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Investigating the Nominal Exchange Rates of Malaysia, Singapore and Thailand

Minoas Koukouritakis[1]

[1]*Department of Economics, University of Crete, Greece. E-mail: m.koukouritakis@uoc.gr*

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Abstract: This paper employs the CHEER approach in order to investigate the behaviour of the nominal exchange rates of Malaysia, Singapore and Thailand. These three East Asian economies have achieved significant growth rates during the last two decades, while their competitiveness levels in the global markets have increased substantially. The sample used in this study consists of monthly observations, while a co-integration technique that allows for structural breaks in the data has been applied. In brief, the evidence indicates that the CHEER model is valid for these three countries, but only in its weakest form. In general, this finding reflects the efforts of these three countries during the last two decades to integrate with the global capital and goods markets. However, several interventions in the exchange rate regimes of these countries from the respective monetary authorities, as well as the existence of quite high non-tariff barriers, prevent these economies from full integration with the global markets.

Keywords: East Asian economies, CHEER model, Structural breaks, Cointegration analysis, Markets' integration.

JEL Classification: F15, F31, F41

1. Introduction

The 1997 Asian financial crisis remains a benchmark for East Asian economies. From July 1997, when Thailand ended the currency peg to the USD in order to deal with intense speculative pressures until the end of that year, when South Korea was brought to the edge of default due to the deterioration of its balance of payments, all East Asian economies were harmed by this crisis. Their growth rates were affected negatively, while capital inflows and investment rates were gradually reduced. As a result, these countries tried to modernise their financial sectors and enhance the linkages among them, in order to secure their economies from similar crises in the future. The Chiang Mai Initiative in 2000 and the Asian Bond Market Initiative that was introduced in 2003 reflect these efforts. Hence, the field of exchange determination in East Asian economies remains quite interesting.

In general, the literature regarding theoretical models of exchange rate determination is quite large and several models have been proposed over the years: the Fundamental Equilibrium Exchange Rate (Williamson, 1985), the Desired Equilibrium Exchange Rate (Bayoumi et al., 1994), and the Behavioural Equilibrium Exchange Rate and the Permanent Equilibrium Exchange Rate (Clark & MacDonald, 1998). However, the implementation of these approaches requires a plethora of data. To avoid this problem, Juselius (1991, 1995), and Johansen and Juselius (1992) implemented an approach that combines the uncovered interest parity (UIP) and the purchasing power parity (PPP). This methodology allows for interactions among nominal exchange rates, interest rates and prices and is referred to as Capital Enhanced Equilibrium Exchange Rate (CHEER) (MacDonald, 2000, 2007; Égert, Halpern & MacDonald, 2006). The lack of data availability led several researchers to employ the CHEER approach in several emerging economies, either in Europe or Asia. Almost all of these studies employed unit root and cointegration analysis and provided evidence that was, in general, robust to the CHEER model (see, among others, Özmen & Gökcan, 2004; Rashid & Ling, 2009; Kêb³owski & Welfe, 2010; Koukouritakis, 2013; Rashid & Saedan, 2013; Prabheesh & Garg, 2018, 2021; Zhao et al., 2019).

Hence, the present study employs the CHEER approach for three highly competitive East Asian countries, namely Malaysia, Singapore and Thailand. It is worth noting at this point that these three economies have implemented different exchange rate regimes (free-floating in Malaysia, and managed floating in Singapore and Thailand). The current analysis applies the cointegration technique in the presence of structural shifts in the data. The reason is that global economic events, such as the 2007-2009 crisis, or country-specific economic policies may have caused structural shifts in the level and trend of the exchange rates of the sample countries. In brief, the findings indicate that for all three countries, the CHEER approach holds only in its weakest form. The reason that the CHEER model is not validated in its strongest form is that even though these countries have implemented successive economic reforms after the 1997 Asian crisis and integrated their capital markets, but their goods market have not yet been integrated probably due to the high non-tariff barriers that still exist in these economies.

The next section describes the theoretical framework of the CHEER model, while section 3 reports the on econometric methodology. Section 4 describes the data and reports the empirical findings, while section 5 concludes the paper.

2. The CHEER Approach

The CHEER model is based on the view that long-term persistence in the real exchange rate is reflected in the interest rate differential. It is assumed that perfect capital mobility and the starting point is the UIP, which can be expressed in the following log-linear form:

$$\Delta s_{t+k}^{e} = i_t - i_t^{*}, \tag{1}$$

where s is the natural logarithm of the nominal exchange rate, defined as units of domestic currency per unit of foreign currency, and i and i^* are the domestic and foreign interest rates, respectively. If the expected exchange rate s_{t+k}^{e} is determined by relative prices (*i.e.*, PPP validation), equation (1) can be written as follows:

$$i_t - i_t^{*} = \beta_2 (p_t - p_t^{*}) - s_t, \tag{2}$$

where p and p^* are the natural logarithms of the domestic and foreign prices, respectively.

Even though the UIP and PPP may hold as independent long-run equilibrium relationships, there may be a possible interaction among interest rates, prices and exchange rates (Johansen & Juselius, 1992; Juselius, 1995). This interaction can generate a long-run equilibrium relationship. Since interest rates are usually $I(1)$ processed, some combination of an appropriate interest rate differential and the real exchange rate may cointegrate as follows:

$$[s_t + \beta_1 (i_t - i_t^{*}) + \beta_2 (p_t^{*} - p_t)] \sim I(0). \tag{3}$$

Thus, the CHEER approach implies the exploitation of the following vectors:

$$y_t' = \left[s_t, i_t, i_t^{*}, p_t, p_t^{*} \right]. \tag{4}$$

Since the CHEER model predicts two long-run relationships (that correspond to the two conditions), the theoretical hypotheses are the following:

- H_1: The UIP is identified with unrestricted prices, while the PPP is identified with unrestricted interest rates.
- H_2: Each condition is identified as a strict individual relationship.
- H_3: The UIP is identified with prices with equal and opposite signs, while the PPP is identified with interest rates with equal and opposite signs.

In general, for a p–dimensional system, the restrictions on the cointegration structure can be tested by formulating $\beta = \left(H_1\theta_1, ..., H_r\theta_r\right)$, where H_i's are $p \times q_i$ design matrices and θ_i's are $q_i \times 1$ vectors of q_i free parameters. Since the theoretical formulation of the CHEER model implies two long-run relationships, the cointegrating vectors for the H_1 are $\beta_1 = (1,-1,1,\theta_{11},\theta_{12})$ and $\beta_2 = (1,\theta_{21},\theta_{22},-1,1)$, while $H_{1a} = (1 \quad -1 \quad 1 \quad 0 \quad 0; \quad 0 \quad 0 \quad 0 \quad 1 \quad 0; \quad 0 \quad 0 \quad 0 \quad 0 \quad 1)^{/}$ and $H_{1b} = (1 \quad 0 \quad 0 \quad -1 \quad 1; \quad 0 \quad 1 \quad 0 \quad 0 \quad 0; \quad 0 \quad 0 \quad 1 \quad 0 \quad 0)^{/}$. In this case, the LR test is distributed asymptotically as χ^2 with 2 degrees of freedom. If the H_1 is not rejected, one proceeds with the H_2, which implies that each of the two conditions hold only individually. In this case, the cointegrating vectors are $\beta_1 = (1,-1,1,0,0)$ and $\beta_2 = (1,0,0,-1,1)$, the design matrices are $H_{2a} = (1 \quad -1 \quad 1 \quad 0 \quad 0)^{/}$ and $H_{2b} = (1 \quad 0 \quad 0 \quad -1 \quad 1)^{/}$, while the LR test is distributed asymptotically as χ^2 with 6 degrees of freedom. Finally, if the H_2 is rejected, one tests the H_3. This theoretical hypothesis means that the two hold together jointly implying strong interaction between the capital market and the goods market. In this case, the cointegrating vectors are $\beta_1 = (1,-1,1,-\theta_{11},\theta_{11})$ and $\beta_2 = (1,-\theta_{21},\theta_{21},-1,1)$, the design matrices are $H_{3a} = (1 \quad -1 \quad 1 \quad 0 \quad 0; \quad 0 \quad 0 \quad 0 \quad -1 \quad 1)^{/}$ and $H_{3b} = (1 \quad 0 \quad 0 \quad -1 \quad 1; \quad 0 \quad -1 \quad 1 \quad 0 \quad 0)^{/}$, while the LR test is distributed asymptotically as χ^2 with 4 degrees of freedom.

3. Econometric Methodology

Since the current analysis is based on cointegration techniques, it is necessary to test for unit roots in the series. Three tests were employed: the ADF and the Phillips-Perron tests, as well as the two-break LM test (Lee & Strazicich, 2003) which includes structural breaks. The main advantage of the latter test is that it allows us to determine breaks 'endogenously'. Also, since they are included under both the null and alternative hypotheses, the rejection of the unit root hypothesis implies clearly trend stationarity.

Moving on to cointegration analysis with structural breaks in the data, the literature includes several techniques. This study employed the approach proposed by Johansen et al. (2000) (henceforth, JMN). This approach extends the Johansen cointegration analysis by adding in the VECM several dummy variables, which account for q possible exogenous breaks in the deterministic components of the process y_t. The asymptotic distribution of the trace statistic and the corresponding *p*-values were derived using response surface techniques. This approach divides the sample into $q+1$ sub-samples according to the location of the break points and assumes the following VECM:

$$\Delta y_t = \Pi y_{t-1} + \mu D_t + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \sum_{i=1}^{k} \sum_{j=2}^{q} g_{ji} D_{j,t-i} + \varepsilon_t, \quad \varepsilon_t \sim iidN(0,\Omega) \tag{5}$$

where $\mu = (\mu_{1,........,}\mu_q)$ and $D_t = (D_{1,t,........,}D_{q,t})'$ are of dimension $(p \times q)$ and $(q \times 1)$, respectively. $D_{j,t}$'s are dummy variables defined as $D_{j,t} = 1$ for $T_{j-1} + k + 1 \leq t \leq T_j$ and $D_{j,t} = 0$ otherwise, for $j = 1, ..., q$. The hypothesis of at most r_0 cointegrating relations $\left(0 \leq r_0 < p\right)$ is tested by the LR statistic:

$$LR_{JMN} = -T \sum_{i=r_0+1}^{p} \ln\left(1 - \hat{\lambda}_i\right), \tag{6}$$

where the eigenvalues $\hat{\lambda}_j$'s can be obtained by solving the related generalised eigenvalue problem, under the additional restrictions that $\mu_j = \alpha \rho_j'$, $j = 1, ..., q$, where ρ_j is of dimension $1 \times r$.

4. Data and Empirical Findings

The dataset consists of monthly observations of nominal exchange rates, interest rates and consumer price indices for Malaysia, Singapore and Thailand. The USA has been chosen as the foreign country because it is the major trade partner of the sample countries. Due to data availability, the time span for Malaysia begins in 2008:01, for Singapore in 1999:01, and for Thailand in 2000:01. All bilateral nominal exchange rates against the USD are end-of-period rates and were collected from International Financial Statistics (IFS) of the International Monetary Fund. For interest rates, I have used 10-year government bond yields. The reason is that these rates reflect the long-run process of the economy and, thus, they are more appropriate when long-run (or, equilibrium) exchange rates are investigated. For Singapore and Thailand these data were obtained from the IFS, while for Malaysia they were collected from its central bank. Finally, for national price levels, I have used consumer price indices (CPI), which were obtained from the IFS for all countries. All nominal exchange rates and price indices are expressed in natural logarithms, while all interest rates are expressed in percentages.

The nominal exchange rates against the USD for the three sample countries are presented in figure 1. This figure shows that after the Asian financial crisis all currencies followed an appreciating trend, which lasted until the early 2010s. It is worth noting that this pattern is similar for these three countries, no matter if they have implemented a free-floating exchange rate regime, such as Malaysia, or a managed floating exchange rate regime, such as Singapore and Thailand.

Moving to the empirical findings, table 1 indicates that the unit root hypothesis cannot be rejected in all cases. Regarding the two-break LM test, the results are the same while the estimated breaks of nominal exchange rates are reported in table 2. These breaks correspond, in general, to international or country-specific economic events that took place during the sample period. More specifically, the first shift in the nominal exchange rate of Malaysia signifies the beginning of the recovery of the country's economy after the global financial crisis, while the second break in 2015 coincides with the rapid depreciation of the ringgit.

Regarding Singapore, the first break in the country's exchange rate coincided with two important events: (a) the establishment of the Asian Bond Market Initiative that aimed at creating regional markets where assets denominated in regional currencies could be floated, and (b) the decline of the nominal effective exchange rate as sentiment worsened due to the outbreak of the SARS virus. Of course, it is very difficult to determine which of these two events caused this break. The second shift in 2012 is probably related to the reduction of the slope of the policy band of the nominal effective exchange rate, as economic activity was expected to slow down. Finally, for Thailand, the single break in the nominal exchange rate in 2003 also coincided with two important events: (a) the establishment of the Asian Bond Market Initiative, and (b) the beginning of a period of low interest rates.

Moving on to the cointegration analysis, since the aim of this study is the investigation of the exchange rate determinants I have used them as breaks for the estimated shifts in exchange rates reported in table 2. The estimation was performed with the use of JMulti software, while the appropriate lag length, k, in each VECM was selected using the criterion based on the sequential modified LR test statistic. Table 3 presents the JMN cointegration test statistics and the respective p-values for the three sample countries. As shown, the two long-run relationships were validated in all cases. Also, table 4 indicates that there were no ARCH errors in each country's VECM. As reported, the null hypothesis of no ARCH errors in the residuals cannot be rejected at the 0.05 level of significance in all cases.

Table 1: Unit Root Tests

		Augmented Dickey-Fuller		*Phillips-Perron*	
Country	*Variable*	*Constant*	*Constant and trend*	*Constant*	*Constant and trend*
Malaysia	s_t	-0.61	-1.85	-0.67	-1.85
	i_t	-2.18	-1.66	-2.37	-1.97
	p_t	-1.10	-2.05	-1.06	-2.77
Singapore	s_t	-1.28	-0.91	-1.34	-1.13
	i_t	-2.51	-2.38	-2.48	-2.63
	p_t	-0.02	-2.32	-0.61	-1.30
Thailand	s_t	-1.58	-0.95	-1.34	-1.15
	i_t	-1.32	-2.41	-2.35	-2.12
	p_t	-0.93	-1.53	-1.02	-1.41
USA	i_t	-1.87	-2.49	-1.49	-2.26
	p_t	0.67	-1.78	-0.26	-1.41

Notes: The null hypothesis is the unit root hypothesis. s_t is the natural logarithm of the nominal exchange rate against the USD, i_t is the 10-year government bond yield, and p_t stands for the CPI. In all cases, the unit root hypothesis cannot be rejected at the 0.05 level of significance.

Table 2: Statistically Significant Breaks of the Exchange Rates

Country	*Model*	*Break dates*
Malaysia	C	2010:10, 2015:07
Singapore	C	2003:03, 2012:04
Thailand	C	2003:03, 2009:02^{n}

Notes: The reported break dates have been estimated based on the endogenous procedure of Lee and Strazicich (2003). ^{n} signifies that the respective break is not significant at the 0.10 level of significance.

Table 3. JMN Cointegration Tests

	Malaysia		*Singapore*		*Thailand*	
r_0	$LR_{JMN}(r_0)$	$\hat{k}$	$LR_{JMN}(r_0)$	$\hat{k}$	$LR_{JMN}(r_0)$	$\hat{k}$
0	198.01* (0.000)	10	187.51* (0.000)	3	136.90* (0.000)	5
1	110.53* (0.013)		111.12* (0.011)		79.67* (0.030)	
2	62.59 (0.236)		53.52 (0.581)		47.62 (0.139)	
3	28.17 (0.745)		24.76 (0.885)		22.46 (0.419)	
4	7.52 (0.944)		9.93 (0.829)		10.49 (0.292)	

Notes: r_0 refers to the number of cointegrating vectors. $\hat{k}$ denotes the estimated lag length in the VECM. Numbers in parentheses are p-values. * denotes rejection of the null hypothesis of at most r_0 cointegrating vectors at the 0.05 level of significance.

Table 4: ARCH Test for Residuals

VECM	*p-value*
Malaysia	0.588
Singapore	0.147
Thailand	0.223

Notes: The null hypothesis states that there are no ARCH errors in the residuals. In all cases, this hypothesis cannot be rejected at the 0.05 level of significance.

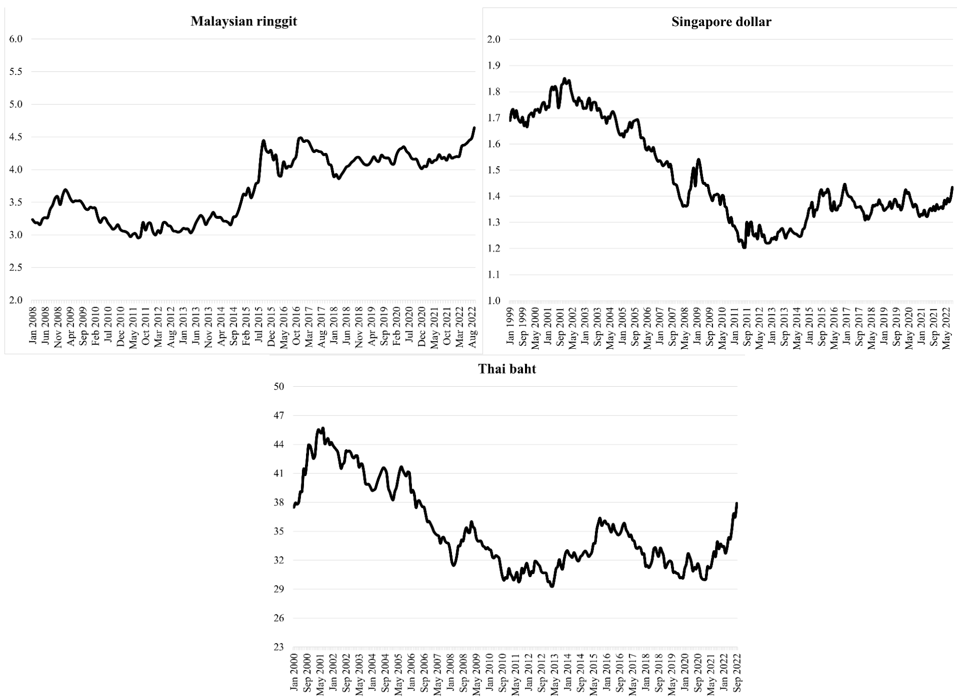

Figure 1: Nominal Exchange Rates against the USD

Table 5: Structure of the Cointegrating Vectors (LR tests)

Null hypothesis	*Malaysia*	*Singapore*	*Thailand*
H_1	5.87	4.57	1.85
(UIP with unrestricted prices,	(2)	(2)	(2)
PPP with unrestricted interest rates)	[0.053]	[0.102]	[0.397]
H_2	65.58*	69.88*	35.43*
(Only UIP, only PPP)	(6)	(6)	(6)
	[0.000]	[0.000]	[0.001]
H_3	56.24*	26.89*	26.65*
(UIP with prices with equal and opposite	(4)	(4)	(4)
signs, PPP with interest rates with equal	[0.000]	[0.000]	[0.000]
and opposite signs)			

Notes: The LR test statistics are distributed asymptotically as χ^2. Numbers in parentheses are degrees of freedom, while numbers in brackets are p-values. * denotes rejection of the respective null hypothesis at the 0.05 level of significance.

Table 5 reports the test results for the theoretical hypotheses analysed in section 2. As indicated, the theoretical hypothesis H_1, which implies that the first vector describes the UIP with unrestricted prices and the second vector describes the PPP with unrestricted interest rates, cannot be rejected for any of the three countries, at the 5 per cent level of significance. Since for these three ASEAN member states, H_1 was not rejected, I initially tested the theoretical hypothesis H_2, which suggests that the first vector includes only the UIP, while the second vector includes only the PPP. As shown, this hypothesis was strongly rejected for all three countries. Finally, the theoretical hypothesis H_3, which implies that the two parity conditions are considered jointly, was tested. Again, it was strongly rejected for all three countries.

Overall, the results of table 5 indicate that the CHEER approach is validated in its *weakest form* for Malaysia, Singapore and Thailand. This means that for each of these countries there exist plausible economic relationships among the nominal exchange rate, the interest rate differential, and the price differential. Finally, table 6 presents a structural representation of the cointegration space for the three sample countries. This representation is based on the results of table 5 and reflects the theoretical hypothesis H_1 for all countries.

The no validation of the *strongest form* of the CHEER approach can be translated into the absence of full markets integration for these countries. Even though they had integrated with global capital markets, and capital inflows had substantially increased (Park, 2013), there was an absence of

Table 6: Structure of the Cointegration Space

	Cointegrating vectors							
Country	s_t	i_t	i_t^*	p_t	p_t^*	*trend*	*tb1*	*tb2*
Malaysia	1	-1	1	-28.99	12.09	0.06	0.03^n	-0.02^n
				(4.14)	(5.02)	(0.02)	(0.03)	(0.02)
	1	-0.95	0.48	-1	1	0.02^n	0.08^n	-0.02
		(0.10)	(0.05)			(0.06)	(0.07)	(0.01)
Singapore	1	-1	1	-9.24	10.11	0.02	-0.01	-0.02
				(1.03)	(1.61)	(0.01)	(0.00)	(0.01)
	1	-0.25	0.30	-1	1	-0.01	(0.01)	(0.01)
		(0.04)	(0.03)			(0.00)	(0.00)	(0.00)
Thailand	1	-1	1	-54.19	33.11^n	-0.09^n	-0.08^n	
				(11.75)	(23.48)	(0.14)	(0.14)	
	1	-0.27	0.47	-1	1	-0.02	0.02	
		(0.05)	(0.04)			(0.01)	(0.01)	

Notes: * stands for the US variables, while *tb1* and *tb2* refer to the first and the second structural break, respectively. The vector of the UIP is reported in the first line, while the vector of the PPP is reported in the second line. Numbers in parentheses are standard errors. ^{n} denotes that the respective variable does not span the cointegration space, at the 0.10 level of significance.

goods markets integration due to wide intra-regional income disparities among these countries and the existing trade barriers, especially the non-tariff ones (Moon, 2013).

5. Concluding Remarks

The present study examines the validity of the CHEER model for three highly competitive East Asian economies. Investigating their exchange rates is important because after the Asian crisis these countries adopted several economic and financial reforms to strengthen their capital markets and integrate them into the global financial system. The empirical findings, which were based on a cointegration technique with structural breaks in the data, validated only the *weakest form* of the CHEER model for Malaysia, Singapore and Thailand. This result was translated as the absence of full market integration and could be attributed to the existence of trade barriers, as well as the absence of price and income convergence (Moon, 2013).

Notes

1. According to world competitiveness ranking in 2022 provided by the International Institute for Management Development in Switzerland, the rank of Malaysia is 32, the rank of Singapore is 3 and the rank of Thailand is 33.

   See https://www.imd.org/centers/world-competitiveness-center/rankings/world-competitiveness/.
2. Several factors may prevent the empirical validation of the UIP and PPP. UIP deviations may be explained by transaction costs, differences in taxation and risk, and capital controls, while PPP deviations can be explained by transportation costs, trade barriers, and the Balassa-Samuelson effect.
3. For the purpose of saving space, the two-break LM test results have not been presented here. Also, all series were tested for a second unit root and this hypothesis was rejected in all cases. All these results are available upon request.

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