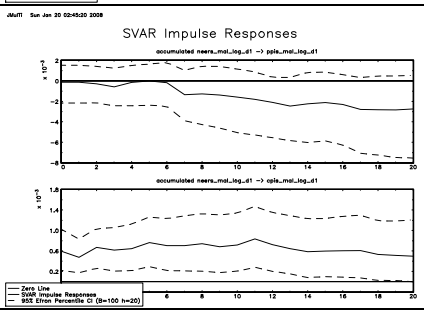
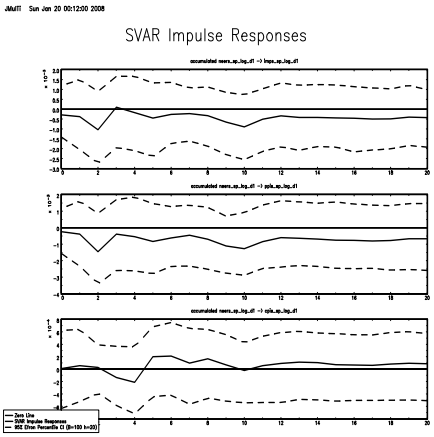
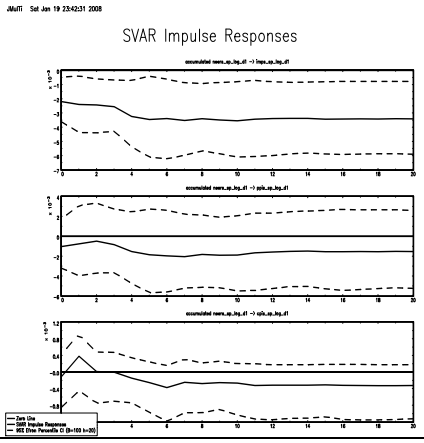
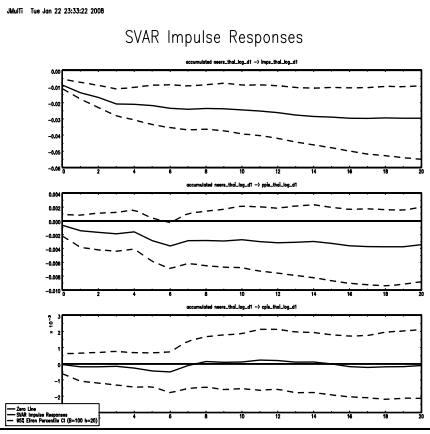
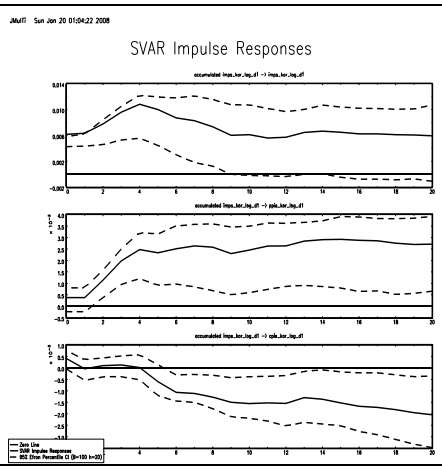
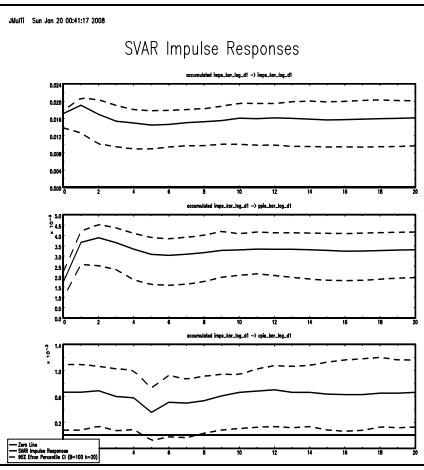
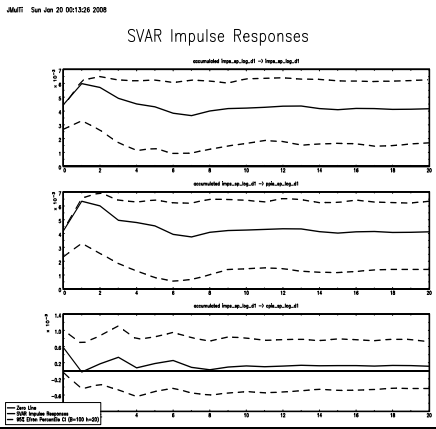
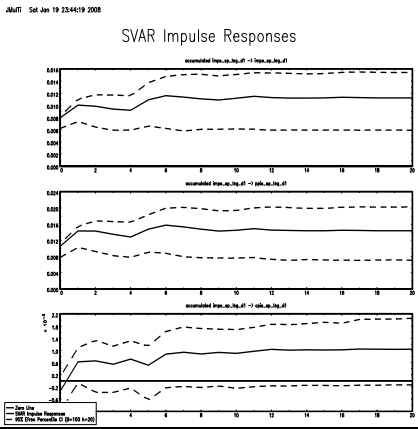
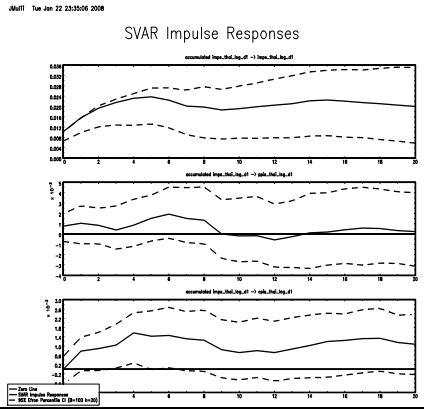
APPENDIX

Figure 1: IRF (Model I): NEER Shocks on Domestic Prices

Countries	Period I	Period II
Korea		
Malaysia		
Singapore		
Thailand		

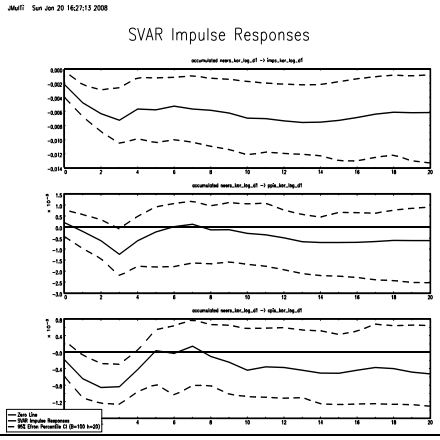
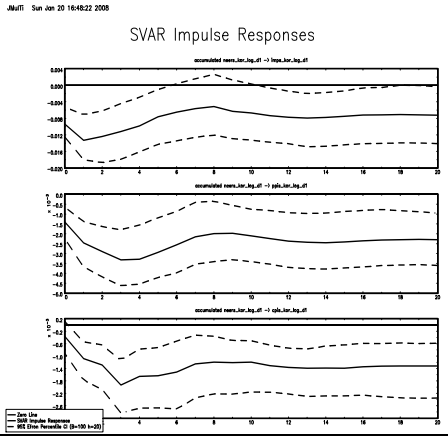
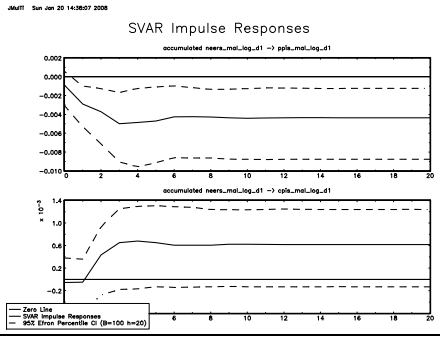
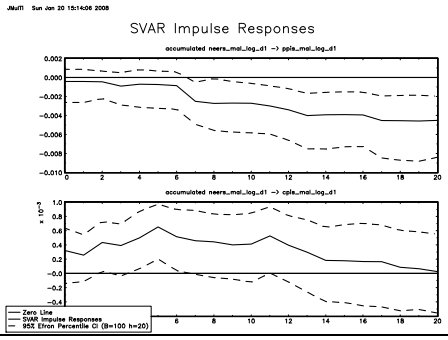
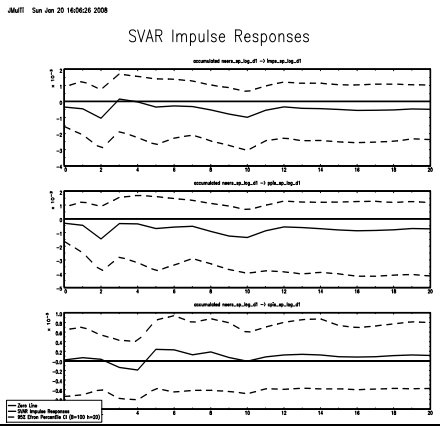
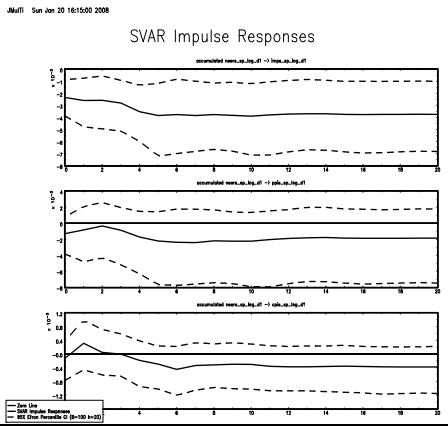
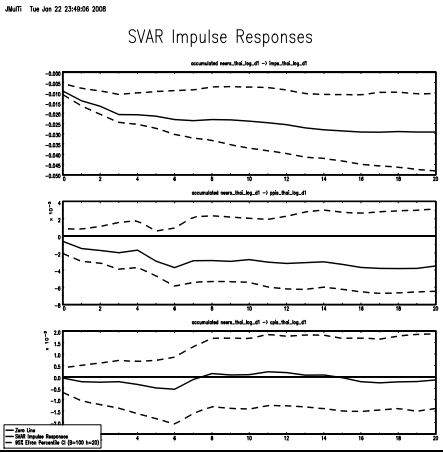
Notes: Period I is the period before crisis (before 1997M7)
Period II is the period after the crisis (1999M1 onwards)
The figures show the response of domestic prices (IMP, PPI CPI) to exchange rate shock (1% appreciation)

Figure 2: IRF (Model I): IMP Shocks on Domestic Prices

Countries	Period I	Period II
Korea		
Singapore		
Thailand		

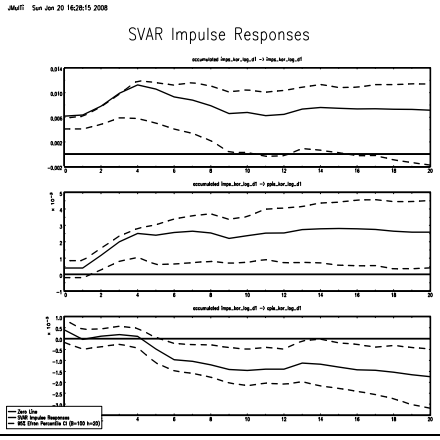
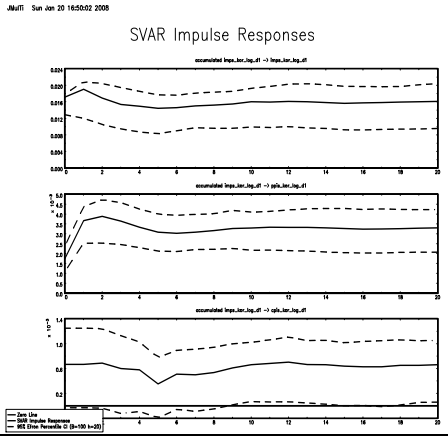
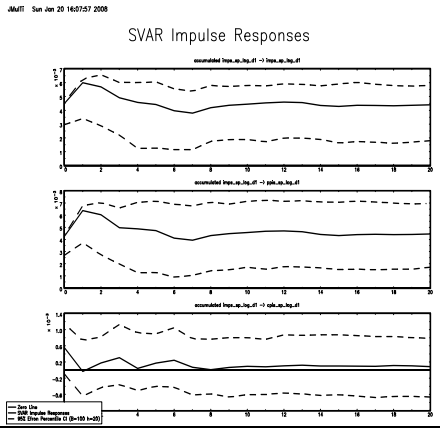
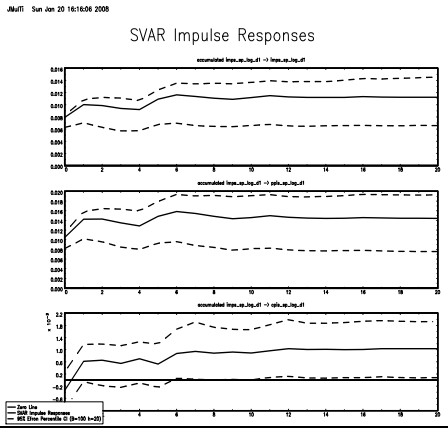
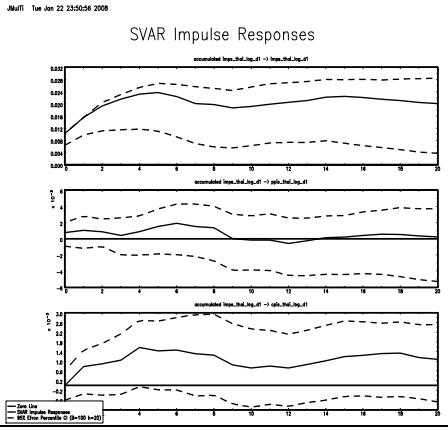
Notes:
Period I is the period before crisis (before 1997M7)
Period II is the period after the crisis (1999M1 onwards)
The figures show the response of domestic prices (IMP, PPI CPI) to one percentage of import price shock

Figure 3: IRF (Model II): NEER Shocks on Domestic Prices

Countries	Period I	Period II
Korea		
Malaysia		
Singapore		
Thailand		

Notes:
Period I is the period before crisis (before 1997M7)
Period II is the period after the crisis (1999M1 onwards)
The figures show the response of domestic prices (IMP, PPI CPI) to exchange rate shock (1% appreciation)

Figure 4: IRF: (Model II): IMP Shocks on Domestic Prices

Countries	Period I	Period II
Korea		
Singapore		
Thailand		

Notes:
Period I is the period before crisis (before 1997M7)
Period II is the period after the crisis (1999M1 onwards)
The figures show the response of domestic prices (IMP, PPI CPI) to one percentage of import price shock

Table I (1a)
Cointegration Tests Between Log(Import Price Index) And Log(NEER)

Country	Johansen trace test statistic					S&L test statistic				
	No of lagged differences	H0: r=0		H0: r=1		No of lagged differences	H0: r=0		H0: r=1	
		t-stat	Critical value	t-stat	Critical value		t-stat	Critical value	t-stat	Critical value
1997M1–1997M6										
Korea[5]	2	14.26	20.16	2.14	9.14	2	5.59	12.26	0.64	4.13
	5	20.81	(20.16	5.95	9.14	5	8.03	12.26	2.62	4.13
Singapore[6]	3	14.87	(25.73	5.40	12.45	1	7.26	15.76	4.52	6.79
1999M1–2007M5[7]										
Korea	2	17.55	20.16	4.50	9.14	2	8.78	12.26	2.01	4.13
Singapore[8]	1	16.62	20.16	5.99	9.14	1	8.63	12.26	0.97	4.13
Thailand[9]	2	10.61	25.73	3.56	12.45	2	7.22	15.76	0.00	6.79

Table I (1b)
Cointegration Tests Between log(PPI) and log(NEER)

Country	Johansen trace test statistic					S&L test statistic				
	No of lagged differences	H0: r=0		H0: r=1		No of lagged differences	r=0		r=1	
		t-stat	Critical value	t-stat	Critical value		t-stat	Critical value	t-stat	Critical value
1997M1–1997M6										
Korea[10]	2	15.77	15.76	0.55	6.79	2	25.86	20.16	4.34	9.14
Malaysia[11]	2	20.02	25.73	4.17	12.45	2	9.18	15.76	1.45	6.79
Singapore[12]	1	51.72	25.73	5.66	12.45	1	6.57	15.76	5.05	6.79
	3	19.46	25.73	3.77	(12.45					
1999M1–2007M5[13]										
Korea[14]	2	11.57	25.73	3.08	12.45	2	9.24	15.76	0.88	6.79
Malaysia[15]	2	38.46	20.16	1.69	9.14	2	28.16	12.26	1.68	4.13
Singapore[16]	1	15.80	20.16	4.69	9.14	1	10.85	12.26	0.25	4.13
Thailand[17]	2	16.94	25.73	5.06	12.45	2	9.27	15.76	0.60	6.79

[5] Deterministic terms: constant, seasonal dummies
[6] Deterministic terms: constant, trend seasonal dummies
[7] Deterministic terms: constant and seasonal dummies.
[8] Deterministic terms: constant, seasonal dummies
[9] Deterministic terms: constant, trend and seasonal dummies
[10] Deterministic terms: constant and seasonal dummies
[11] Deterministic terms: constant, trend and seasonal dummies.
[12] Deterministic terms: constant, trend and seasonal dummies
[13] Deterministic terms: constant, trend and seasonal dummies
[14] Deterministic terms: constant, trend and seasonal dummies
[15] Deterministic terms: constant and seasonal dummies
[16] Deterministic terms: constant and seasonal dummies
[17] Deterministic terms: constant, trend and seasonal dummies

Table I (1c)
Cointegration Tests Between log(CPI) and log(NEER)

Country	Johansen trace test statistic					S&L test statistic				
	No of lagged differences	H0: r=0		H0: r=1		No of lagged differences	H0: r=0		H0: r=1	
		t-stat	Critical value	t-stat	Critical value		t-stat	Critical value	t-stat	Critical value
1997M1–1997M6										
Korea[18]	2	17.55	20.16	4.50	9.14	2	8.78	12.26	2.01	4.13
Malaysia[19]	2	26.68	25.73	9.76	12.45	2	14.99	15.76	0.53	6.79
Singapore[20]	1	16.09	25.73	2.77	12.45	1	4.58	15.76	2.02	6.79
1999M1–2007M5[21]										
Korea[22]	2	22.77	25.73	2.99	12.45	2	7.01	15.76	1.61	6.79
Malaysia[23]	2	11.80	25.73	5.17	12.45	2	8.04	15.76	2.75	6.79
Singapore[24]	1	9.18	20.16	2.94	9.14	1	5.98	12.26	0.17	4.13

Table I (1d)
Test for cointegration in the Thai Log(CPI)-log(NEER)-log(PPI_US) system

Country	Johansen trace test statistic					S&L test statistic				
	No of lagged differences	H0: r=0		H0: r=1		No of lagged differences	H0: r=0		H0: r=1	
		t-stat	Critical value	t-stat	Critical value		t-stat	Critical value	t-stat	Critical value
1999M1–2006M12										
Thailand[25]	2	49.38	2.77	21.95	25.73)	2	28.71	28.52	6.24	15.76

[18] Deterministic terms: constant and seasonal dummies
[19] Deterministic terms: constant, trend and seasonal dummies.
[20] Deterministic terms: constant, trend and seasonal dummies
[21] Deterministic terms: constant, trend and seasonal dummies
[22] Deterministic terms: constant, trend and seasonal dummies
[23] Deterministic terms: constant and seasonal dummies
[24] Deterministic terms: constant and seasonal dummies
[25] Deterministic terms: constant, trend and seasonal dummies