Exchange Rate Pass-Through into Import Prices: Empirical Evidences from Major Southeast Asian Countries

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Abstract

Most of the empirical studies on exchange rate pass-through focus on industrialized countries, and only a few studies have been done for developing countries. In this paper we estimate exchange rate pass-through for four Southeast Asian countries: Indonesia, the Philippines, Singapore and Thailand, by employing cointegration analysis and Error Correction Mechanism. The results of the estimation using quarterly data show that the long run exchange rate pass-through into import prices for Indonesia, the Philippines, Singapore, and Thailand are 0.983, 1.179, 0.200, and 0.800, respectively. When we use monthly data, the estimates of the long run exchange rate pass-through are 0.885, 1.529, 0.109, and 0.396 for Indonesia, the Philippines, Singapore, and Thailand, respectively. To compare exchange rate pass-through in Southeast countries with those of industrialized countries we estimate the exchange rate pass-through of Australia, Canada, and New Zealand. The exchange rate pass-through of Southeast Asian countries do not have systematic difference with the exchange rate pass-through of the sample of industrialized countries. Macro variables that appear to contribute to the variation of exchange rate pass-through across countries sample are inflation and money growth. From micro side, the presence MNCs together with intra-firm trade seems to have contribution for the variation of exchange rate pass-through across countries.

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1. Introduction

One of the central issues in international economics is exchange rate pass-through, which is defined as the percentage change in domestic prices caused by a one percent change in exchange rate. Since the 1980s there have been a large number of empirical studies on exchange rate pass-through. These studies can be broadly categorized into three categories. The first category includes the studies examining exchange rate pass-through into import prices of specific industry (for example, Bernhofen & Xu, 1999; Goldberg, 1995). The second category includes the studies of exchange rate pass-through into aggregate import prices (for example, Hooper & Mann, 1989; Campa & Goldberg, 2002). Finally, the third category includes the studies of exchange rate pass-through into the Consumer Price Index (CPI) or the Wholesale Price Index (WPI) (for example, McCarthy, 2000; Papell, 1994). The growing research on exchange rate pass-through at the industry-specific and aggregate level is partly motivated by the rise in the industrial organization and strategic trade theory. Studies on the exchange rate pass-through into the CPI and the WPI also grow along with development in open economy macroeconomic models.

Most of the empirical studies on exchange rate pass-through have focused on the industrialized countries, particularly the US and Japan. A survey by Menon (1995) on 48 studies on exchange rate pass-through finds that most of the research in this area is for the U.S. and Japan. Moreover, Goldberg & Knetter (1997) noted that in the 1980s, research on exchange rate pass-through was dominated by the analysis of exchange rate pass-through in the U.S. In addition to studies on the industrialized countries, a few studies provide estimates of exchange rate pass-through for developing countries (Rana and Dowling (1985), Alba and Papell (1998), Anaya (2000), Calvo and Reinhart (2000), and Garcia and Restrepo (2001)). Using data from nine Asian developing countries, Rana and Dowling (1985) examine the effects of the exchange rate on inflation. Alba & Papell (1998) use a structural open economy model to estimate the relationship between exchange rate and inflation for three Southeast Asian countries: Malaysia, the Philippines, and Singapore. Anaya (2000) examines the effects of dollarization on the degree of exchange rate pass-through into the CPI for each of the 13 countries in Latin America. Calvo and Reinhart (2000) uses a VAR model to estimate exchange rate pass-through into the CPI in several developing countries. More recently, an empirical study by Garcia and Restrepo (2001) estimates the exchange rate pass-through into inflation rate in Chile.

The main purpose of this paper is to estimate exchange rate pass-through into import prices in some Southeast Asia countries. The countries are chosen considering data availability. Although there have been some studies that provide estimates of the exchange rate pass-through in some developing countries including some Southeast Asian countries, this paper has significant differences from those previous studies in a number of respects. First, the previous studies (Rana & Dowling, 1985; Alba and Papell, 1998; and Calvo and Reinhart, 2000) estimate exchange rate pass-through into domestic inflation rather than import prices. The problem of using the CPI in measuring exchange rate pass-through is that the CPI contains a large number of non-traded goods which theoretically are not influenced by exchange rate changes. Second, all these studies estimate exchange rate pass-thorough based on the macroeconomics model without micro-foundation. For example, noted by Calvo and Reinhart (2000), estimates of exchange rate pass-through should be based on a micro-founded model.

Moreover, many studies on exchange rate pass-through have shown that the presence of imperfect exchange rate pass-through is explained by microeconomic factors. In this paper we examine pass-through of exchange rate into import prices based on the model derived from Law of One Price with the assumption that the exporting firms have some degree of monopoly power. The model used in this paper has been widely used in empirical studies on the exchange rate pass-through, for example, Hooper & Mann (1989), Menon (1995), and Campa & Goldberg (2002). Finally, in this paper we estimate the model using longer and more up to date data that runs from 1974 to 2000.

The second purpose of this paper is to examine variation of exchange rate pass-through among Southeast Asian countries, and between Southeast Asian countries and some industrialized countries. Many studies have tried to explain factors determining the differences in exchange rate pass-through across countries and across industries. Given that Southeast Asian countries and industrialized countries have different economic characteristics, then we expect that they have different exchange rate pass-through. For example, imperfect competition models predict that the stability of import prices in local currency prices tends to be higher in the country with more competitor industries[2].

By assuming that the exporting countries face a smaller number of competing firms in Southeast Asian countries than in industrialized countries, then exchange rate pass-through in Southeast Asian countries should be larger than those of industrialized countries. To examine the difference in exchange rate pass-through between Southeast Asian countries and industrialized countries, in addition to estimating exchange rate pass-through of Southeast Asian countries, we also estimate exchange rate pass-through for some industrialized countries.

There are at least two reasons for the importance of estimating and understanding exchange rate pass-through. First, exchange rate pass-through has implications for optimal monetary policy and the international macroeconomic transmission mechanism. This is one of the issues in the new open economy macroeconomics model. Using the new open economy macroeconomics framework, the implications of the extent of exchange rate pass-through on optimal monetary policy and exchange rate regime have been analyzed in several studies[3]. With the new open economy macroeconomics model, for example, the welfare effect of monetary policy can be very different depending on the degree of exchange rate pass-through of the country in question (Betts and Devereux, 2000; Tille 2000). Second, understanding exchange rate pass-through at the industry level gives insight about international market power in that industry (for example, Knetter, 1993; Bernhofen & Xu, 1999). Using the US, the UK, Germany and Japan industry data, Knetter measures the degree of price discrimination across export destinations based on the degree of exchange rate pass-through across industries. Bernhofen & Xu (1999) provides evidence that incomplete exchange rate pass-through can be attributed to non-competitive conduct by foreign firms.

The results of this paper are expected to provide more understanding about exchange rate pass-through in Southeast Asian countries that can be used both for international monetary policy and international trade policy. Using the more up to date

[2] Dornbusch's (1987) model of exchange rate and prices under Cournot oligopoly, for example, suggests that prices in importer's currency for a given change in exchange rate is more stable if the number of foreign firms faced by exporting country is larger.
[3] Obstfeld (2002) provides a survey on this issue.

data and methodology in estimating the exchange rate pass-through for these countries, we expect to obtain more accurate predictions of the policies related to the exchange rate pass-through.

The remainder of the paper is organized as follows. In section 2 we provide an overview of the theoretical framework of exchange rate pass-through used in this paper. Section 3 provides a description of the data. Section 4 describes the estimation method briefly. Estimation results are presented in section 5. Finally, section 6 provides some concluding remarks.

2. Theoretical Framework

In this section, we provide an overview of the theoretical relationship between the exchange rate and import prices. Exchange rate pass-through is defined as the percentage change in import currency prices as a result of a one percent change in the exchange rate between exporting and importing countries. One-to-one response of import prices to exchange rate is widely known as "full" or "complete" exchange rate pass-through, while less than one-to-one response of import price to exchange rate is widely known as "limited" or "incomplete" exchange rate pass-through.

Exchange rate movements are transmitted to domestic prices through three channels: (i) prices of imported consumption goods, (ii) prices of imported intermediate goods, and (iii) domestic goods priced in foreign currency. Through imported consumption goods and domestic goods priced in foreign currency, exchange rate movement affects domestic prices directly. Through imported intermediate goods, exchange rate movements affect domestic price through the production cost of the consumption goods.

The model we use to estimate the degree of exchange rate pass-through is derived from the Law of One Price (LOP). The model is similar to the model used in much of the literature in this area (for example, Hooper and Mann (1989); Goldberg and Knetter (1997); and Campa and Goldberg (2002)). Consider a representative foreign firm that has some degree of control over the price of its goods in importing countries. Suppose this representative firm sets the price of its export to country j in its own currency (PX_t^j) at a markup (λ_t^j) over its marginal cost of production (C_t^*), that is,

$$PX_t^j = \lambda_t^j C_t^* \tag{2.1}$$

The import price in the importing currency (PM_t^j) is obtained by multiplying export price of exporting firm (PX_t^j) with the exchange rate of the importing country j (E_t^j), that is,

$$PM_t^j = E_t^j PX_t = E_t^j \lambda_t^j C_t^* \tag{2.2}$$

The markup is assumed to respond to competitive pressure in the importing country. Competitive pressure in importing country is measured by the gap between the competitors' prices in the importing market (P_t^j) and the production cost of exporting firm[4]. Therefore, the markup λ_t^j can be represented by

$$\lambda_t^j = \left(\frac{P_t^j}{E_t^j C_t^*} \right)^{\alpha} \tag{2.3}$$

Substituting equation (2.3) into equation (2.1) we get

$$PM_t^j = \left(E_t^j C_t^* \right)^{1-\alpha} \left(P_t^j \right)^{\alpha} \tag{2.4}$$

Taking the logarithmic form of the equation (2.4) and dropping country index j, we get

$$pm_t = (1-\alpha)e_t + (1-\alpha)c_t^* + \alpha p_t \tag{2.5}$$

where lowercase letters denote the logarithmic values of the variables.

In equation (2.5), exchange rate pass-through, defined as the partial elasticity of import price with respect to exchange rate, is (1-α). In the extreme cases, when α=0, the exchange rate pass-through is complete and the exporting firm does not face competition in the importing markets. On the other hand, when α=1, the exchange rate pass-through is zero, and the exporting firm sets import price equal to competitors' price in the importing

[4] This method follows Hooper & Mann (1989).

market. An incomplete exchange rate pass-through is characterized by the value of α between zero and one.

One of the weaknesses of this model is that it imposes the restriction that pass-through of exchange rate and foreign cost into import price are the same and there is a unit homogeneity in exchange rate, as well as foreign cost, and competitors' prices. As shown in Hooper and Mann (1989), Menon (1995), and Bache (2002), these restrictions do not necessarily hold. In this paper we test these restrictions rather than imposing them in estimation. Another weakness is that the model is static insofar that it does not allow import prices to adjust gradually due to the changes in the explanatory variables. To capture gradual adjustment of the coefficients, time series techniques such as Polynomial Distributed Lag (PDL), Vector Autoregressive (VAR) or Error Correction Model (ECM) can be employed.

3. Data

The main problem in conducting empirical studies on developing countries is data availability. Many developing countries do not have adequate time series data to be used for analysis. For example, quarterly data for GDP, a variable needed in many empirical studies, in most of the Southeast Asian countries are not available in the relatively long series of time. The other problem is the available data is quite often far from reliable to gain insight on the underlying trend in the variables.

In estimating the model we use quarterly data and monthly data. The proxies for the variables we use in the model are as follows. Domestic import price (PM) is measured by the index of average import prices in domestic currency. The exchange rate variable is measured using either nominal currency unit per US dollar or nominal effective exchange rate. For Southeast Asian countries, the proxy for exchange rate (E) is nominal exchange rate measured in period-average domestic currency units per US dollar. We use the bilateral exchange rate against the US dollar because most of the international trade in Southeast Asia is invoiced in US dollars. Empirical evidence suggests that trade between East Asian countries with Japan and the US, the two largest trading partners of countries in this region, and trade between East Asian countries is dominated by invoice in the US dollar (McKinnon, 1999). For Canada, we use Canadian dollar per US dollar due to the fact that about 70 percent of Canadian imports come from the US. Finally, the measure of exchange rate for Australia and New Zealand are nominal effective exchange rates.

The proxy for domestic competitors' price (P) is either Producer Price Index (PPI) or Wholesale Price Index (WPI). In this case, Thailand has PPI data while Indonesia, Philippines and Singapore have WPI. As noted in the IFS publication, if both PPP and WPI are available, PPI is preferable because the concept, weighting pattern, and coverage tend to be more consistent with national accounts and industrial production statistics. For Australia and New Zealand, PPI refers to index of manufacturing output price, and for Canada PPI refers to aggregate industrial price index. Finally, we use foreign PPI as the proxy for foreign marginal cost (C*). This foreign variable is constructed by taking the weighted average of the corresponding variables of the foreign countries where they have significant contribution to domestic import. In this case, we use share of imports values as the weights of each foreign country. Data for PM, E, P, and C* are obtained from International Financial Statistics CD-ROM and Datastream. The value of imports is obtained from World Import and Export Data, CD-ROM of 1980-1997 released by Center for International Data of UC Davis.

Ideally, to be more representative for Southeast Asian economy, this study covers ASEAN-5 countries, i.e., Indonesia, Malaysia, the Philippines, Singapore and Thailand. These five countries together contribute more than 90 percent of the total export and imports in Southeast Asia. After exploring data availability from various sources, we end up with a 4 country sample, i.e. Indonesia, the Philippines, Singapore, and Thailand. For Malaysia we could not find import price data in domestic currency in the long enough series of time. In average, the share of total export and import of Indonesia, the Philippines, Singapore and Thailand in Southeast Asia during 1974-2000 is about 75 percent. Data for Indonesia runs from 1985:1 to 2000:9, data for the Philippines runs from 1974:1 to 1991:12, and data for Thailand and Singapore cover the period of 1974:1-2000:9.

4. Econometrics Methods

Considering that there is a possibility of the long run equilibrium relationship among variables, we employ Error Correction Mechanism (ECM) to estimate the relationship of the variables. Application of the ECM requires that each series in the equation is non-stationary and they have a linear combination that is stationary. In this section, we describe briefly the econometric procedure we employ for the unit root test, cointegration test and ECM estimation.

4.1 Unit Root Test

A standard unit root test widely used in empirical studies is Augmented Dickey-Fuller (ADF) test. Suppose we need to test the null hypothesis that the series x_t is characterized by the unit root process. The ADF test statistic is given by the t-ratio of the null hypothesis a_1=0 in the regression of

$$\Delta x_t = a_0 + a_1 x_{t-1} + a_2 t + \sum_{i=1}^{p} b_i \Delta x_{t-i} + \varepsilon_t \qquad (4.1)$$

If we fail to reject the null hypothesis then we conclude that the series x_t is a unit root process.

Although the standard ADF test has been widely used, as shown by Perron (1989), in the presence of the structural break this test is biased toward non-rejection of the unit root. The procedure proposed by Perron (1989) for the unit root test in the presence of a structural break can be described as follows. Suppose there is a possible structural break in a series x_t at time T_b. First, data are detrended by estimating either of the following equations

$$x_t = a_0 + a_1 t + a_2 DU_t + \tilde{x}_t \qquad (4.2)$$

$$x_t = a_0 + a_1 t + a_2 DU_t + a_3 DT^* + \tilde{x}_t \qquad (4.3)$$

$$x_t = a_0 + a_1 t + a_3 DT^* + \tilde{x}_t \qquad (4.4)$$

where $DU_t = 1$, if t > T_b and zero otherwise

$DT_t^* = t - T_b$ if t > T_b and zero otherwise

$\tilde{x}_t$ is the residual of the regression

The next step is, to estimate the regression

$$\tilde{x}_t = \mu\tilde{x}_{t-1} + \sum_i^p \theta_i \Delta\tilde{x}_{t-i} + \delta\sum_{i=1}^p \delta_j D(T_b)_{t-j} + e_t \qquad (4.5)$$

or $$\tilde{x}_t = \mu\tilde{x}_{t-1} + \sum_i^p \theta_i \Delta\tilde{x}_{t-i} + e_t \qquad (4.6)$$

where $D(T_b)_t = 1$ if $t=T_b+1$ and zero otherwise. Equation (4.5) is estimated for model (4.2) and (4.3), and equation (4.6) is estimated for model (4.4). The test is based on the t-statistic for the null hypothesis μ=1. If the t-statistic is greater than critical value calculated by Perron (1989) then the hypothesis of a unit root is rejected.

In estimating regressions (4.1), (4.5) and (4.6) we need to choose an appropriate lag length p. One of the methods that can be used to choose the lag length is *general-to-specific sequential t rule*[5]. Suppose we know that p is less than or equal to some known p_{max}. Starting from an autoregression of p_{max}, if the last lag is significant then the lag length is set equal to p_{max}. Otherwise, the lag length is reduced one period and the regression is reestimated and the same test is repeated. If the process is continued until the last length is insignificant, then lag length is set equal to zero. The other procedures that commonly used in choosing the lag length p are based on Akaike Information Criteria (AIC) and Schwarz Bayesian Criteria (SBC) given by

AIC = T ln(sum of squared residuals) + 2n

SBC = T ln(sum of squared residuals) + n ln(T)

where n is the number of parameters estimated, and T is the number of usable observations. The lag length p is chosen based on the lowest value of AIC and/or SBC.

4.2 Cointegration Test and Error Correction Mechanism

Given that each variable under the studies follow the unit root process, it is possible that they are cointegrated, that is, they have a linear combination that is stationary. Formally, variables $x_{1t}, x_{2t}, \ldots, x_{kt}$ are said to be cointegrated of order (d,b) if: (i) all $x_{1t}, x_{2t}, \ldots, x_{kt}$ are integrated of order d; and (ii) there exists a vector $\beta=(\beta_1, \beta_2, \ldots, \beta_k)$ such that $(\beta_1 x_{1t} + \beta_2 x_{2t} + \ldots + \beta_k x_{kt})$ is integrated of order (d-b) where b>0, (Engel and Granger, 1987).

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[5] See Hayashi (2000) for details.

In this paper, to test the presence of cointegration we employ Johansen's (1991, 1995) procedure described as follows[6]. Consider the VAR representation of the vector $X_t = (x_{1t}, x_{2t}, ..., x_{kt})'$ is given by

$$X_t = \Pi_0 + \Pi_1 X_{t-1} + ...\Pi_p X_{t-p} + \varepsilon_t \qquad (4.7)$$

where Π_0 is a (kx1) vector of intercept, Π_i is (kxk) coefficient matrices and $\varepsilon_1,...\varepsilon_T$ are IINp (**0,Λ**). This equation can be transformed into the difference form

$$\Delta X_t = \Pi_0 + \Pi X_{t-p} + \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{p-1} \Delta X_{t-p+1} + \varepsilon_t \qquad (4.8)$$

where, $\Pi = -(I - \Pi_1 - ... - \Pi_p)$; and

$$\Gamma_i = -(I - \Pi_1 - ... - \Pi_i)$$

Let r represents the rank of matrix Π. If r=0 then equation (4.8) is just a VAR representation of X_t in the differenced variables. If r=k then vector X_t is a stationary process and we can estimate equation (4.7) directly. If 0<r<k then there exist kxr matrices α and β such that Π= α β' and $\beta' X_t$ is stationary. In this case, equation (4.8) can be interpreted as an ECM. Each column of matrix β is known as a cointegrating vector, and α is the adjustment parameters. If X_t has an error correction representation, estimating X_t as a VAR in the first difference is inappropriate.

The number of distinct cointegrating vectors is determined based on the significance of the characteristic roots of Π. Suppose characteristic roots of Π are $\lambda_1, \ldots, \lambda_k$. The number of significant cointegrating vectors is based on the trace statistics (Q_{trace}) and maximum characteristics roots statistics (Q_{max}) given by

$$Q_{trace} = -T \sum_{i=r-1}^{k} \ln(1 - \hat{\lambda}_i)$$

and

$$Q_{\max} = -T \ln(1 - \hat{\lambda}_{r+1})$$

where $\hat{\lambda}$ is the estimated value of characteristic roots. Trace statistic Q_{trace} tests the null hypothesis that the number of cointegrating vectors is r against the general alternative.

[6] Engel and Granger (1987) test for cointegration has important number of defects: (i) the result of the test depends on the variable chosen for normalization; and (ii) no systematic procedure for the separate estimation of the multiple cointegration vectors.

The maximum characteristic root statistic Q_{max} tests the null hypothesis that the number of cointegrating vectors is less than or equal to r against the alternative r+1. The critical values for Q_{max} and Q_{trace} are provided by Johansen and Juselius (1990) and Osterwald-Lenum (1992).

5. Estimation Results

The relationship among variables represented by equation (2.5) is captured as follows. Let $\boldsymbol{\beta}$ be a cointegration vector for *pm, e, p, c** and a constant. Then the long run relationship between *pm, e, p,* and *c** can be represented in an import price equation

$$pm_t = \beta_0 + \beta_1 e_t + \beta_2 p_t + \beta_3 c_t^* \tag{5.1}$$

Given that *pm, e, p,* and *c** are cointegrated, then the short run dynamic of the model can be captured by an error correction representation in the form

$$\Delta pm_t = \alpha_0 + \alpha_1 v_{t-1} + \sum_{i=1}^{p} \gamma_{1i} \Delta pm_{t-i} + \sum_{i=1}^{p} \gamma_{2i} \Delta e_{t-i} + \sum_{i=1}^{p} \gamma_{3i} \Delta p_{t-i} + \sum_{i=1}^{p} \gamma_{4i} \Delta c_{t-i}^* + \varepsilon_t \tag{5.2}$$

where $v_t = pm_t - \beta_0 - \beta_1 e_t - \beta_2 p_t - \beta_3 c_t^*$ is an error correction term.

For each Southeast Asian country sample, the models are estimated using quarterly data as well as monthly data. On the other hand, for industrialized country samples, i.e., Australia, Canada, and New Zealand, we only estimate the models with quarterly data due to the data availability.

5.1 Unit Root Tests

Before we estimate the model, we need to conduct a unit root test for each variable in the model. From the plots of the data presented in Appendix Figure 1 and Appendix Figure 2, we can see that for each series there is a possibility of structural break. Considering the presence of a structural break in the series, we employ Perron's (1989) procedure for unit root test. The lag length of the unit root test for each series is determined by using *general-to-specific sequential t rule*. The maximum lag length for quarterly data is chosen equal to 8, which is considered a reasonable value for quarterly data. Except for Indonesia and Thailand data, the break points are chosen based on the inspection of the data visually without any prior information about the events at that break point. The break points for Indonesia and Thailand data are chosen based on the currency crisis in this area that happened in the third and fourth quarter of the 1997.

Table 1. Results of Unit Root Tests for Southeast Asian Countries' Quarterly Data

Variables	Indonesia		Thailand		Singapore		Philippines	
	t-stat	5% alpha	t-stat	5% alpha	t-stat	5% alpha	t-stat	5% alpha
pm	-2.09	-3.69	-2.44	-3.69	-3.29	-3.87	-2.27	-3.69
e	-3.42	-3.69	-3.36	-3.69	-2.28	-3.68	-2.74	-3.69
p	-3.45	-3.69	-2.08	-3.69	-2.74	-3.87	-2.49	-3.69
c*	-2.77	-3.68	-3.46	-3.87	-3.48	-3.87	-2.34	-3.94

Note: Critical values are obtained from Perron (1989)

The results of the unit root test reported in Table 1 show that we cannot reject the null hypothesis of the unit root for all variables in each country sample. Using a similar procedure, the unit root test is conducted for monthly data. Following the reasoning used for quarterly data, the maximum lag length for the unit root test of monthly data is set equal to 24. As reported in Appendix Table 1, the result of the unit root test for monthly data show that for all variables the unit root cannot be rejected at 5 percent significance level. These results lead us to test the presence of cointegrations among variables in the model, both with quarterly data and monthly data.

5.2 Cointegration Tests and the Long Run Estimates

In implementing the cointegration test, first we need to determine the lag length. Here the lag length is based on AIC and SBC criteria. Since we have 4 variables then there is a possibility of 0, 1, 2 , 3, and 4 cointegration vectors. As reported in Table 2, the results of the contegration test using quarterly data indicate that Indonesia, the Philippines and Singapore has one cointegration vector at significance level 5%, and Thailand at significance level 10%.

Table 2. Results of Cointegration Tests for Southeast Asian Countries' Quarterly Data

Country		Trace Statistics				Maximum Statistics			
	H_0	R=0	r≤1	r≤2	R≤3	r=0	r≤1	r≤2	r≤3
	H_a	R≥1	r≥2	r≥3	R≥4	r=1	r=2	r=3	r=4
Indonesia		73.91	28.12	7.85	1.01	45.79	20.27	6.84	1.01
Philippines		56.69	27.37	11.64	2.02	29.32	15.73	9.62	2.02
Singapore		71.76	26.85	11.05	1.95	44.91	15.80	9.10	1.95
Thailand		44.15	18.16	7.43	0.05	25.99*)	10.73	7.38	0.05
Critical value 5%		47.21	29.68	15.41	3.76	27.07	20.97	14.07	3.76

Note: The critical values are based on the Osterwald-Lenum's (1992) Table.

From cointegration vectors we obtain the long run equilibrium relationships among the variables in the model. By normalizing cointegration vectors with respect to *pm* we get the long run import price equations for quarterly data as follows.

Indonesia: $$pm = 0.983e - 0.216p + 1.574c^* - 9.291$$
$$(4.99) \quad (-0.86) \quad (2.07)$$

Philippines: $$pm = 1.179e - 0.367p + 2.211c^* - 7.704$$
$$(3.15) \quad (-1.13) \quad (4.43)$$

Singapore: $$pm = 0.200e + 0.465p + 0.465c^* - 0.582$$
$$(2.33) \quad (6.47) \quad (3.37)$$

Thailand: $$pm = 0.800e + 0.664p + 0.613c^* - 4.155$$
$$(5.19) \quad (4.10) \quad (3.0)$$

The sign of all variables in equations for Singapore and Thailand are consistent with the theory and are significant. For Indonesia and Philippines the sign of exchange rate and foreign cost are significant and consistent with the theory, while the sign of domestic price is negative but not significant. Thus, in the long run, exchange rate and foreign prices have significant effect on domestic import prices in all Southeast Asian countries sample. The significant effects of domestic price are found in Singapore and Thailand, but not in Indonesia and Philippines. From this result it appears that domestic prices in Indonesia and Philippines are not taken into account by the exporting firm when they set the price of the goods they sell in these two countries. Domestic firms in these two countries may be not producing enough products that compete with importing goods. On the other hand, Singapore and Thailand may have firms that produce enough goods that compete with importing goods. When the exporting firms set the price of goods exported to Singapore and Thailand they take in to account the price of the goods produced in these two countries.

The estimates of exchange rate pass-through for Indonesia, Philippines, Singapore and Thailand are 0.983, 1.179, 0.200 and 0.800, respectively. From the result of testing the null hypothesis that exchange rate pass-through is equal to one, we find that complete exchange rate pass-through cannot be rejected for Indonesia, Philippines and Thailand. On the other hand, complete exchange rate pass-through for Singapore is rejected at 5 percent significance level. Thus, among these Southeast Asian countries, only Singapore that have incomplete exchange rate pass-through, while Indonesia, the Philippines, and Thailand have complete exchange rate pass-through in the long run.

Based on the theoretical model, the long run equilibrium of import price necessitates that the coefficients of the exchange rate and foreign cost should be equal, and there is unit homogeneity of the exchange rate coefficient, as well as the foreign cost coefficient, with the domestic price coefficient. We test all these restrictions, and the results are reported in Table 3. Except the restriction of unit homogeneity between the exchange rate and foreign cost coefficient for Thailand, all restrictions of the model for all countries cannot be rejected.

Table 3. t-statistics of the Restrictions of the Model with Quarterly Data

Country	Restrictions		
	$\beta_1 = \beta_3$	$\beta_1 + \beta_2 = 1$	$\beta_2 + \beta_3 = 1$
Indonesia	0.75	-0.73	0.45
Philippines	1.66	-0.38	1.42
Singapore	1.63	-1.19	0.64
Thailand	-0.73	2.08	1.06

Since all variables for monthly data follow the unit root process, as shown in Appendix Table 1, then we test the presence of cointegration for monthly data. From the results of cointegration test reported in Appendix Table 2, we find that all countries sample have one cointegration vector. The long run import price equations for each country using monthly data are as follows.

Indonesia: $pm = 0.885e - 0.056p + 1.672c^* - 9.711$
$(8.35) \quad (-0.45) \quad (3.46)$

Philippines: $pm = 1.529e - 0.713p + 2.839c^* - 10.116$
$(3.21) \quad (-1.67) \quad (4.13)$

Singapore: $pm = 0.109e + 0.767p + 0.119c^* + 0.462$
$(2.48) \quad (16.32) \quad (2.83)$

Thailand: $pm = 0.396e + 1.248p + 0.131c^* - 1.780$
$(5.91) \quad (22.29) \quad (1.32)$

Using monthly data we still get results similar to those of the quarterly data in terms of sign and significance of the variable. As shown in Appendix Table 3, except for Thailand, we still cannot reject the restrictions on the coefficients imposed by theoretical model. Although the magnitude of the exchange rate pass-through for each country changes, we still cannot reject the null hypothesis of complete exchange rate pass-through for Indonesia and the Philippines, and incomplete exchange rate pass-through for Singapore. On the other hand, using monthly data, the null hypothesis of complete exchange rate pass-through for Thailand is rejected. This is in contrast with the result of using quarterly data, where the complete exchange rate pass-through in Thailand cannot be rejected.

5.3 Short Run Dynamics

The short run dynamics of the model is captured by coefficients of the error correction term v_t and the lags of variables in ECM representations. In estimating the model, we employ two different approaches. The first approach is to use general-to-specific method. This method starts with an unrestricted model with reasonable maximum lag length. For quarterly data we choose maximum lag of 4 periods based on the assumption that the effect of exogenous variables on import prices will not last more than one year. The maximum lag of 4 periods is commonly used in quarterly data. After we run the regression with maximum number of lag then we remove non-significant variables, unless removing such variables causes autocorrelation. Estimation results of the model using general-to-specific method with quarterly data are reported in Table 4.

These results show that the error correction terms are significant for the all country in the sample. The absolute values of this coefficient can be interpreted as the speed of adjustment of the short-run deviation to the long run equilibrium. The speed of adjustment varies across countries where Indonesia has the highest value and Thailand has the lowest value. In Indonesia, about 86 percent of the adjustment occurs in the first quarter while in Thailand only about 15 percent of the adjustment occurs in the first quarter.

Tabel 4. Regression Results for ECM of Southeast Asian Countries with Quarterly Data

Country	lag	Variables					Summary Statistics
		V	Δpm	Δe	Δp	Δc*	
Indonesia (1986:1-2000:3)	1	-0.865 (-6.37)	-1.354 (-5.26)	0.496 (3.93)			Adj-R2: 0.664 SS-Resid: 0.124 F-stat: 17.50 DW: 1.97
	3				-0.870 (-6.15)	1.930 2.27)	
Philippines (1974:1-1991:4)	1	-0.532 -5.42			1.134 (4.22)		Adj-R2: 0.434 SS-Resid: 0.338 F-stat: 11.29 DW: 2.05
	2			-0.983 (-3.85)		-1.13 (-1.87)	
	3		0.301 3.25				
Singapore (1974:1-2000:3)	1	0.183 (2.54)	0.332 (3.31)				Adj-R2: 0.192 SS-Resid: 0.046 F-stat: 9.19 DW: 1.97
	2				-0.138 (-1.76)		
Thailand (1974:1-2000:3)	1	-0.153 (-3.19)				0.906 (5.24)	Adj-R2: 0.728 SS-Resid: 0.056 F-stat.:68.48 DW: 1.91
	4		-0.136 (-2.43)				

Although coefficients on the error correction term give meaningful results, however, the estimates of the coefficients of the lags of variables show mixed results, as shown in Table 4. For example, while the lag of exchange rate has significant positive effect on import price in Indonesia, in Philippines the effect is negative and in Singapore and Thailand there is no significant effect. The mixed results also occur in the coefficients of the lags of other variables.

The general-to-specific approach is also carried out for monthly data and the results are reported in Appendix Table 4. Except for Singapore, coefficients of the error correction term are significant. Estimation results show that in Indonesia the adjustment to the long run equilibrium occurs in the first month is about 18 percent, while in Philippines and Thailand is about 22 percent and 9 percent, respectively. The estimates of the coefficients of the lags of variables still cannot be explained where the results are mixed.

The other method that commonly used in capturing short run dynamic of the model is by imposing restrictions on the coefficients of the lags of variables using Polynomial Distributed Lags (PDL) procedure. With this method, the coefficients of the variables lags are smoothed over time. The literature suggests that the polynomial degree should be low. As noted by Greene (2000), for example, in application of the PDL the order of the polynomial is rarely exceeding 3 or 4. This number is reasonable because if we use a large degree polynomial, say larger than 4, then we will not get the smooth dynamic of the coefficients. In this paper we use polynomial of degree 3 and the results are shown in Appendix Figure 3 and Appendix Figure 4 for quarterly and monthly data, respectively.

As shown in Appendix Figure 3, dynamic of the coefficients using quarterly data is not quite obvious. However, when we use monthly data, as we can see in Appendix Figure 4, dynamic of the coefficients are much more obvious. First, we observe that the dynamic of the coefficients of the exchange rate are quite similar across countries, although the magnitudes are different. For all countries, the largest effect of current exchange rate change on the import price occurs in the next period and fall gradually to the negative before finally approaching zero. Second, for all countries the effect of domestic price on the next period import price are positive and the pattern of the effect for the subsequent periods are different across country. For Indonesia and Singapore, the highest effect of domestic price change occurs in the next period and then fall gradually toward zero. On the other hand, the highest effect of domestic price in Philippines and Thailand occur in 4 month and 6 month, respectively. Finally, dynamic of the foreign prices coefficients are quite different across countries both the initial effect and the pattern of the effects in the subsequent periods.

5.4 Estimation Results for the Sample of Industrialized Countries

Using the same method we employ for Southeast Asian countries we estimate exchange rate pass-through for Australia, Canada, and New Zealand. The results of the unit root tests show that all variables for each country follow the unit root and then we need to test the presence of cointegration in each country. The results of the cointegration tests for Australia, Canada and New Zealand are shown in Table 5.

Table 5. Results of Cointegration Tests for Australia, Canada and New Zealand

Country		Trace Statistics				Maximum Statistics			
	H_0	r=0	r≤1	r≤2	r≤3	R=0	r≤1	r≤2	r≤3
	H_a	r≥1	r≥2	r≥3	r≥4	r=1	r=2	r=3	r=4
Australia		48.13	22.79	8.11	2.54	25.34	14.68	5.57	2.54
Canada		62.73	29.63	8.00	1.70	33.10	21.63	6.30	1.70
New Zealand		68.49	26.98	11.90	3.75	41.51	15.08	8.15	3.75
Critical value 5%		47.21	29.68	15.41	3.76	27.07	20.97	14.07	3.76

Note: The critical values are based on the Osterwald-Lenum's (1992) Table.

From the estimates of the cointegration vectors we get the long run import prices for Australia, Canada and New Zealand as follows.

Australia: $$pm = 0.803e - 0.266p + 1.641c^{*} - 5.422$$
$$\quad (9.45) \quad (-3.24) \quad (13.8)$$

Canada: $$pm = 0.946e - 0.847p + 2.026c^{*} - 1.154$$
$$\quad (5.86) \quad (-3.05) \quad (6.62)$$

New Zealand: $$pm = 0.057e + 0.742p - 0.538c^{*} + 3.419$$
$$\quad (0.258) \quad (4.11) \quad (-1.59)$$

For Australia and Canada, all coefficients are significant where exchange rate and foreign price have positive sign, and domestic price has negative sign. For New Zealand, only the domestic price is significant and has the correct sign, while neither the exchange rate nor the foreign price is significant. Although the coefficients of the domestic price for Australia and Canada are significant, however, the signs are not consistent with the theory.

The short run dynamic of the model is examined using both general-to-specific method and PDL approaches. The results of the short run dynamic of the model for Australia, Canada and New Zealand using general to specific approach are reported in Table 6. Coefficients of the error correction terms for Australia and Canada are significant. In Australia about 25 percent of the adjustment to the long run equilibrium occurs in the first quarter and in Canada about 29 percent of the adjustment occurs in the first quarter. The estimates of the coefficients of the lags of variables are mixed.

Table 6. Regression Results for ECM of Australia, Canada and New Zealand

Country	lag	Variables					Summary Statistics
		V	Δpm	Δe	Δp	Δc*	
Australia (1974:1-2000:3)	1	-0.251 (-3.41)		0.237 (3.03)		0.922 (2.55)	Adj-R^2: 0.322 SS Resid: 0.072
	2		0.328 (1.88)	-0.295 (-2.08)		-1.10 (-2.56)	F-stat.: 6.38 DW: 2.01
	4			-0.164 (-2.33)			
Canada (1974:1-2000:3)	1	-0.286 (-7.60)					Adj-R^2: 0.377 SS Resid: 0.036 F-stat.: 13.22 DW: 1.81
	2			-0.275 (-2.25)			
	3		-0.153 (-1.70)	0.326 (2.33)			
	4			-0.231 (-1.91)			
New Zealand (1974:1-2000:3)	1	0.018 (0.61)	-0.323 (-2.06)	0.461 (3.46)	1.597 (4.31)	1.60 (4.31)	Adj-R^2: 0.397 SS Resid: 0.057
	4		-0.315 (-3.00)			0.53 (1.84)	F-stat.: 9.40 DW: 1.94

As shown in Appendix Figure 6, the short dynamic of the lags of variables using PDL can be observed. For all countries the effect of the exchange rate change on the import price reach the highest level in the next period and then gradually fall toward zero. The coefficient dynamics of the domestic price are quite similar between Canada and New Zealand, where the highest effect on import price occurs in the next period. On the other hand, the coefficients dynamics of the foreign price are quite similar between

Australia and New Zealand, where the highest effect on import price occurs in the next period.

5.5 Factors Explaining Variation of Exchange Rate Pass-Through across Countries

Since the sample size is very small, we only examine variations in the long run exchange rate pass-through across countries descriptively. Comparing exchange rate pass-through between countries sample from Southeast Asia with exchange rate pass-through from the sample of industrialized countries, we cannot see any systematic difference. Compared with the exchange rate pass-through of Australia and Canada, while the Philippines has higher value, Singapore has much lower value[7]. Thus, whether or not a country is an industrialized country does not seem to have a significant contribution to the magnitude of exchange rate pass-through of that country.

An interesting result that needs to be examined is the high variation of exchange rate pass-through among Southeast Asian countries. In particular, why is the exchange rate pass-through very low in Singapore and very high Philippines relative to other country sample? To explain such diversity we examine variation of several macro and micro variables of these countries. Table 7 provides the average value of the variables for each of the countries sample.

Table 7. Averages Values of Some Aggregate Variables of Countries Sample

Countries\ Variables	Indonesia	Philippines	Singapore	Thailand	Australia	Canada
Inflation	13.7	14.4	3.1	6.2	6.9	5.4
Money Growth	22.9	16.4	10.0	13.1	11.5	9.35
Exchange Rate Volatility	0.051	0.031	0.019	0.028	0.035	0.016
GDP Growth	6.0	3.2	7.6	6.4	3.3	3.0
Manufacturing/ GDP	17.1	24.4	25.5	24.8	13.7	18.8
Manufacturing share in Import	70.8	56.6	67.1	68.2	80.9	79.9
Import/GDP	24.1	33.7	176.4	34.6	17.9	28.3
Export/GDP	27.4	16.6	179.9	29.0	16.6	29.4
FDI/GDP	0.6	1.1	9.0	1.5	1.6	1.8

[7] Since the coefficient of exchange rate for New Zealand is not significant then we do not include it in the comparison.

Note: Except for exchange rate volatility, all variables are simple average of the yearly data obtained from World Development Indicator, 2002. The measure for exchange rate volatility is coefficient of variation calculated from quarterly exchange rate data obtained from IFS.

From Table 7, we can see that, relative to other countries sample, Singapore is characterized by high economic growth, low inflation, low money growth, high ratio of trade to GDP, and high ratio of FDI to GDP. On the other hand, the Philippines is characterized by high inflation, high money growth, low manufacturing share in total import, and low ratio FDI to GDP. The question, therefore, is whether there is a theoretical explanation that the difference in those variables leads to the difference in the exchange rate pass-through.

Based on Taylor (2000) hypothesis, Campa and Goldberg argue that the lower inflation rate leads to the lower import price pass-through. Following that argument, variations of exchange rate pass-through across country sample can be explained by variations in their inflation rate. Another macroeconomic variable that can explain variation in exchange rate pass-through across countries sample is monetary stability. Using money growth as a measure of monetary stability, relatively low money growth in Singapore appears to be one of the reasons why it has relatively low exchange rate pass-through. This is consistent to the theoretical study by Devereux and Engel (2001) where they show that countries with lower monetary volatility may prefer to price in their own currency. If that is the case, then a country with more stable monetary policy will have lower exchange rate pass-through.

From the micro side, the presence of multinational companies (MNCs) and intra-firm trade may contribute to the low exchange rate pass-through in Singapore. As argued by Menon (1995), intra-firm pricing policy that actively employed by MNCs prevent or at least stagger full pass-through of exchange rate changes into the selling prices in individual market. By assuming that a country with the high ratio of FDI/GDP together with the high ratio trade/GDP can indicate that it has many MNCs with high intra-firm trade, then this variable can be characterized as one of the factors that causes low exchange rate pass-through in Singapore.

6. Conclusion

In this paper we estimate exchange rate pass-through into import price in some Southeast Asian countries: Indonesia, the Philippines, Singapore and Thailand. The empirical model is derived from the Law of One Price with assumption that the exporting firms have some degree of monopoly power in importing markets. Using quarterly and monthly data the models are estimated by employing cointegration analysis and Error Correction Mechanism.

The results of the unit root tests show that all variables in the model follow the unit root process. For each country, cointegration tests show that import price, exchange rate, domestic price and foreign price are cointegrated of order one. Using quarterly data, we find the long run exchange rate pass-through estimates 0.983, 1.179, 0.200 and 0.800 for Indonesia, the Philippines, Singapore and Thailand, respectively. Using monthly data, the long run exchange rate pass-through for Indonesia, Philippines, Singapore, and Thailand are 0.885, 1.529, 0.109, and 0.396, respectively. Although the magnitudes of the exchange rate pass-through with monthly data different from those of with quarterly data, except for Thailand, the conclusion on the completeness of exchange pass-thorough are not changed. Using quarterly data and monthly data we find that the long run exchange rate pass-through in Indonesia and Philippines are complete, and in Singapore is incomplete. For Thailand we find that the long run exchange rate pass-through is complete when we use quarterly data, but becomes incomplete when we use monthly data.

Comparing the exchange rate pass-through of Southeast Asian countries with exchange rate pass-through of an industrialized country sample, the results does not show any systematic difference. If we compare exchange rate pass-through across country sample, only exchange rate pass-thorough of Singapore that different significantly from those of other countries, where it has incomplete and relatively low exchange rate pass-through. From macro side, inflation rate and money growth appear to contribute to the variation of exchange rate pass-through across countries. On the micro side, the presence of MNCs with intra-pricing policy appears to have significant contribution.

From estimation results of the ECM we find that using quarterly data, the error correction terms for all countries are significant. The speeds of adjustment from the short run deviation to the long run equilibrium are 0.865, 0.532, 0.183 and 0.153 for Indonesia, the Philippines, Singapore and Thailand, respectively. When we use monthly data, except for Singapore, the error correction terms are significant where the speed of adjustment are 0.181, 0.216, and 0.092 for Indonesia, the Philippines, and Thailand respectively. In Singapore, estimation results of monthly data show that exchange rate does not affect import price in the short run, where neither error correction term nor lag of the exchange rate is significant. The results of the model with PDL provide the coefficients dynamic of the lags of variables and the results are relatively obvious when we use monthly data.

One of the possible extensions of the analysis in this paper is to estimate the model for Southeast Asian countries using panel data estimation. With panel data, we may get more information, more variability, more degrees of freedom and more efficiency that lead to more reliable parameter estimates. The standard panel data techniques, however, are not appropriate to the data we use in this paper due to their non-stationary characteristic. As argued by Kao and Chiang (1998), for example, the standard method of estimation such as OLS and Fully-Modified OLS is subject to non-negligible bias. Fortunately, non-stationary panel data techniques such as panel unit root test and panel cointegration test have been developed in recent years. These techniques seem applicable for extension of the analysis in this paper.

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Appendix Table 1. Results of the Unit Root Tests for Monthly Data

Variables	Indonesia		Philippines		Singapore		Thailand	
	t-stat	5% alpha	t-stat	5% alpha	t-stat	5% alpha	t-stat	5% alpha
Pm	-2.58	-3.75	-2.34	-3.76	-3.09	-3.77	-2.33	-3.69
E	-3.31	-3.75	-2.30	-3.76	-2.32	-3.69	-3.41	-3.69
P	-3.35	-3.75	-2.57	-3.76	-2.58	-3.77	-1.88	-3.69
c*	-2.60	-3.68	-1.60	-3.72	-3.04	-3.77	-3.11	-3.77

Note: Critical values are obtained from Perron (1989)

Appendix Table 2. Results of Cointegration Tests for Monthly Data

Country		Trace Statistics				Maximum Statistics			
	H_0 H_a	r=0 r≥1	r≤1 r≥2	r≤2 r≥3	R≤3 R≥4	r=0 r=1	r≤1 r=2	r≤2 r=3	r≤3 r=4
Indonesia		59.07	21.83	5.34	1.93	37.24	16.49	3.42	1.93
Philippines		51.21	24.53	11.46	2.46	26.68	13.07	9.00	2.46
Singapore		48.87	21.34	6.44	2.42	27.53	14.90	4.02	2.42
Thailand		47.31	16.99	5.00	0.01	30.32	11.99	4.99	0.01
Critical value 5%		47.21	29.68	15.41	3.76	27.07	20.97	14.07	3.76

*) Significant at 10%

Appendix Table 3. t-statistics of the Restrictions of the Model Using Monthly Data

Country	Restrictions		
	$\beta_1 = \beta_3$	$B_1 + \beta_2 = 1$	$\beta_2 + \beta_3 = 1$
Indonesia	1.59	-1.05	1.24
Philippines	1.57	-0.29	1.39
Singapore	0.16	-1.92	-1.79
Thailand	-4.38	7.33	1.02

Appendix Tabel 4. Estimation Results of ECM Using Monthly Data

Country	lag	Variables					Summary Statistics
		v	Δpm	Δe	Δp	Δc*	
Indonesia (1986:1-2000:3)	1	-0.181 (4.73)	-0.790 (-7.62)	0.454 (9.72)			Adj-R2: 0. 627 SS-Resid: 0.081 F-stat: 24.19 DW: 1.87
	3		-0.636 (-5.40)	0.277 (4.96)			
	4		0.241 (3.00)				
	5		-0.581 (-5.65)	0.282 (5.66)			
	7		-0.56 (-5.70)	0.238 (5.31)		-0.968 (-2.28)	
	9					1.142 (2.66)	
Philippines (1974:1-1991:4)	1	-0.216 (-3.36)	-0.578 (-7.67)	0.681 (2.10)	1.28 (3.22)		Adj-R2: 0.464 SS-Resid: 1.70 F-stat: 23.23 DW: 2.00
	2		-0.258 (-3.28)				
	3		-0.173 (-2.69)		0.57 (1.65)		
	9					2.50 (2.84)	
Singapore (1974:1-2000:3)	1	0.00			0.351 (7.12)		Adj-R2: 0.171 SS-Resid: 0.04 F-stat: 8.90 DW: 1.87
	2				-0.162 (-3.07)		
	3				0.129 (2.61)		
	5		0.449 (2.32)		-0.345 (-2.03)		
	6				-0.119 (-2.43)		
	12					0.192 (2.25)	
Thailand (1974:1-2000:3)	1	-0.092 (-4.91)	-0.262 (-3.78)	0.545 (6.27)		0.524 (1.81)	Adj-R2:0.201 SS-Resid: 0.23 F-stat: 9.63 DW: 1.98
	4		0.14 (2.70)				
	10			-0.135 (-1.95)	-0.340 (-2.04)		
	11		0.137 (2.50)				