

Beyond the Purchasing Power Parity: Exchange Rates, Prices and Interest Rates in ASEAN-5 Countries

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ABSTRACT

This study examines the association among price, exchange rates and interest rates in ASEAN-5 economies. Several studies have suggested the importance of the linkages between goods and assets market in the determination of exchange rates and one way to account for such linkages is to incorporate interest rate and prices. By using cointegration test, we found evidence on the long run relationship among the variables indicating the importance of interest rate and price on exchange rate when structural break is considered. The findings thus show that the linkages between goods and assets market found in developed countries has general applicability to other small open economies specifically for Malaysia only when structural break caused by the financial crisis 1997 is considered. The different in results for the sub period indicate that not only it is important to consider multivariate approach but also the impact of financial crisis in the future research examining exchange rate in ASEAN-5 countries.

Key words: purchasing power parity; Johansen cointegration; exchange rate determination; ASEAN economies

ABSTRAK

Kajian ini meneliti perhubungan di antara harga, kadar pertukaran dan kadar faedah bagi ekonomi ASEAN-5. Beberapa kajian menunjukkan betapa pentingnya perkaitan di antara pasaran barangan dan pasaran aset dalam penentuan kadar pertukaran dan salah satu cara untuk mengambilkira perkaitan tersebut ialah dengan memasukkan kadar faedah ke dalam persamaan kadar pertukaran. Melalui ujian kointegrasi, kami menemui bukti yang menunjukkan wujudnya

perhubungan jangka panjang di antara pembolehubah-pembolehubah tersebut yang mana mencerminkan pentingnya kadar faedah dan harga ke atas kadar pertukaran apabila 'structural break' diambil kira.. Penemuan ini menunjukkan bahawa perkaitan di antara pasaran barangan dan aset yang ditemui bagi negara maju juga terpakai bagi ekonomi kecil yang lain terutamanya bagi kes Malaysia apabila mengambil kira 'structural break' yang disebabkan oleh krisis kewangan 1997. Perbezaan dalam hasil penemuan bagi sub jangkamasa menunjukkan penggunaan pendekatan multivariat dan mengambil kira kesan krisis kewangan adalah penting dalam kajian masa depan yang melibatkan penentuan kadar pertukaran dalam negara ASEAN-5.

Kata kunci: pariti kuasa beli, kointegrasi Johansen, penentuan kadar pertukaran, ekonomi ASEAN.

INTRODUCTION

Many studies have devoted to testing on the determination of exchange rates. One such study is focusing on the relationship between prices and exchange rates which commonly known as purchasing power parity (PPP). The theory of PPP states that exchange rates between any two currencies will adjust to reflect changes in the relative price levels of the two countries. However, most of the previous studies on testing the relationship come out with mixed conclusions, among others, study by Papell (1997), Christev and Noorbakhsh (2000) and Sarno and Valente (2006) for developed economies and Salehizadeh and Taylor (1999), Baharumshah and Ariff (1997), Bahmani-Oskooee (1993) and Lee, Lim and Azali (2003) for emerging or developing economies. Eiteman, Stonehill and Moffet (2007) gave two general conclusions that can be gathered from studies on PPP. Firstly, the relationship holds up well over the very long run but poorly for shorter time periods and secondly, the theory holds better for countries with relatively high rates of inflation and underdeveloped capital markets. However, whether or not such a relationship holds in the long run, it has also not been without controversy in the literature (Cheng 1999). In addition, there are some studies that used data from developed countries with relatively low rates of inflation but still found strong support for PPP, for example Sarno and Valente (2006) found evidence for G5 countries and Alba and Papell (2007) for some European countries. These mixed conclusions of previous studies have given impetus for more studies to be conducted on relationship of relative price on exchange rate.

However, such a bivariate framework overlooked the links between goods and asset markets in the determination of exchange rates and it could be one of the reasons why the evidence does not support for PPP (Johansen & Juselius 1992). In addition, any inferences on the interaction of variables made from the omission of relevant variables may be biased (Lutkepohl 1982). On this issue, several studies have examined the behaviour of exchange rates by looking at the relationship between prices, exchange rates and interest rates, for example Johansen and Juselius (1992), Juselius (1995), Cheng (1999) and Caporale, Kalyvitis and Pittis (2001) have augmented earlier studies on PPP by including interest rate variables and found evidence on the relationship among these variables. All of these studies has focused on data from developed economies. Several questions posted from these findings are whether it is an isolated phenomenon in the particular period under study and valid solely for large open economies, or whether the result has general applicability to other small open economies and the answer requires additional empirical evidence based on data from other small open economies (Juselius 1995).

The link between prices, exchange rates and interest rates can be explained by the sticky price model by Dornbusch (1976). The simple version of the model assumes that in the long run the uncovered interest parity (UIP) and PPP relations both hold. In the model, the nominal exchange rate is a function of both the price level differential and also the interest rate differential. Furthermore, as suggested by Baxter (1994), interest rate variable is added to prices and exchange rate relationship because standard international economies maintains that if the domestic interest rate is above the foreign interest rate, foreign demand for domestic securities tends to increase, thus increases the value of domestic currency. Therefore, an increase in a domestic interest rate may cause the domestic currency to appreciate.

The purpose of this study is to examine the determination of exchange rate on major ASEAN economies taking into considerations the linkages between prices, exchange rates and interest rates. Study on ASEAN-5 economies is relevant since these countries have opened their economies through external trade and capital flows which may influence and be influenced by the behavior of exchange rates (Lane 2001). The growth of the external trade (in terms of exports and imports) from 1990 to 2000 of five major ASEAN economies is shown in Table 1.

Empirically, some of previous studies on PPP have used the traditional tests for unit roots that focus on coefficient restrictions, however such tests often impose undue restrictions on several variables (Lee, 1999) and

TABLE 1. Exports and imports for five major ASEAN countries

Country Year	Thailand Exports (billion)	Singapore Exports (million)	Philippines Exports (million)	Malaysia Exports (million)	Indonesia Exports (million)
1990	589.81	95206	197962	79646	25675.2
1995	1406.31	167515	450487	184987	45417
2000	2777.73	237826	1773140	372913	62124
	Imports (billion)	Imports (million)	Imports (million)	Imports (million)	Imports (million)
1990	844.45	109806	317977	79119	21837
1995	1763.59	176317	729960	194345	40630
2000	2494.16	232176	1494500	312355	33514.8

Source: IMF's International Financial Statistics CD-ROM data disk (International Monetary Fund, 2002)

do not adequately account for possible existence of long run relationships between exchange rates and price indices (Salehizadeh & Taylor, 1999), thus leading to the application of cointegration techniques. In relation to this, Sosvilla-Rivero and Garcia (2003) has pointed out PPP testing would seem to provide the perfect context for applying cointegration methods. Following Cheng (1999) this study apply the multivariate cointegration to examine the relationship among interest rate, price and exchange rate for less developed economies. Cheng (1999) focus on industrialized economies and found evidence for the relationship among the variables.

LITERATURE REVIEW

The economic implications of PPP have motivated a large number of studies on the validity of PPP. Estimates of PPP are often used for practical purposes such as determining the degree of misalignment of the nominal exchange rate and the appropriate policy response, the setting of exchange rate parities, and the international comparison of national income levels (Sarno & Valente 2006). As such, if PPP does not hold, these practical purposes would be of limited use. A large literature on PPP has examined the validity of PPP in a bivariate framework that is by testing the relationship between prices and exchange rates. This include among others, study by Papell (1997), Christev and Noorbakhsh (2000) and Sarno and Valente (2006) for developed countries and Bahmani-Oskoe (1993), Baharumshah and Ariff

(1997), Salehizadeh and Taylor (1999), and Lee et al. (2003) for emerging or developing economies. All of these studies applied either unit root methodology or cointegration techniques however the results provided mixed conclusions on the validity of PPP.

Focusing on data from developed countries Papell (1997) and Sarno and Valente (2006) provided evidence in support of PPP. Papell (1997) examined PPP in a bivariate framework for 20 developed countries. Using monthly and quarterly data for consumer price index and nominal exchange rate of local currency against German and US currency, the findings are in favour of long run PPP. Similar evidence is documented by Sarno and Valente (2006) for G5 countries. Using a century of data for the four dollar exchange rates obtaining among the G5 countries, they examined the validity of PPP by applying the regime-shift framework. Such framework allows for the possibility that different exchange rate regimes generate regime shifts in the structural dynamics of PPP deviations, especially when using long-spans data. In contrast, Christev and Noorbakhsh (2000) found weak evidence of PPP for European countries and the US. Their study employed the error correction model on monthly data of nominal exchange rates and consumer price index for the period 1990 to 1998.

For less developed economies, a bivariate framework has not provided much support of PPP, applying either unit root methodology or cointegration techniques. Examining data for five major ASEAN economies namely Malaysia, Singapore, Indonesia, Thailand and Indonesia, Bahmani-Oskoe (1993) have found strong support for PPP only in Philippines but not in other countries while Baharumshah and Ariff (1997) and Lee et al. (2003) failed to find support for PPP in all the countries. Examining data for a large group of emerging or developing economies, Salehizadeh and Taylor (1999) found relatively strong evidence in favor of PPP for fourteen countries out of twenty seven countries. For the five major ASEAN economies that were included in the study, only Thailand appeared in the list of the fourteen countries.

Johansen and Julius (1992) argued that one of the possible reasons some studies that focused on a bivariate framework failed to find support for PPP is due to the missing link between goods and asset markets in the exchange rate determination. With regards to this issue Said & Janor (2001) have documented evidence that there is a bilateral interactions between inflation and interest rates in ASEAN countries applying causality test. They concluded that in the interest rates determination process, one cannot ignore information on inflation trends and vice versa. According to Lutkepohl (1982), any inferences on the interaction of variables made from

the omission of relevant variables may be biased. Based on the theoretical framework of Dornbusch (1976) on the exchange rate determination and as suggested by Baxter (1994), Johansen and Julius (1992) and several other studies such as Juselius (1995), Cheng (1999) and Caporale et al. (2001) have augmented earlier studies on relation between prices and exchange rates by including interest rate variables for developed economies. Even though all of the study differs in terms of the techniques used but they found evidence in support of PPP.

In Johansen and Julius (1992) and Caporale et al. (2001), not only their study allows for possible interaction between prices, exchange rates and interest rates but they also allows for different short and long run dynamics. Using data from United Kingdom and for German mark and Japanese yen respectively, both studies were able to show evidence on the PPP. Similar evidence is found for Denmark and German economies analysed by Juselius (1995). In the study, the long run foreign transmission effects are examined in a multivariate time-series model of Danish and German prices, exchange rates and interest rates. The results showed that the goods and the capital markets in Denmark and Germany economies are strongly interrelated and that the real PPP exchange rate is an important link between the two markets. As for Cheng (1999), examining the causality between the dollar and the yen in a multivariate framework, they found causality running from relative prices to exchange rates along with interest rates between the US and Japan in the long run. Thus the study supports the long run PPP hypothesis for the 1951-94 periods.

DATA AND METHODOLOGY

DATA

This study uses monthly observations of exchange rates, price indexes and interest rates for the 21-year period January 1986 to December 2006. All the data were obtained from DataStream. The ratios of price indices were computed using consumer price index (CPI). In testing for PPP, CPI, Wholesale Price Index (WPI), Gross Domestic Product (GDP) Deflator and Wage Rate Indices (WRI) can be used as proxies for price indices. The study use CPI since it is the most commonly used among the researchers (Sosvilla-Rivero & Garcia, 2003) and also due to data availability. All bilateral exchange rates are the rates between each country against the US. While the relative prices represent the ratios of each country price to that of US. The US is chosen as the base country because the global importance

of both the US economy and the US dollar, along with the availability of US dollar-based exchange rate data (Salehizadeh & Taylor 1999). As for the interest rates, this study used one month deposit rate due to the availability of data for all the countries examined. Other studies have used various measures of interest rates for similar reasons, for example Cheng (1999) used discount rates because this is the only interest rate that is available in Japan prior to 1965.

METHODOLOGY

The relationship between the exchange rate and the price as implied by PPP is as follows:

$$s_t = \alpha + \beta p_t + u_t \quad (1)$$

where, s_t are the exchange rate (a nominal exchange rate measured in local currency per US dollar) and p_t the ratio of price indices (consumer price index (CPI) divided by US CPI) respectively, while u_t is the error term. Tests of PPP often take the form of testing the null hypothesis of $\beta = 1$.

Prior studies of the PPP have used the unit root methodology and cointegration techniques. This study used Johansen cointegration to test for PPP after the time series properties of the variables have been examined.

Taken into consideration the link between goods and asset market interest rate variables is included into eq. (1) as follows:

$$s_t = \alpha + \beta_1 p_t + \beta_2 z_t + u_t \quad (2)$$

where, s_t denotes the initial exchange rates, p_t is the ratio of CPI of each country to US CPI, and z_t represents the percentage rate of interest rates between each country against U.S. Following Cheng (1999), we use interest rate ratio of $z_t = (1+i)/(1+i^*)$, which reflects better approximation of the actual nominal interest rate differential.

In order to examine the linkage for different periods, this study divides the monthly data into two periods based on the break in trends of the exchange rates: period prior to financial crisis (1986m1-1997m6 for all five ASEAN countries) and period after the crisis ranging from 1998m7-2006m12 (the specific years for the period vary according to each country data, in which the selection is based on Chow stability test and the graphical inspection). We run the data for the whole period from 1986m1 to 2006m12 and compare the results with those of the two sub-samples.

The data comprises of the nominal exchange rate measured in local currency per US dollar (EM, EI, ET, EP, ES represent log of each country

exchange rate for Malaysia, Indonesia, Thailand, Philippines, and Singapore, respectively), price ratio of CPI of each country to US CPI (PM, PI, PT, PP, PS represent log of each country price ratio for Malaysia, Indonesia, Thailand, Philippines, and Singapore, respectively) and relative interest rates measured by percentage rate of interest rates between each country against US (RM, RI, RT, RP, RS are log of each country price ratio for Malaysia, Indonesia, Thailand, Philippines, and Singapore, respectively).

Our empirical approach consists of the following steps. First, we test each variable for unit root using augmented Dickey-Fuller (ADF) procedure. This is to ensure that the variables are nonstationary in levels and have the same order of integration. Unit root tests are conducted on the series at levels and at first difference. Once we accept the hypothesis of order 1 integration for each variable, then we test the variable for cointegration using Johansen's likelihood test.

It is demonstrated in Johansen (1991) that the procedure involves the identification of rank of $(n \times n)$ matrix Γ in the specification given by:

$$\Delta X_t = \pi + \sum_{i=1}^{k-1} \Pi_i \Delta X_{t-i} + \Gamma X_{t-k} + e_t \quad (3)$$

where X_t is a column vector of n variables, Π and Γ represent the OLS coefficient matrices, Δ is a difference operator, k denotes the lag length, and π is a vector of constant terms. The likelihood ratio test is of the null hypothesis of zero cointegrating relations for Γ has zero rank. On the other hand the alternative hypothesis depends on the rank r of Γ . If the rank r is greater than zero, however, there exist r possible stationary linear combinations.

We run the Johansen procedure under both the bivariate and multivariate approaches. Firstly, we test for the integration between two variables of exchange rates and price ratio of each country. We examine the existence of long run relationship between exchange rates and price using the Johansen cointegration for testing the PPP hypothesis; for the whole period and for the sub-two periods. Secondly, we run for multivariate cointegration to include the relative interest rate to account for the linkages between goods and assets market as highlighted in the above section. We test the long run relationship among exchange rates, price and interest rate by applying the multivariate approach (Cheng, 1999); also for both whole period and for the sub-two periods.

EMPIRICAL RESULTS

UNIT ROOT TEST AND JOHANSEN COINTEGRATION TEST FOR THE WHOLE PERIOD

Table 2 shows the ADF unit root test (with the number of lag length selected by Akaike Information Criteria (AIC) as stated in the bracket beside the test value). The results indicate that for all five countries for the whole period of 1986m1 to 2006m12, the exchange rate series along with the series of price and interest rate ratio are found to be non-stationary in levels. On the other hand, the test results on the first difference show that in all cases we can reject the hypothesis of non-stationary.

TABLE 2. Unit Root Test Statistics for 1986m1 to 2006m12

Variables	Augmented Dickey Fuller Test	
	Level	First differences
Thailand Bath per USD (ET)	-0.066796*(AIC 2)	-15.08510**(AIC 0)
Thailand interest rates (RT)	-2.881695*(AIC 1)	-12.60710**(AIC 0)
Thailand relative price level (PT)	-0.477473*(AIC 0)	-14.21280**(AIC 0)
Indonesia relative price level (PI)	1.198336*(AIC 1)	-8.4999630**(AIC 0)
Indonesia interest rate (RI)	-1.927852*(AIC 1)	-12.15775**(AIC 0)
Rupiah per USD (EI)	-0.066796*(AIC 0)	-15.08510**(AIC 0)
Malaysia relative price level (PM)	-3.359873*(AIC 1)	-12.44448** (AIC 0)
Malaysia interest rates (RM)	-2.252728*(AIC 1)	-12.18257**(AIC 0)
Malaysian Ringgit per USD (EM)	-0.600537*(AIC 0)	-15.63912**(AIC 0)
Philippines relative price Level (PP)	-1.584153*(AIC 1)	-9.218369**(AIC 0)
Peso per USD (EP)	-0.970798*(AIC 0)	-16.82514**(AIC 0)
Philippines interest rates (RP)	-2.914619*(AIC 1)	-14.49416**(AIC 0)
Singapore relative price level (PS)	-3.113700*(AIC 0)	-14.94126**(AIC 0)
Sing per USD (ES)	-1.235330*(AIC 0)	-15.70871**(AIC 0)
Singapore interest (RS)	-3.262500*(AIC 2)	-5.348092**(AIC 9)

*since $|t \text{ stat value}| > |\text{ADF test stat value}|$; accept null—unit root or nonstationary at 5%

** since $|t \text{ stat value}| < |\text{ADF test stat value}|$; reject null—no unit root or stationary at 5%

Since all the data are nonstationary and integrated at same level $I(1)$ we proceed with the cointegration test. Firstly, we test for the bivariate approach. The Johansen likelihood test for cointegration (maximal eigenvalue and trace tests) is applied to the vector X_t consisting of s_t and p_t with a lag length chosen by AIC. As s_t represent bilateral exchange rates vis-à-vis US dollar. Table 3 presents the results for bivariate approach

TABLE 3. Unrestricted Cointegration Rank Test (Maximal eigenvalue and Trace) of Exchange Rate (local currencies per US dollar) and Relative Prices with Linear deterministic trend for the whole period 1986m1-2006m12

	Maximal eigenvalue test				Trace test		
	H ₀	H ₁	Eigen value	C.V. 95%	H ₁	LR ratio	C.V. 95%
EI & PI (AIC 7)	r = 0 r ≤ 1	r = 1 r = 2	37.03* 0.160	21.13 3.8	r ≥ 1 r ≥ 2	45.93* 0.160	29.80 3.8
EM & PM (AIC 2)	r = 0 r ≤ 1	r = 1 r = 2	8.409 1.644	14.1 3.8	r ≥ 1 r ≥ 2	10.05 1.644	15.4 3.8
EP & PP (AIC 7)	r = 0 r ≤ 1	r = 1 r = 2	7.571 4.160*	14.1 3.8	r ≥ 1 r ≥ 2	11.73 4.157*	15.4 3.8
ES & PS (AIC 4)	r = 0 r ≤ 1	r = 1 r = 2	13.00 0.097	14.1 3.8	r = 1 r ≥ 2	13.097 0.097	15.4 3.8
ET & PT (AIC 6)	r = 0 r ≤ 1	r = 1 r = 2	9.918 1.575	14.1 3.8	r ≥ 1 r e" 2	11.493 1.575	15.4 3.8

C.V.= critical value; H₀=null hypothesis; H₁=alternative hypothesis

* denotes rejection of the hypothesis at the 5% level

which shows no support for PPP for all the countries under studied except for Indonesia.

To address the linkages between goods and assets market as suggested by Dornbusch (1976) and Baxter (1994), next we run the Johansen cointegration test to include interest rate ratios in the vector X_t . In this case, instead of two variables (exchange rate and price), we have three variables to be included in the test. The results for multivariate cointegration are presented in Table 4.

While this result seems to indicate that there exists a long run relationship among the three variables for Indonesia (by both maximal eigenvalue and trace tests) and Malaysia (by trace test), but no long run relationship is found for the other three countries. In general, the results of bivariate and multivariate give no much different outcomes when no structural break in data is considered. It seems to indicate that the role of asset market is not important in influencing PPP through interest rate for ASEAN countries. This finding is in contrast with studies found by Johansen and Juselius (1992), Juselius (1995), Cheng (1999) and Caporale, Kalyvitis and Pittis (2001) in developed countries. Our results suggest no evidence

TABLE 4. Unrestricted Cointegration Rank (Maximal eigenvalue and Trace) of Exchange Rate, Interest Rate and Relative Prices of Five ASEAN Countries with Linear deterministic trend for the whole period 1986m1-2006m12

	Maximal eigenvalue test				Trace test		
	H_0	H_1	Eigen	C.V.	H_1	LR	C.V.
			value	95%		ratio	95%
EI, RI & PI (AIC 7)	$r = 0$	$r = 1$	37.03*	21.13	$r \geq 1$	45.93*	29.80
	$r \leq 1$	$r = 2$	8.579	14.26	$r \geq 2$	8.903	15.49
	$r \leq 2$	$r = 3$	0.324	3.84	$r \geq 3$	0.323	3.84
EM, RM & PM (AIC 9)	$r = 0$	$r = 1$	19.47	21.13	$r \geq 1$	32.53*	29.80
	$r \leq 1$	$r = 2$	11.37	14.26	$r \geq 2$	13.07	15.49
	$r \leq 2$	$r = 3$	1.69	3.84	$r \geq 3$	1.69	3.84
EP, RP & PP (AIC 6)	$r = 0$	$r = 1$	15.021	21.13	$r \geq 1$	27.922	29.80
	$r \leq 1$	$r = 2$	8.705	14.26	$r \geq 2$	12.901	15.49
	$r \leq 2$	$r = 3$	4.196*	3.84	$r \geq 3$	4.196*	3.84
ES, RS & PS (AIC 5)	$r = 0$	$r = 1$	13.670	20.9	$r \geq 1$	21.352	29.68
	$r \leq 1$	$r = 2$	7.577	14.1	$r \geq 2$	7.682	15.41
	$r \leq 2$	$r = 3$	0.105	3.76	$r \geq 3$	0.105	3.76
ET, RT & PT (AIC 9)	$r = 0$	$r = 1$	16.066	20.9	$r \geq 1$	30.611	29.68
	$r \leq 1$	$r = 2$	13.100	14.1	$r \geq 2$	14.544	15.41
	$r \leq 2$	$r = 3$	1.445	3.76	$r \geq 3$	1.445	3.76

C.V.= critical value; H_0 =null hypothesis; H_1 =alternative hypothesis

*denotes rejection of the hypothesis at the 5% level

of PPP for all ASEAN countries considered except for Indonesia and Malaysia for the time series of 1986m1-2006m12.

UNIT ROOT AND JOHANSEN COINTEGRATION TEST FOR THE TWO SUB PERIODS

Next, taking structural break into consideration, we run the data for ADF unit root tests for both pre-and post-crisis periods. Table 5 shows that all series are at unit roots at level except for Thailand exchange rate (in pre-crisis period and price in post-crisis period) and Indonesia exchange rate (in post-crisis period). Therefore, we exclude these $I(0)$ variables from cointegration testing. Subsequently, for the rest of the variables we run the Johansen cointegration test.

For the bivariate approach, the results from Table 6 show that there is one cointegration meaning there is a long run relationship between the

TABLE 5. Unit Root Test Statistics for period pre- and post- financial crisis

Variables	Augmented Dickey Fuller Test			
	Pre-crisis period		Post-crisis period	
	Level	1st differences	Level	1st differences
Thailand Bath per USD (ET)	-3.068349** (SIC 1)	-	-1.789236* (SIC 1)	-6.213139** (SIC 0)
Thailand relative price level (PT)	1.053771* (SIC 0)	-9.501715** (SIC 1)	-2.738003* (SIC 0)	-8.409270** (SIC 1)
Thailand interest rates (RT)	-1.887634* (SIC 0)	-10.34603** (SIC 0)	-8.209729** (SIC 0)	-
Rupiah per USD (EI)	-2.781535* (SIC 0)	-11.68201** (SIC 0)	-4.046133** (SIC 0)	-
Indonesia relative price level (PI)	0.011652* (SIC 1)	-9.991545** (SIC 0)	0.163896* (SIC 1)	-8.190866** (SIC 0)
Indonesia interest rate (RI)	-1.933566* (SIC 1)	-15.65055** (SIC 0)	-3.129319** (SIC 1)	-
Malaysian Ringgit per USD (EM)	-2.479205* (SIC 1)	-9.706030** (SIC 0)	-0.330315* (SIC 10)	-12.09258** (SIC 0)
Malaysia relative price level (PM)	-2.103968* (SIC 0)	-10.81075** (SIC 0)	-1.490608* (SIC 0)	-8.152460** (SIC 1)
Malaysia interest rates (RM)	-1.197211* (SIC 1)	-7.331428** (SIC 0)	-2.274985* (SIC 1)	-7.826072** (SIC 0)
Peso per USD (EP)	-1.968016* (SIC 0)	-15.28993** (SIC 0)	-1.338063* (SIC 0)	-8.995662** (SIC 0)
Philippines relative price Level (PP)	0.373852* (SIC 1)	-6.909542** (SIC 0)	-0.097054* (SIC 2)	-7.416138** (SIC 1)
Philippines interest rates (RP)	-1.718450* (SIC 0)	-12.86983** (SIC 0)	-1.838820* (SIC 0)	-10.57442** (SIC 0)
Sing per USD (ES)	-0.727246* (SIC 0)	-9.825690** (SIC 0)	-0.901472* (SIC 0)	-10.65219** (SIC 0)
Singapore relative price level (PS)	-2.735973* (SIC 0)	-2.58608*** (SIC 6)	-0.895532* (SIC 0)	-11.56187** (SIC 0)
Singapore interest (RS)	-1.267399* (SIC 2)	-5.899438** (SIC 1)	-1.374119* (SIC 1)	-6.165476** (SIC 0)

*since $|ADF \text{ test stat value}| < |t \text{ stat value}|$; accept null—unit root or nonstationary at 5%

** since $|t \text{ stat value}| > |ADF \text{ test stat value}|$; reject null—no unit root or stationary at 5%

**** since $|t \text{ stat value}| > |ADF \text{ test stat value}|$; reject null—no unit root or stationary at 10%

two variables for the pre-crisis period but only for Malaysia in the post period. This reflects that PPP is more evidence for the period before the financial crisis.

TABLE 6. Unrestricted Cointegration Rank (Maximal eigenvalue and Trace) of Exchange Rate and Relative Prices of Five ASEAN Countries with Linear deterministic trend for Pre- and Post-crisis Period

	H_0	H_1	Pre-Crisis		Post-Crisis	
			Trace Statistics	Max Eigenvalue	Trace Statistics	Max Eigenvalue
ET & PT (AIC; 4)	$r = 0$ $r \leq 1$	$r = 1$ $r = 2$	- # - #	- # - #	13.62186 1.523573	12.09829 1.523573
EI & PI (AIC 4;7) [@]	$r = 0$ $r \leq 1$	$r = 1$ $r = 2$	28.08850* 4.818828	23.26967* 4.818828	- # - #	- # - #
EM & PM (AIC 4;4) [@]	$r = 0$ $r \leq 1$	$r = 1$ $r = 2$	20.33696* 3.251534	17.08543* 3.251534	33.32651* 12.03041	79.37527* 5.774695
EP & PP (AIC 4;6) [@]	$r = 0$ $r \leq 1$	$r = 1$ $r = 2$	31.97388* 4.886462	27.08742* 4.886462	15.19121 4.251394	10.93981 4.251394
ES & PS (AIC 4;12) [@]	$r = 0$ $r \leq 1$	$r = 1$ $r = 2$	27.88376* 4.519259	27.88376* 4.519259	16.20405 4.680379	11.52367 4.680379

H_0 =null hypothesis; H_1 =alternative hypothesis

[@] Lag length based on AIC for pre-crisis and post-crisis respectively.

exchange rate for Indonesia is stationary at level for post period.

* denotes rejection of the null hypothesis at the 5% level based on critical values.

On the other hand, the relationship among exchange rate, price and interest rate under multivariate approach is depicted by Table 7. The results show that there is one cointegrating vector, indicating that the three $I(1)$ variables are cointegrated under both sub-periods for all countries considered. This is consistent with previous studies which found significant long-run relationship among the three variables such as Juselius (1995), Cheng (1999) and Caporale et al. (2001). Comparing the findings between bivariate and multivariate approach, the later approach produces more significant relationships for all the countries especially during the post-crisis period. This findings indicate that the inclusion of interest rate in examining exchange rate and price relationship is significant, thus reflecting the significant role of asset market specifically interest rates in examining PPP for ASEAN-5 countries taking into consideration the structural break caused by the 1997 financial crisis.

TABLE 7. Unrestricted Cointegration Rank (Maximal eigenvalue and Trace) of Exchange Rate, Interest Rate and Relative Prices of Five ASEAN Countries with Linear deterministic trend

	H_0	H_1	Pre-Crisis		Post-Crisis	
			Trace Statistics	Max Eigenvalue	Trace Statistics	Max Eigenvalue
EI, RI & PI (AIC 4;7) [@]	$r = 0$	$r = 1$	48.52524*	37.26165*	- #	- #
	$r \leq 1$	$r = 2$	11.26359	7.100799	- #	- #
	$r \leq 2$	$r = 3$	4.162794	4.162794	- #	- #
EM, RM & PM (AIC 2;4) [@]	$r = 0$	$r = 1$	44.56479*	20.15079	105.1256*	90.66821*
	$r \leq 1$	$r = 2$	24.41400	16.42541	14.45735	7.328072
	$r \leq 2$	$r = 3$	7.988593	7.988593	7.129280	7.129280
EP, RP & PP (AIC 8;6) [@]	$r = 0$	$r = 1$	50.15926*	50.15926*	46.68839*	31.28464*
	$r \leq 1$	$r = 2$	17.99559	17.99559	15.40374	9.247318
	$r \leq 2$	$r = 3$	6.525277	6.525277	6.156424	6.156424
ES, RS & PS (AIC 5;4) [@]	$r = 0$	$r = 1$	51.14331*	31.89258*	50.25470*	27.79923*
	$r \leq 1$	$r = 2$	19.25073	13.15535	22.45546	17.83877
	$r \leq 2$	$r = 3$	6.095377	6.095377	4.616697	4.616697

H_0 =null hypothesis; H_1 =alternative hypothesis

[@] Lag length based on AIC for pre-crisis and post-crisis respectively.

exchange rate for Indonesia is stationary at level for post period.

* denotes rejection of the null hypothesis at the 5% level based on critical values.

CONCLUSIONS

This study examines the validity of purchasing power parity (PPP) for five major ASEAN economies. To address the issue of the linkages between the goods and assets markets as suggested by Dornbusch (1976) and Baxter (1994) and empirically supported for developed economies, among others, by Cheng (1999) and Caporale, Kalyvitis and Pittis (2001), this study employs cointegration techniques to test the relationship between prices, exchange rates and interest rates. Without considering structural break in the data, the results for bivariate approach show no support for PPP for all the countries under studied except for Indonesia. While this result under multivariate approach seems to indicate that there exists a long run relationship among the exchange rate, price and interest rate for Indonesia (by both maximal eigenvalue and trace tests) and Malaysia (by trace test), but no long run relationship is found for the other three countries. In general, the results of bivariate and multivariate give no much different outcomes when no structural break is considered.

On the other hand, when structural break is considered in the data, both bivariate and multivariate approaches give more significant relationships among the variables for all countries. Comparing the findings of between bivariate and multivariate, the later approach produces more significant relationships for all the countries especially during the post-crisis period. The different in results for the sub period indicate that not only it is important to consider multivariate approach but also the impact of financial crisis in the future research in examining exchange rate in ASEAN-5 countries.

For future research undertakings, the study can be expanded by examining the role of individual country characteristics since several studies have demonstrated that country characteristics such as geographic location, exchange rate volatility and level of trade openness can help in explaining both adherence to and deviations from long-run PPP (Alba & Papell, 2007). In addition, studies such as Wu and Wu (2001), Papell (2006) and Alba & Papell (2007) have applied panel cointegration technique and provided strong support of PPP for developed countries. Applying such technique in our study would also provide valuable understandings on the validity of PPP for less developed countries.

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