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Equilibrium Real Exchange Rate, Misalignment, and Export Performance in Developing Asia

Juthathip Jongwanich

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Contents

Abstract			v
I.	Introduction		1
II.	Theoretical Model: Equilibrium Real Exchange Rate		2
	A.	Fundamental Equilibrium Exchange Rate	3
	B.	Uncovered Interest Parity	4
	C.	Internal and External Balances	6
III.	Real Exchange Rate Misalignments: Concepts and Empirical Survey		8
	A.	Concepts	8
	B.	Empirical Studies	9
IV.	Measurements of Real Exchange Rate		11
	A.	Which Price Measure Should be Chosen?	12
	B.	Which Weights should be Chosen?	13
	C.	How is the Real Effective Exchange Rate Calculated?	14
V.	Empirical Model and Variable Measurements		15
VI.	Econometric Procedure		16
VII.	Results: Equilibrium Real Exchange Rate and Misalignments		18
VIII.	Real Exchange Rate Misalignment and Export Performance		24
	A.	Model and Econometric Procedure	24
	B.	Results	26
IX.	Conclusions		29
Appendix 1: Cointegration Tests			30
Appendix 2: Regression Results: Export Performance			31
References			33

Abstract

This paper examines the equilibrium real exchange rate and real exchange rate misalignments in developing Asian countries during the period 1995–2008. In addition, the relationship between real exchange rate misalignment and export performance is investigated. In the lead-up to the 1997–1998 financial crisis, real exchange rate exhibited persistent overvaluation in the crisis-affected countries. After the crisis, real exchange rate undervaluation was evident in many Asian countries such as People's Republic of China (PRC), Malaysia, and Thailand. This study also shows that real exchange rate misalignment could have a negative impact on export performance in developing Asia. With its implications on economic activity, monitoring real exchange rate equilibrium and misalignment is a useful tool for governments/central banks to ensure balance in the economy.

I. Introduction

Equilibrium real exchange rate is one of the most important concepts in open macroeconomics. The significant and persistent deviation of real exchange rates (RER) from equilibrium level, i.e., RER misalignment, could have implications on the balance of the economy. There is a vast theoretical and empirical literature that suggests that RER misalignment is one of the key indicators in identifying a country's economic vulnerability. Particularly, persistence of RER overvaluation is regarded as a precursor to the crisis (Edwards 1989 and 2000, Williamson 1983 and 1994, Stein et al. 1995). The sustained real overvaluation reflects unsustainable macroeconomic conditions within the countries, making them vulnerable to speculative attack and currency crisis. By contrast, persistent real undervaluation could lead to economic overheating, which puts pressure on domestic prices and misallocates resources between tradable and nontradable sectors.

Despite the important implication of equilibrium RER and RER misalignment on economic activities, there is limited empirical evidence examining its movements in developing Asia by using the same analytical framework. In addition, assessment of RER misalignment has been limited in developing Asia after the 1997–1998 Asian financial crisis. In fact, this issue has even become more important in recent years since the global financial crisis could have severe repercussions on developing Asian countries when a country faces a high level of economic vulnerability.

Thus, the purpose of this study is to examine the equilibrium RER and RER misalignment in developing Asian countries during the period 1995–2008. The theoretical model of equilibrium RER is first examined to identify the economic fundamentals that could affect movements of equilibrium RER. The RER misalignments—overvaluation or undervaluation—are further assessed using the deviation of the actual RER from its equilibrium level. In addition, the implication of RER misalignment on export performance in these developing Asian countries is examined. The RER misalignment is included in the export model in addition to traditional factors, namely, RER, world demand (WD), production capacity (PC), and foreign direct investment (FDI). The estimation would provide solid evidence on implications of RER misalignment on economic activities.

The rest of the paper is structured as follows. The following section provides the theoretical model of equilibrium RER. The discussion includes purchasing power parity (PPP) theory, fundamental equilibrium exchange rate (FEER), uncovered interest parity, and internal and external balance approach. Section III discusses concept and empirical studies of RER misalignment. Measurements of RER are discussed in Section IV. Section V presents the empirical model of equilibrium RER and discusses variable measurements. Econometric procedure and estimation results of equilibrium RER and RER misalignments are provided in Sections VI and VII, respectively. In Section VIII, the export model is presented as well as the relationship between RER misalignment and export performance. The final section provides concluding remarks.

II. Theoretical Model: Equilibrium Real Exchange Rate

The determinant of equilibrium RER was first based on PPP theory. The PPP theory postulates that the exchange rate change between two currencies over any period of time is determined by the change in the two countries' relative price levels. When the prices of each good, in a common currency, are equalized across countries and the same goods enter each country's market with the same weights, the equilibrium RER can be determined as follows:

$$RER^{*} = \frac{eP^{*}}{P} = 1 \qquad (1)$$

where RER^* is the equilibrium real exchange rate, e is the nominal exchange rate (in unit of foreign currency), P^* is the foreign price, and P is the domestic price.

Equation (1) is referred to as the *absolute* PPP, which relies on the assumption of the law of one price. The law of one price always implies integrated competition markets. However, the spot price of a given commodity will not necessarily be equal in different locations at a given time because of the inability to shift commodities instantaneously from one location to another. The basket of commodities across countries tends to be different, and the price measures across countries are unlikely to be constructed in terms of absolute prices. The *relative* PPP is introduced to take into account such possibilities. Under the relative PPP, the equilibrium RER is as follows:

$$RER^{*} = \frac{eP^{*}}{P} = \theta \qquad (2)$$

where θ is constant mainly reflecting the obstacles to trade and the difference in (consumption) basket compositions.

Both the *absolute* and *relative* PPP theories postulate that equilibrium RER is constant over time. However, many empirical studies cast doubt on the validity of this theory.[1] There is the slow (or no) mean reversion to PPP observed in the data. Invalidation of the PPP theory can arise from two main causes. Firstly, a given tradable good does not obey the law of one price. There are several factors that can explain the violation of the law of one price. For example, the increasing importance of differentiated characteristics, especially in manufactured goods, causes finite elasticities of demand under an environment of imperfect competition. Transportation costs, trade restrictions, and taxes may vary the prices of tradable goods across countries. The presence of medium-term labor contracts could be another source, because such contracts keep wages and unit production costs sticky so that producers are often inclined not to adjust prices in response to exchange rate changes. The role of market segmentation and market-specific costs (i.e., costs specific to a particular destination) could also be another reason. These include (nonexhaustively) distribution, networking and service costs, legal costs, advertising and market strategy, inventory and holding costs, and other government regulations (beyond trade restrictions) (Kasa 1992, Faruqee 1995, and Corsetti and Dedola 2002).

Secondly, there are major differences in the production function, consumer preferences, and factor endowments across countries, so that the relative prices of nontradables across countries can be different. Inadequacy of the PPP theory has motivated a number of studies[2] to sort out alternatives to understanding factors influencing movements of equilibrium RER.

A. Fundamental Equilibrium Exchange Rate

One of the most widely used concepts in determining equilibrium RER is FEER (Williamson 1994). The FEER is defined as the RER that simultaneously attains internal and external balances. Internal balance is reached when the economy is at full employment output and operating in a low inflation environment. External balance is characterized as a sustainable balance of payments position over the medium term, ensuring desired net flows of resources and external debt sustainability. The FEER tends to abstract from the short-run cyclical and speculative forces in the foreign exchange market.

To determine FEER, the current account position (*CA*) is first set as a function of equilibrium real exchange rate (RER*), full employment output of the local (Y^{d*}), and

[1] Even though the possibility of "noise" that can diverge the *RER* from a constant level in the short run is taken into account (i.e., the *RER* that satisfies PPP theory would be stationary), some studies find that the PPP is rejected (Frenkel 1981, Adler and Lehman 1983). See also Froot and Rogoff (1995) for a survey of the empirical evidence on PPP.

[2] See Khan and Montiel (1987), Edwards (1989), Neary (1988), Edwards and Ostry (1990), Khan and Ostry (1992), Stein et al. (1995), and Montiel (1999).

foreign (Y^{f*}) economies. The CA is then equated to the level of equilibrium capital account over the medium term (*CAP**). This equation can be written as in equation (3).

$$CA = f(RER^*, Y^{d*}, Y^{f*}) = CAP^* \tag{3}$$

Given the level of domestic and foreign output at full employment (Y^{d*} and Y^{f*}) and that of equilibrium capital account (CAP*), the fundamental equilibrium RER is derived as follows:

$$RER^* = f(CAP^*, Y^{d*}, Y^{f*}) \tag{4}$$

However, the FEER is a normative measure of equilibrium RER as it involves some notion of "ideal" economic circumstances of internal and external balances. In particular, defining external balances, i.e., sustainable CA balance, tends to be controversial. In addition, to determine FEER, trade elasticity needs to be calculated to determine the response of exports and imports to relative price changes. Different forms of CA equations could lead to different values of the trade elasticity. Relying too much on trade elasticity may generate an inaccurate estimate of the FEER trajectory. Note that empirical studies that apply the FEER approach often rely on a full-blown multicountry macroeconomic model to capture the linkages of key macroeconomic variables. The sustainable value of the CA balance is set exogenously.

To avoid the normative measure that could emerge from applying the full-blown multicountry macroeconomic model, although it can have advantages in terms of ensuring internal consistency of the macroeconomic linkages, the behavior equilibrium exchange rate (BEER) is adopted. In contrast to FEER, the BEER approach is not a normative measure as the BEER would not be subject to the explicit assumption of "sustainable external and internal balance". The equilibrium rate under the BEER approach is consistent with the prevailing level of economic fundamentals. There are two theoretical models adopted in determining economic fundamentals.

B. Uncovered Interest Parity

Clark and MacDonald (1998) underpin the equilibrium RER on the basic concept of uncovered interest parity. That is

$$E_t(e_{t+1}) - e_t = i_t - i_t^* \tag{5}$$

where $E_t(e_{t+1})$ represents the expected value of the nominal exchange rate in period t for t+1 and *i* and *i** denote local and foreign nominal interest rate, respectively. Subtracting the expected inflation differential from both sides of equation (5), we can convert the nominal interest parity to real interest parity.

$$E_t(RER_{t+1}) - RER_t = r_t - r_t^* \tag{6}$$

where r_t and r^*_t are the domestic and foreign real interest rate. By rearranging equation (6), the observed RER can be represented as a function of the expected value of the RER $E_t(RER_{t+1})$ and the current real interest rate differential.

$$RER_t = E_t(RER_{t+1}) - (r_t - r_t^*) \tag{7}$$

Clark and MacDonald (1998) assume that the unobservable expectation of the RER $E_t(RER_{t+1})$ is determined by a vector of long-run economic fundamentals. They include four key fundamentals, which are the terms of trade (*TOT*), productivity differentials (*PROD*), net foreign assets (*NFA*), and government expenditure (or government debt) (*GEXP*). Thus, under Clark and MacDonald, the equilibrium RER is determined as a function of both the (long-run) economic fundamentals and the interest rate differential. The equilibrium RER can be rewritten as follows:

$$RER^* = f\left(PROD, TOT, NFA, GEXP, r - r^*\right) \tag{8}$$

Differences in the rate of productivity growth in tradable-good production of a country compared to that of the main trading partner countries (*PROD*) are potential factors that affect the *RER**. An increase in *PROD* will raise the demand for labor employed in the tradable sector. Under full employment condition, labor must be drawn from the nontradable sector toward the tradable one and this puts pressure on wage rate in the nontradable sector. This causes the *RER** to appreciate to restore both internal and external balance. Thus, the *RER** will have a negative relationship with *PROD.* This effect is known as Harrod-Balassa-Samuelson (Obstfeld and Rogoff 1996).

The *TOT*, defined as the ratio of export to import prices, is included to capture exogenous changes in world prices that will affect the *RER**. An exogenous increase in export prices relative to import prices improves the country's TOT. *TOT* improvement generates an income effect, which increases domestic demand. To restore the internal and external equilibria, nontradable prices have to increase relative to tradable prices (*RER** appreciation) in order to switch the demand from nontradable toward tradable goods. This effect could, however, be counter balanced by a substitution effect where demand for tradable goods increases from relatively lower import prices, and leads to an overall real depreciation. Thus, in theory, the relationship between the *RER** and *TOT* is ambiguous. However a sizable empirical literature has found that in developing countries, an improvement in *TOT* tends to cause appreciation in *RER** because the income effect generally tends to overwhelm the substitution effect (Edwards 1989, Elbadawi 1994, Baffes et al. 1999).

An increase in *NFA* tends to improve a country's wealth. The nontradable prices increase in response to a rise in domestic demand. The equilibrium RER appreciates. As well, the higher real interest rate differentials lead to an increase in capital flows and RER appreciation. While *GEXP* is mostly spent for nontrabable products, nontradable prices increase in response to a rise in domestic demand. Thus, the negative relationship (appreciation) between GEXP and equilibrium RER is expected.

Note that since the equilibrium rate (*RER**) is unobservable, there are two steps in estimating equilibrium RER. The first step involves estimating the relationship between actual *RER* and the prevailing economic fundamentals. The second step is to use the estimated coefficients together with the economic fundamentals in calculating the equilibrium RER. While economic fundamentals tend to involve both transitory and permanent components, to derive the (long-run) equilibrium RER, a number of empirical studies use only the permanent component of economic fundamentals.

C. Internal and External Balances

Another theoretical model defines the equilibrium RER as the relative prices of tradables to nontradable goods that, for given sustainable (equilibrium) values of other relevant variables, result in the simultaneous attainment of *internal* and *external* equilibria (Edwards 1989, Baffes et al. 1999). The concept of this theoretical model is similar to that of FEER (Williamson 1994). The *internal* balance is defined as a situation in which the demand for and supply of nontradable goods are equal, as shown in the following equation.

$$Y_N(RER) = C_N + G_N = (1-\theta)RER \cdot C + G_N \quad (8)$$

where y_N is the supply of nontradable goods ($\frac{\partial y_N}{\partial RER} < 0$), c_N and g_N are private and government spending on nontradable goods, respectively, θ is the share of total private spending on tradable goods, and *c* is total private spending in terms of tradable goods. Equation 8 depicts the relationship between *RER* and *c* that is consistent with the internal balance. Starting from a position of internal balance, a rise in *c* creates excess demand for nontradable goods so that the real appreciation (decrease in *RER*) is required to restore the balance. Such real appreciation would switch resources toward nontradable goods and create demand for tradable goods. This implies a negative relationship between *c* and *RER*.

The *external balance* implies reaching the steady state of change in total net foreign asset ($\dot{f}$) in the economy (Faruqee 1995, Baffes et al. 1999). The change in NFA is defined as follows:

$$\dot{f} = y_T(RER) - \theta c - g_T + rf \quad (9)$$

where y_T is the supply of tradable goods ($\frac{\partial y_T}{\partial RER} > 0$), *rf* is the real yield on net foreign asset , and g_T is the government spending in tradable goods.[3] When NFA reaches steady state (i.e., $\dot{f}$ = 0), equation (2) can also trace out the relationship of *RER* and *c*. Starting from a position of external balance, a rise in *c* causes a CA deficit. The real depreciation is required to switch resources toward the tradable sector and create demand for nontradable goods to restore external balance. There is, thus, a positive relationship between *RER* and *c*.

RER equilibrium is attained when the country simultaneously reaches internal and external equilibria. This can be determined by solving equations (8) and (9). The equilibrium RER is given by equation (10):

$$RER^* = f(\underset{-}{G_N}, \underset{+}{G_T}, \underset{-}{rf^*}) \qquad (10)$$

where * denotes the steady-state values of endogenous variables with the signs of the corresponding partial derivative with respect to *RER**. Under the assumption of credit constraint (i.e., demand for credit tends to exceed supply of credit), an assumption that is more relevant for developing countries (Baffes et al. 1999), the steady state level of *r f* * can be proxied by an actual level of a country's NFA.

Equation (10) can be extended to capture other variables that shift internal and external balance and affect the *RER**. Three variables are generally included, namely, *PROD*, *TOT*, and trade policy (*OPEN*).[4] This is similar to the model based on uncovered interest parity. Note that trade openness (*OPEN*) is included since a shift in a country's trade policy toward greater liberalization leads to an increase in demand for tradable goods. The *RER** is required to depreciate in order to switch the demand from tradable goods toward nontradable goods and then restore the equilibrium. Thus the *RER** is positively related to the degree of trade liberalization. All in all, equilibrium real exchange rate under this approach can be rewritten as follows:

$$RER^* = f(\underset{-}{G_N}, \underset{+}{G_T}, \underset{-}{NFA}, \underset{-}{PROD}, \underset{-}{TOT}, \underset{+}{OPEN}) \qquad (11)$$

Note that although the theoretical model that underpins the economic fundamentals is different between equations (8) and (11), the economic fundamentals included in determining the equilibrium RER are similar but the internal and external balances approach tends to include only long-run economic fundamentals, while the uncovered interest parity include real interest rate differential classified as medium-term fundamentals. In some empirical studies (e.g., MacDonald 2004), the fundamentals are extended to include property prices as a proxy for wealth and the negative relationship (appreciation) between equilibrium RER and this variable is expected. Under internal and external balance approach, two-step estimation is also applied as equilibrium real exchange rate (RER^*) is unobservable.

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3 See more details in Hinkle and Montiel (1999).

4 See Edwards (2000) and the works cited therein.

III. Real Exchange Rate Misalignments: Concepts and Empirical Survey

A. Concepts

RER misalignment is defined as the deviation of actual *RER* from its (long-run) equilibrium real exchange rate (*RER**). The actual RER is composed of three key components, which are medium to long-run fundamentals (i.e., real interest rate differentials, NFA, PROD, TOT, etc.) and transitory (short-run) variables. In other words, the actual RER can be determined as:

$$RER_t = \beta_t^{'} Z_{1t} + \beta_2^{'} Z_{2t} + \tau^{'} T_t + \varepsilon_t \qquad (12)$$

where T is a set of transitory, or short-run, variables and ε is a random error, and Z_{1t} and Z_{2t} are medium and long-run economic fundamentals. While the equilibrium RER is determined by medium and long-run economic fundamentals, the (current) misalignment is given by

$$CMS_t = \tau^{'} T_t + \varepsilon_t \qquad (13)$$

Thus, the current misalignment is simply the sum of transitory and random errors. As mentioned above the economic fundamentals are composed of transitory and permanent components, the (long-run) equilibrium RER is redefined as:

$$RER^{*} = \beta_t^{'} \bar{Z}_{1t} + \beta_2^{'} \bar{Z}_{2t} \qquad (14)$$

where $\bar{Z}_{1t}$ and $\bar{Z}_{2t}$ are the permanent components of medium and long-run economic fundamentals. Thus, total misalignment (TMS) would come from subtracting equation (12) by equation (14). The result is as follows:

$$TMS_t = \tau^{'} T_t + \varepsilon_t + \beta_t^{'} (Z_{1t} - \bar{Z}_{1t}) + \beta_2^{'} (Z_{2t} - \bar{Z}_{2t}) \qquad (15)$$

Equation (15) indicates that the TMS at any point in time can be decomposed into the effect of the transitory factors, the random disturbances, and the extent to which the economic fundamentals are diverted from their sustainable values.

B. Empirical Studies

A number of empirical studies estimate the long-run equilibrium RER and exchange rate misalignment in East and Southeast Asian economies, especially the PRC. The behavior equilibrium real exchange rate (BEER) is mostly applied in the empirical studies mainly because of the advantage of avoiding the normative measure in determining the internal and external balances. Five key fundamental variables, namely, NFA, PROD, government spending, trade policy openness, and TOT, are generally included in estimating the long-run equilibrium RER under the BEER approach. Other variables such as property prices and the output gap may be included in some countries where such factors play an important role in determining the RER. Hodrick-Prescott Filter (HP filter) is generally used to decompose transitory and permanent components of fundamental factors. The choice of economic fundamentals, methodology in decomposing transitory and permanent components, and period coverage could lead to a different pattern of equilibrium RER and RER misalignment. Table 1 summarizes selected empirical studies of (long-run) equilibrium RER and *total* exchange rate misalignment (*TMS*) in East and Southeast Asia.

In Hong Kong, China, Zhang (2002) estimates behavior equilibrium RER during 1984–1988 by including four economic fundamentals, namely, TOT, resource gap (export-import/gross domestic product [GDP]), private investment, and trade openness. Overvaluation was found during 1993Q3–1995Q2, and in 1994Q1 overvaluation was the highest at around 20%. After the second half of 1995, the currency tended to adjust back toward equilibrium. Leung and Ng (2007) also estimate the equilibrium RER for Hong Kong, China during 1987–2006 by including three key fundamentals, namely, PROD, TOT, and government consumption over GDP. Slight undervaluation is revealed in the late 1990s but no obvious misalignment of exchange rate is found in the study.

There are a number of studies examining RER misalignment in the PRC. For example, Goldstein (2004) and Frankel (2005) applied fundamental equilibrium RER approach and found that in 2000, the PRC's RER undervalued by 15–25% and 35%, respectively. Wang (2004), by contrast, applies the BEER approach by including PROD, NFA, and trade policy openness during 1980–2003. No obvious misalignment is found after 1995. However, Cheng and Orden (2005) who apply the BEER approach but include fiscal policy, capital flows, and TOT in 1978–2002, found that the PRC's RER undervalued in 2002 by 22.7%.

Recent empirical studies are rather limited in other countries. Cheng and Orden (2005) apply the same framework in estimating RER misalignment in India during 1975–2002. The RER tended to overvalue during 1980–1990 and in 1990 the overvaluation was more than 10%. However, after the 1991 crisis, the RER moved more or less in equilibrium.

Table 1: Empirical Studies of Real Exchange Misalignment in East and Southeast Asia

Author	Method	Variables	Misalignments
PRC			
Cheng and Orden (2005)	BEER (1975–2002)	PROD, fiscal policy, capital flows, TOT	22.7% undervaluation in 2002
Frankel (2005)	FEER	Balance of payment is target at 0%	35% undervaluation in 2000
Goldstein (2004)	FEER	2.5% of GDP	15–30% undervaluation
Wang (2004)	BEER (1980–2003)	PROD, NFA, trade policy openness	Small undervaluation (near 0%)
Hong Kong, China			
Zhang (2002)	BEER (1984–1988)	TOT, resource gap, private investment and trade policy openness	Overvaluation in 1993Q1–1995Q2 20% overvaluation in 1994Q1
Leung and Ng (2007)	BEER (1987–2006)	Productivity, TOT, government consumption	Undervaluation in late 1990s
India			
Cheng and Orden (2005)	BEER (1975–2002)	PROD, fiscal policy, capital flows, TOT	Overvaluation in 1980–1990; in 1990, overvaluation by more than 10%.
Indonesia			
Sahminan (2005)	BEER (1993Q1–2005Q2)	TOT, productivity, real interest rate differentials, NFA	40% overvaluation in 1996–1997
Korea			
Kinkyo (2008)	BEER (1981Q1–2000Q3)	Net foreign asset, TOT, real interest rate differential, productivity differential, fiscal balance	10% overvaluation in 1996Q1–1997Q3; 30% undervaluation in 1998Q1
Singapore			
MacDonald (2004)	BEER (1983Q1–2003Q2)	NFA, PROD, output gap, TOT, openness, private and government consumption, property prices	Small undervaluation
Thailand			
Lim (2000)	BEER (1988–1997)	Nominal interest rate differentials, inflation differentials, foreign debt over GDP. Note that to calculate misalignment, actual interest rate differentials were replaced by "sustainable" interest rate differentials, which described the scenario that the market supports the policy determined spot rate at the given inflation rates.	16% overvaluation in 1996
Jongwanich (2008)	BEER (1970–2000)	GEXP, TOT, CA net of reserve changes, FDI, portfolio, productivity, trade policy openness	12% overvaluation in 1996

BEER = behavior equilibrium exchange rate, PROD = productivity differential, TOT = terms of trade, GDP = gross domestic product, NFA = net foreign assets, GEXP = government expenditure , FDI = foreign direct investment.

In Indonesia, Sahminan (2005) estimates the equilibrium RER during 1993Q1–2005Q2, including four fundamentals—TOT, PROD, real interest rate differential, and NFA. Overvaluation of 40% was found in 1996–1997 while undervaluation was found in 1998–2003. In 2004, the RER began to exhibit overvaluation. Kinkyo (2008) applies the

BEER approach in determining the equilibrium RER in 1981Q1–2000Q3. Fiscal balance is included in addition to the above four fundamental variables. In the period preceding the currency crisis of 1997–1998, the RER overvalued by more than 10%. However, the significant nominal depreciation in 1998 resulted in the undervaluation of RER by 30% in 1998Q1.

Macdonald (2004) applies the BEER approach for Singapore during 1983Q1–2003Q2. Over and above the five key economic fundamentals, the output gap and property prices are included in the model. The output gap (i.e., output gap in Singapore relative to the output gap in the trading partner countries) is included since it may be viewed as an alternative measure of growth, or growth potential, in an economy. Hypothecation over the relative strength of the United States (US) dollar against the euro during the estimation period emphasized this variable. The property price is included to reflect households' wealth in Singapore. On average, the RER in Singapore tends to exhibit undervaluation in the post-1998 period but no obvious misalignment is found. In Thailand, Jongwanich (2008) applies the BEER approach in determining the equilibrium RER during 1970–2000. Capital inflows, disaggregated into portfolio and FDI, are included in the model, in addition to the basic fundamentals. There are two periods of RER overvaluation, i.e., during 1984–1985 and 1990–1996. In 1996 (before the crisis period), the RER exhibited overvaluation by 12%.

IV. Measurements of Real Exchange Rate

The RER is a broad summary measure of the prices of one country relative to the prices of another country or group of countries, both expressed in a common currency. It can generally be expressed as:

$$RER = \frac{eP^*}{P} \tag{16}$$

where e is the nominal exchange rate defined as units of home currency to a unit of the foreign currency, P^* denotes the foreign (world market) price level, and P is the domestic price level. Since the RER in equation (16) measures relative prices between countries, it is referred to as *external* RER. An increase in the value of RER indicates that foreign goods become more expensive relative to domestic goods so that international competitiveness improves. An increase (decrease) in RER is referred to as depreciation (appreciation).

RER is used to measure the internal relative price incentive in a particular economy for producing or consuming tradable as opposed to nontradable goods. In this case, the RER is defined as the relative prices of tradable and nontradable goods and is referred to as the *internal* RER. A rise in the *internal* RER (a real depreciation) means that the tradable sector has become more competitive in relation to the nontradable sector. Therefore, the incentive structure favors switching of resources from nontradable to tradable production, and demand moves from tradable to nontradable goods.

In fact, a movement of the *internal* RER can be used to reflect the country's international competitiveness when the law of one price holds for tradable goods. When it holds, the domestic tradable price is set by international markets adjusted by a nominal exchange rate so that firms are price takers. Thus, the ability to improve the country's international competitiveness position depends on incentives and profitability in domestic production of the tradable goods sector. However, when the law of one price does not hold, internal RER could not reflect well the country's international competitiveness aspects (Little et al. 1993, Hinkle and Nsengiyumva 1999).

Even though concepts of the RER are relatively straightforward, a number of choices have to be made when measuring it. These include three key elements: (i) choice of prices, (ii) country weights, and (iii) operational formula to be used.

A. Which Price Measure Should be Chosen?

The most commonly used price series in constructing RER for measuring international competitiveness are consumer price indices (CPIs). These have the advantage of being timely, similarly constructed across countries, and available for a wide range of countries over a long time span. Because they capture the relative costs of a broad basket of goods and services across countries, CPI-based RER measures provide a good reflection of the purchasing power of the domestic currency. However, the fact that CPI baskets contain a significant nontraded component makes CPI-based RER less than ideal for assessing competitiveness.

A measure based on the price of traded goods or a measure of business costs would be more appropriate in assessing competitiveness. Producer price index, which relatively contains a high proportion of traded goods, and unit labor cost are used to reflect this matter. Nevertheless, it is often difficult to obtain data on these alternative price indices on a comparable basis across countries over a reasonable length of time. The empirical work is, therefore, heavily reliant on CPI-based measures.

Note that even though conceptually, measuring *internal* competitiveness (i.e., the relative price of tradable to nontradable goods) could be different from measuring *external* competitiveness, because of unavailable data, the former has to be proxied by available domestic and world price indices and nominal exchange rate as in equation (16), i.e., international measure. According to composition baskets, producer price or wholesale price indices adjusted by nominal exchange rate are usually used to represent prices of tradable goods while CPI is employed in reflecting nontradable prices.

B. Which Weights should be Chosen?

The choice of weighting scheme depends crucially on the purpose for which the RER is being constructed. For countries without substantial unrecorded or misrecorded trade, actual trade weights can be used for assessing changes in competitiveness. However, when the intercountry pattern of trade is significantly different for imports and exports, it may be preferable for some analytical purposes to use either export or import weights rather than averaging these together. In addition, the weights should reflect reasonably well the structure of trade in the period being analyzed. Using current weight schemes could mitigate the problem of changing trade structure and should be used for current policy analysis (Hinkle and Nsengiyumva 1999).

While the key trading partners in each country are comparable, total trade weight and export weight provide a similar pattern of RER. Total trade weight is chosen to capture the effect of both export and import in determining RER. Table 2 provides the trade weight used in calculating RER in 10 developing Asian economies. The weight in each country covers 70–75% of total exports during the period 2000–2005. Note that export data used here excluded re-exports. It is clear that PRC, Japan, and United Sates are important trading partners in these economies. The PRC is the key trading partner of Hong Kong, China; and Malaysia of Singapore.

Table 2: Key Trading Partners of Ten Developing Asian Economies, 2004–2007

PRC	US (0.20) Japan (0.17) Hong Kong, China (0.13) Korea (0.11) Germany (0.06) Singapore (0.03) Malaysia (0.03) Canada (0.02)	Netherlands (0.03) Russia (0.03) United Kingdom (0.02) Thailand (0.02) France (0.02) India (0.02) Italy (0.02)	Philippines (0.02) Brazil (0.02) Indonesia (0.02) Saudi Arabia (0.02) Spain (0.01) Belgium (0.01)
Hong Kong, China	PRC (0.6) US (0.13) Japan (0.10)	Singapore (0.06) Korea (0.05)	Germany (0.03) United Kingdom (0.02)
India	US (0.18) PRC (0.14) Germany (0.07) Singapore (0.07) United Kingdom (0.06) Belgium (0.06) Japan (0.05) Hong Kong, China (0.05)	Korea (0.05) Italy (0.04) Malaysia (0.03) France (0.03) Indonesia (0.03) Saudi Arabia (0.02) Netherlands (0.02)	Russia (0.02) Thailand (0.02) Sri Lanka (0.02) Canada (0.02) Spain (0.02) Brazil (0.01)

continued.

Table 2: *continued.*

Indonesia	Singapore (0.21) Japan (0.20) PRC (0.12) US (0.11) Korea (0.08)	Malaysia (0.06) Thailand (0.05) India (0.03) Germany (0.03) Saudi Arabia (0.03)	Netherlands (0.02) Hong Kong, China (0.02) United Kingdom (0.02) Italy (0.01)
Korea	PRC (0.27) US (0.18) Japan (0.18) Hong Kong, China (0.05) Saudi Arabia (0.05) Germany (0.05)	Singapore (0.04) Indonesia (0.03) Malaysia (0.03) United Kingdom (0.02) Russia (0.02)	India (0.02) Italy (0.02) Thailand (0.02) Canada (0.02) France (0.02)
Malaysia	US (0.20) Singapore (0.18) Japan (0.15) PRC (0.12)	Thailand (0.07) Korea (0.06) Hong Kong, China (0.05) Germany (0.04)	Indonesia (0.04) Netherlands (0.03) India (0.03) Philippines (0.02)
Singapore	Malaysia (0.17) US (0.15) PRC (0.13) Indonesia (0.10) Japan (0.09)	Hong Kong, China (0.08) Korea (0.05) Thailand (0.05) Germany (0.04) India (0.03)	United Kingdom (0.03) Philippines (0.03) Saudi Arabia (0.02) France (0.02)
Thailand	Japan (0.24) US (0.16) PRC (0.12) Malaysia (0.08) Singapore (0.08) Hong Kong, China (0.05)	Indonesia (0.04) Korea (0.04) Germany (0.03) Saudi Arabia (0.03) United Kingdom (0.03) Philippines (0.02)	Netherlands (0.02) Viet Nam (0.02) France (0.02) India (0.02) Italy (0.02) Belgium (0.02)

C. How is the Real Effective Exchange Rate Calculated?

To convert a set of bilateral indices into a multilateral RER, a weighted average of the bilateral indices needs to be taken. The geometric average of the indices is the preferable choice. Percentage movements in an arithmetic index will differ in magnitude depending on whether the bilateral rates are expressed as unit of home currency per foreign currency unit, or the other way around. Exchange rate indices based on arithmetic averages can also be distorted when the base period is changed. By contrast, a geometric average treats increases and decreases in exchange rate symmetrically and is not affected by the choice of base year. The weighted average of the real bilateral exchange rate is thus generally calculated as:

$$RER = \prod_{i=1}^{I} \frac{\left(e_i P_{i,f}^{*}\right)^{W_i}}{P_D} \qquad (17)$$

The weight, w_i, which is applied to each bilateral RER, sums to one.

V. Empirical Model and Variable Measurements

To estimate the (long-run) equilibrium RER, the empirical model in this study is based on equation (11).[5] That is

$$RER^{*} = f(G_N, G_T, NFA, PROD, TOT, OPEN) \qquad (18)$$
$$\quad - \quad + \quad - \quad - \quad - \quad + \text{`}$$

where G_N is government spending toward the nontradable sector, G_T is government spending toward the tradable sector, *NFA* is net foreign assets, *PROD* is productivity differentials, *TOT* is terms of trade, and *OPEN* is trade policy openness.

The empirical model is estimated based on eight East and Southeast Asian countries, namely PRC; Hong Kong, China; Indonesia; Republic of Korea (henceforth Korea); Malaysia; Philippines; Singapore; and Thailand, during the period 1995Q1–2008Q2. For G_N and G_T , there is no data available for these countries to separate government spending into tradable and nontradable goods. The ratio of total government spending to GDP (*GEXP*) is, therefore, used as an explanatory variable. Since government spending tends to be relatively more intensive in nontradable goods, the negative relationship between *GEXP* and RER is expected.

NFA is measured as the ratio of NFA of financial institution to (nominal) GDP while the ratio of a country's real GDP per capita (US$ prices) to its key trading partners is used to measure the *PROD* or Harrod-Balassa-Samuelson effect. An increase in this variable implies productivity improvement in the host country, compared to the key trading partners. The price of the export relative to the price of the import is the terms of trade variable (*TOT*). The sum total value of exports and imports divided by (nominal) GDP is used as a proxy for trade policy openness (*OPEN*). Trade liberalization is associated with an increase in OPEN variable.

Government spending, NFA of financial institution, and nominal GDP are compiled from the International Financial Statistics online database of the International Monetary Fund (IMF). Real GDP in terms of US$ and population is compiled from World Development Indicators of the World Bank. Prices of exports and imports, and exports and imports value are from CEIC Data Company, Ltd. For RER, the trade weight of key trading partners is compiled from the IMF's Direction of Trade Statistics, while nominal exchange rate and consumer prices are from the IMF's International Financial Statistics online database.

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[5] Note that real interest rate differentials are included in the estimations but they turned out to be insignificant in almost all countries.

VI. Econometric Procedure

While the variables contain unit roots and are nonstationary, cointegration analysis is applied to determine (long-run) equilibrium RER. Cointegration analysis provides a natural conceptual framework for examining long-term comovements between a set of time-series variables. Cointegrated variables may drift apart temporarily, but must converge systematically over time. Hence, any model that imposes a deterministic long-run relationship between a set of integrated economic variables, which allow those variables to deviate over the short term, will exhibit cointegration.

As a matter of definition, a set of N differences stationary variables are said to be cointegrated if there exists at least one linear combination (cointegration vector) of these variables that is stationary, defining their long-run relationship. In addition, the number of independent cointegrating vector r must be such that 0<r<N. If there were exactly N such linearly independent combinations, then the set of variables must all be stationary, i.e., integrated of order zero or I(0). If no combinations exist (r=0), the series are independent difference stationary, i.e., integrated of order one or I(1) variables.

The econometric method used to estimate the model is that of Johansen (1988). This method is based on a Full Information Maximum Likelihood algorithm and therefore has the potential to address problems of simultaneity. This approach defines a $(n\times 1)$ vector of variable, x_t consisting of the vector of dependent and independent variables, which may be I(1) or I(0), and assumes that it has a vector autoregressive representation of the form:

$$x_t = \eta + \sum_{i=1}^{p} \prod x_t + \varepsilon_t \tag{19}$$

where η is a $(n\times 1)$ vector of deterministic variables, and ε is a $(n\times 1)$ vector of white noise disturbances, with mean zero. Equation (18) can be rewritten in terms of the vector error correction mechanism as follows:

$$\Delta x_t = \eta + \sum_{i=1}^{p-1} \Phi \Delta x_{t-i} - \prod x_{t-1} + \varepsilon_t \tag{20}$$

where Δ denotes the first difference operator, Φ is a $(n\times n)$ coefficient matrix, Π is a $(n\times n)$ whose rank determines the number of cointegration vectors. If Π is of either full rank, n, or zero rank, $\Pi=0$, there will be no cointegration amongs the elements in the long-run relationship. If, however, Π is of reduced rank, r, where r<n, there will exist $(n\times r)$ matrices α and β such that $\Pi=\alpha\beta'$, where β is the matrix whose columns are the linearly independent cointegrating vectors and the α matrix is interpreted as the adjustment matrix, indicating the speed with which the system responds to last period's deviation from the equilibrium level of exchange rate. Thus the existence of the vector

error correction mechanism model relative to a VAR in first differences depends upon the existence of cointegration.

The existence of cointegration among the variables contained in x_t is revealed by using the Trace test as proposed by Johansen (1988). For the hypothesis that there are at most r distinct cointegrating vectors, this has the form:

$$TR = T \sum_{i=r+1}^{N} \ln(1 - \hat{\lambda}_i) \tag{21}$$

where $\breve{\lambda}_i$ are the N-r smallest squared canonical correlations between x_{t-k} and Δx_t series where all of the variables entering x_t are assumed I(1), corrected for the effect of the lagged differences of the x_t process. The method for extracting the λ's is described in Johansen and Juselius (1990) and Johansen (1988).

RER misalignment is calculated by comparing the long-run equilibrium real exchange rate (*RER**) to actual *RER*. For the *RER**, the long-run coefficients are based on the results in Table 3. The permanent values of all fundamentals (*GSPEND, TOT, PROD, OPEN,* and *NFA*) are generated by Hodrick-Prescott filter.[6]

[6] Note that other methods, such as exponential smoothing and the Kalman filter, provide virtually identical results.

VII. Results: Equilibrium Real Exchange Rate and Misalignments

The test statistics for cointegration for eight developing Asian economies based on Johansen procedure are reported in Table 3. The p value is set differently in each country depending on Akaike Information Criteria and key diagnostic tests, especially serial correlation test. For the PRC and Korea, the lag interval is set to one while the lag interval for Hong Kong, China; India; Indonesia; Malaysia; and Singapore is set at two. The third lag is set in the case of Thailand. Given the relatively small period (1995Q1–2008Q2), a 99% significant level is used as benchmark in determining a number of cointegration vectors. On the basis of this, there is clear evidence of one significant cointegration vector in these eight economies (Appendix 1).

In the PRC, all long-run coefficients are correctly signed, of plausible magnitude, and statistically significant. *GEXP* and *TOT* tend to explain movements of RER with a larger magnitude than other variables. A 1% increase in government spending would lead to 0.68% appreciation of RER while the RER would appreciate by 0.47% in response to 1% increase in TOT. The negative coefficient on *TOT* supports the hypothesis that the income effect of the TOT improvement overwhelms the substitution effect in the PRC. As expected, an improvement in productivity and NFA would lead to an appreciation of RER by 0.35% and 0.22%, respectively. By contrast, the positive sign of *OPEN* supports the hypothesis that trade-liberalizing reforms tend to depreciate the equilibrium *RER*. A 10% rise in *OPEN* brings about a 0.5% depreciation in the RER.

In Hong Kong, China; Korea; Malaysia; and Singapore, the coefficient corresponding to trade openness is positive but statistically insignificant. It is possible that trade liberalization in these countries, except India, measured by the sum total value of exports and imports divided by (nominal) GDP, has been relatively high and stable during the estimation periods so that its ability to explain the movements of RER in these countries is rather limited. To some extent, the role of TOT tends to dominate trade openness. Particularly in Singapore and Hong Kong, China, a 1% increase in TOT would result in an appreciation of RER by 1.76% and 0.70%, respectively.

Among these four countries, GEXP tends to play an important role in influencing the RER in Korea and Singapore. The RER in these two countries appreciates by 1.04% and 0.91%, respectively, in response to a 1% rise in GEXP. Government spending is also an important variable in Malaysia but the coefficient associated with productivity tends to be larger in magnitude. A 1% increase in productivity would lead to 1.21% appreciation of the RER while real appreciation would be around 0.5% when GEXP increases by 1% in Malaysia.

Table 3: Estimation Results

PRC

$$RER = 6.67 - 0.22NFA - 0.35PROD - 0.68GEXP - 0.47TOT + 0.05OPEN + 0.02Trend$$

(-12.43)* (-8.33)* (-18.20)* (-3.46)* (1.77)* (9.53)

LM(1):p-value = 0.74 LM(2): p-value = 0.61 White heteroskdasticity: p-value = 0.98

Hong Kong, China

$$RER = 5.98 - 0.01NFA - 0.86PROD - 0.05GEXP - 0.70TOT$$

(-1.36)*** (-21.88)* (-1.90)** (3.35)*

LM(1):p-value = 0.07 LM(2): p-value = 0.06 White heteroskdasticity: p-value = 0.77

India

$$RER = -1.18 - 0.11NFA - 1.23PROD - 0.64GEXP - 0.06TOT$$

(-12.78)* (-9.76)* (-7.70)* (-1.87)**

LM(1):p-value = 0.64 LM(2): p-value = 0.48 White heteroskdasticity: p-value = 0.31

Indonesia

$$RER = 1.05 - 0.17PROD - 1.29GEXP - 4.15TOT + 0.54OPEN - 0.11Oilprice$$

(-2.85)* (-3.79)* (-6.09)* (1.71)** (-1.75)**

LM(1):p-value = 0.06 LM(2): p-value = 0.07 White heteroskdasticity: p-value = 0.30

Korea

$$RER = 2.54 - 0.03NFA - 1.04PROD - 1.04GEXP - 0.25TOT$$

(-2.85)* (-14.27)* (-37.35)* (-4.97)*

LM(1):p-value = 0.14 LM(2): p-value = 0.65 White heteroskdasticity: p-value = 0.94

Malaysia

$$RER = 2.43 - 0.11NFA - 1.21PROD - 0.54GEXP$$

(-2.003)* (-8.21)* (-7.54)*

LM(1):p-value = 0.55 LM(2): p-value = 0.66 White heteroskdasticity: p-value = 0.57

Singapore

$$RER = 4.87 - 0.23NFA - 0.91GEXP - 1.76TOT + 0.01Trend$$

(-3.44)* (-8.01)* (-2.57)* (7.31)*

LM(1):p-value = 0.05 LM(2): p-value = 0.10 White heteroskdasticity: p-value = 0.05

Thailand

$$RER = 2.41 - 0.07NFA - 0.82PROD - 0.22GEXP - 0.58TOT + 0.20OPEN$$

(-4.84)* (-22.87)* (-3.20)* (-6.72)* (4.61)*

LM(1):p-value = 0.16 LM(2): p-value = 0.72 White heteroskdasticity: p-value = 0.36

Note: All variables are in logarithm formula.
Source: Author's estimates.

In India, trade openness becomes statistically insignificant in explaining long-term movements of RER. The dominant role of domestic demand in the country and the relatively stable share of exports and imports in (nominal) GDP, compared with other variables, could explain the insignificance of trade openness variable. This could also result in the relatively small magnitude of the TOT coefficient. A 1% rise in TOT leads to only 0.06% appreciation of RER while the same amount of productivity improvement and government spending results in 1.23% and 0.64% appreciation of RER, respectively.

In Thailand, movements of the long-run RER are mainly determined by productivity improvement and the TOT. The RER would appreciate by 0.82% and 0.58%, respectively, in response to a 1% rise in these two variables, compared to 0.2% appreciation in response to a 1% increase in government spending. As in the PRC, trade openness is positive and statistically significant, implying that trade liberalization would result in depreciation of long-run RER. A 1% rise in *OPEN* seems to bring about a 0.2% depreciation in the RER.

TOT and GEXPs play a crucial role in determining long-run RER in Indonesia. The RER would appreciate by 4.15% and 1.29%, respectively, when TOT and GEXP increase by 1%, compared to 0.17% appreciation in response to productivity improvement by 1%. In addition to TOT, oil prices could separately influence the movements of long-run RER in Indonesia. The RER appreciates by another 0.11% in response to oil price rise. Trade policy openness is statistically significant in explaining the depreciation of RER, with 0.54% depreciation in response to a 1% rise in trade openness. This confirms the role of trade liberalization in depreciating the long-run RER in Indonesia.

Figure 1 shows the actual and (long-run) equilibrium RER of eight developing Asian economies. In the lead-up to the 1997–1998 financial crisis, the real exchange rate exhibited persistent overvaluation in crisis-affected countries. Real overvaluation increased to around 10–15% in 1997 in Korea, Malaysia, and Thailand while it exceeded 20% in Indonesia. As pointed out in Jongwanich (2008) such overvaluation resulted mainly from the huge movement of short-term capital inflows since the authorities opened the door wide for these investment inflows. However, the crisis-driven depreciation of the nominal exchange rate resulted in significant RER undervaluation in these countries. Particularly in Indonesia, the real exchange rate undervaluation reached almost 100%.

For other economies, i.e., PRC; Hong Kong, China; and India, the real exchange rate tended to exhibit undervaluation in the lead-up to the crisis period. This tends to reflect the lower degree of the countries' vulnerability in facing currency speculation and currency crises. In Singapore, the real exchange rate exhibited a slight overvaluation in 1995 but in 1996–1997, the exchange rate was maintained well within its equilibrium level. This evidence tends to provide some support that real exchange rate misalignment is one of the important indicators in measuring the level of a country's vulnerability to currency speculation and crises.

After the 1997–1998 crisis, real exchange rate depreciation in many Asian countries was associated with real undervaluation. In the PRC where foreign currency reserves had surpassed that of Japan to make the PRC the largest holder of reserves, the real exchange rate tended to show a depreciation trend during 1998–2006. In particular, when the real exchange rate is compared to its equilibrium level, undervaluation was revealed during 1995–2007, with the noticeable undervaluation in 2003–2006 of around 10%. The undervaluation revealed in this study is lower than in some empirical studies. For example, Goldstein (2004) and Frankel (2005) found that in 2000, the PRC's real exchange rate undervalued by 15–25% and 35%, respectively. Cheng and Orden (2005) who estimate equilibrium real exchange rate in 1978–2002, found that the PRC's real exchange rate undervalued in 2002 by 22.7%. There are only few studies such as Wang (2004) who found no misalignment of the PRC's real exchange rate after 1995. However, after the PRC began a gradual revaluation of its currency, the *yuan*, against the US dollar in July 2005 in response mainly to pressure from the US, the real exchange rate showed an appreciation trend, mainly because of appreciation of nominal (effective) exchange rates. In 2008, the overvaluation of the real exchange rate was revealed in this study.

Real exchange rate depreciation is also found in other Asian countries. In Hong Kong, China, the real exchange rate continued to depreciate during 1998–2008. However, the real depreciation tended to be consistent with economic fundamentals. There was no significance of real exchange rate misalignment during this period, even in 2008 where the real exchange rate began to show the depreciation trend. In contrast, the real exchange rate depreciation shown in Singapore during 1999–2004 was associated with real undervaluation. The undervaluation was around 9% in 1999–2003 before gradually declining to less than 1% in 2007. The real exchange rate has showed an appreciation trend in Singapore since the third quarter of 2007, and in 2008, the overvaluation of the real exchange rate was revealed.

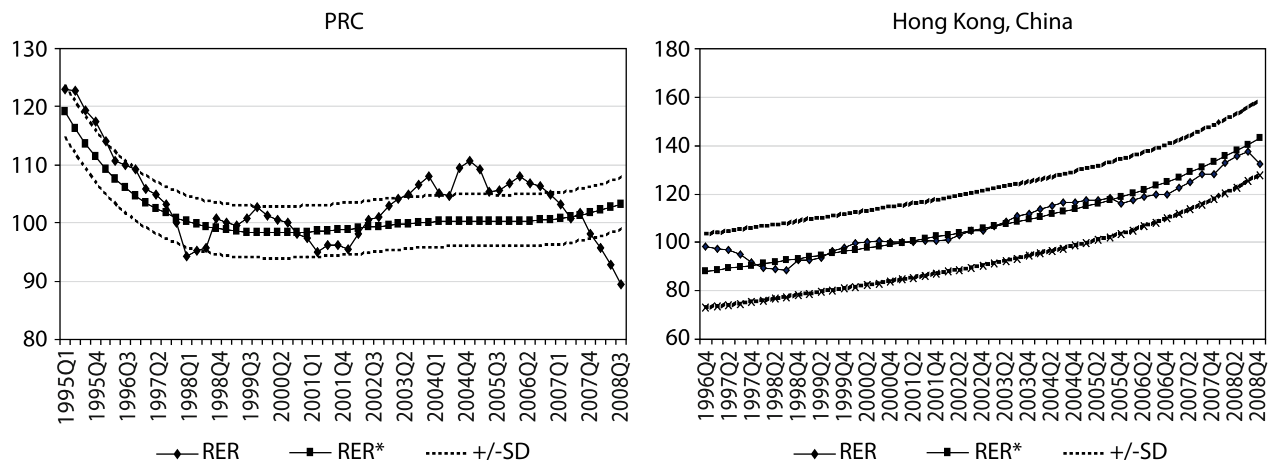
In Malaysia and Thailand, real exchange rate undervaluation was found after the crisis in 1997–1998. In Thailand, on average during 2001–2008, the real exchange rate undervalued by almost 15% while it was around less than 10% in Malaysia. It is possible that there is still significant intervention in the foreign exchange markets in these two countries in order to maintain nominal and real exchange rate undervaluation to boost exports and trade balance.

However, in some Asian countries, such as Indonesia and Korea, the real exchange rate exhibited appreciation trend after the 1997–1998 crisis. In Korea, the real exchange rate appreciated by 18% during the period 2001–2007. However, the appreciation during this period tended to be consistent with the economic fundamentals, i.e., no significant misalignment of real exchange rate. Thus, although movements of real exchange rate did not support export growth and trade surplus, the consistency of real appreciation with economic fundamentals resulted in lesser concern on currency overvaluation and speculation. However, because of a noticeable depreciation of the nominal exchange rate, in 2008, the real exchange rate showed a significant depreciation and for the whole year, the real exchange rate was undervalued by 13%. In Indonesia, the real exchange rate appreciation during 2001–2006 tended to be consistent with its equilibrium level. In 2007–2008, the real exchange rate tended to exhibit overvaluation, but it tended to move back to the equilibrium level in late 2008.

In India, the real exchange rate has appreciated since 1996, and in 2008, the appreciation was almost 20% compared to the 1996 level. Such appreciation could contribute to persistent trade and current account deficits in the country. However, there is no sign of significant and persistent misalignment during this period, except in 2007 where the overvaluation was around 6%.

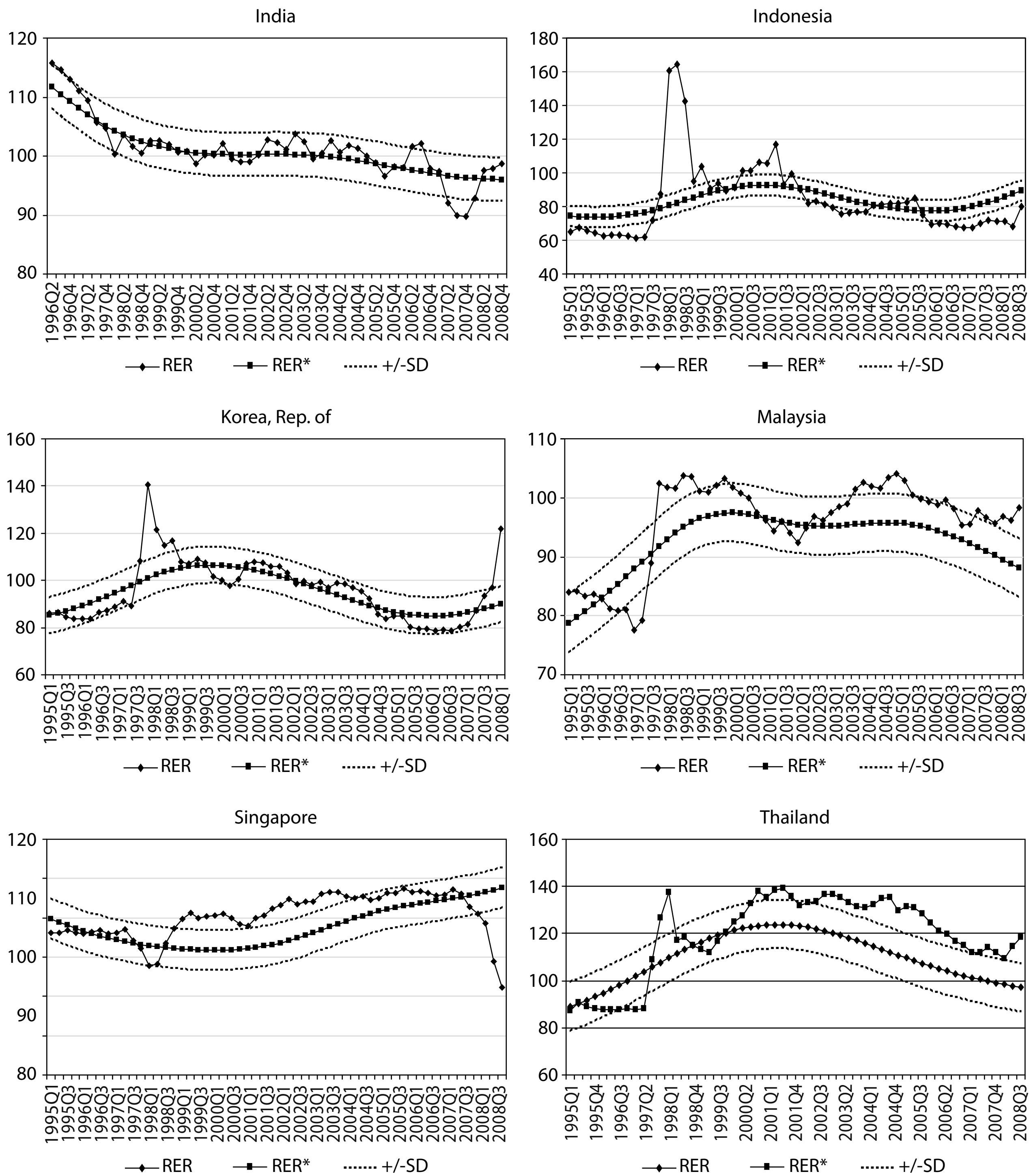
All in all, after 1997–1998, there has been no sign of persistent real exchange rate overvaluation in almost all East and Southeast Asian economies. Although real appreciation was found in some Asian countries, the movements had so far been consistent with economic fundamentals. However, the overvaluation in the PRC and Singapore in 2008 and the undervaluation found in Korea, Malaysia, and Thailand may need to be closely monitored.

Figure 1: Real Exchange Rate Misalignment in Selected Developing Asia



continued.

Figure 1: *continued.*



Note: 1. RER is the actual real exchange rate while RER* is the equilibrium real exchange rate.
2. An increase in RER refers to real exchange rate depreciation.
3. When the actual RER exceeds the equilibrium level, this refers to undervaluation.
4. SD represents standard deviation.

Source: Author's estimates.

VIII. Real Exchange Rate Misalignment and Export Performance

In addition to being one of the leading indicators in determining a country's vulnerability, RER misalignment could have implications for other key variables, especially export performance. This section examines relationship between export performance and RER misalignment.

A. Model and Econometric Procedure

The reduced-form model of export performance applied in a number of empirical studies (e.g., Goldstein and Khan 1985, Bushe et al. 1986, Arndt and Huemer 2004, Athukorala 2004, Chinn 2003 and 2005, and Jongwanich 2009), is extended by including the magnitude of RER misalignment. That is

$$X_i = f(RER, WD, PC, FDI, Absmis) \quad (22)$$

where X_i is the total export volume, *RER* is the real effective exchange rate, *WD* is the real income in importing countries, *PC* is the domestic production capacity, *FDI* is the inflows of FDI, and *Absmis* is absolute value of RER misalignment reflecting magnitude of RER misalignment.

Ideally, we should have worked with a fully specified export model, which captures demand and supply side influences separately, while appropriately allowing the possibility of simultaneous integration involved in the determination of quantity and prices. Unfortunately, high-frequency data are not available for this purpose. However, the simultaneity issue is not a binding constraint because the econometric procedure that is applied in this study, i.e., general-to-specific modeling (GSM) procedure, would permit us to test for the cointegration (long-term relationship).[7] If the particular vector of related variables is put together on the basis of sound econometric reasoning, the cointegration relationship among them can be interpreted as the equilibrium (long-run) relationship.

The above model was estimated using quarterly data for eight countries during 1995–2008. Export volume is derived from adjusting export values by appropriate export price indices. The export value here refers only to domestic exports, i.e., excluding re-exports. *WD* is measured as the weighted average of the real incomes of key export partners, which together account for 75% of shipments of East and Southeast Asia to all trade partners. The PC is proxied by the trend of their real output using the Hodrick-Prescott filter method. Other methods, such as exponential smoothing and the Kalman filter, provide virtually identical results but the Hodrick-Prescott filter is selected as it has the best performance in terms of diagnostic test in determining export equations.

[7] Bound test could be applied to test for their equilibrium (long-run) relationship (i.e., cointegration); see Pesaran et al. 2001.

Data series of export value (total and subcategories), export prices, CPI, producer price index, real GDP and net FDI inflows were compiled from CEIC Data Company Ltd. Nominal exchange rates were compiled from the International Financial Statistics (CD-ROM), IMF, and CEIC Data Company Ltd. All data series are used in natural logarithms in regression estimation.

In line with standard practice in time-series econometrics, the time series property of data was tested at the outset using the Augmented Dickey-Fuller test. According to the test results, the variables under consideration do not have the same order of integration in each country. In all these eight countries, RER misalignment (*Absmis*) is stationary (I(0)) variables while others are nonstationary I(1).

Under the different order of integration, the fashionable cointegration econometric procedures, such as the two-step residual-based procedure adopted by Engle-Granger (1987), and the system-based reduced rank regression approach due to Johansen (1988) for modeling nonstationary data are inappropriate. The econometric analysis in this study is based on the GSM procedure (Hendry et. al. 1984, Wickens and Breusch 1988, Hendry 1995, Pesaran et al. 2001). The GSM procedure is applicable when a set of variables includes series that are nonstationary or a mixture of nonstationary and stationary.
In the case of a finite sample and nonstationary data series, this procedure tends to provide more precise estimates than the Johansen procedure. In particular, the Johansen procedure tends to deteriorate significantly in small samples, generating estimates with “fat tails” (frequent outliers) and sometimes substantial mean bias (Hargreaves 1994).

The GSM can be written in terms of short-run and long-run (cointegration) relationship as in equation (2).

$$\Delta Y_t = \alpha + \sum_{i-1}^{m-1} A_i^* \Delta Y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{m-1} B_{ij}^* \Delta X_{j,t-i} + C_0 Y_{t-m} + \sum_{j=1}^{k} C_1 X_{j,t-m} + \mu_t \quad (23)$$

where α is a constant, Y_t is the endogenous variable, $X_{j,t}$ is the j^{th} explanatory variable and A_i and B_{ij} are the parameters.
$A_i^* = -\left[I - \sum_{i=1}^{m-1} A_i\right], B_{ij}^* = \left[\sum_{i=0}^{m-1} B_{ij}\right], C_0 = -\left[I - \sum_{i=1}^{m} A_i\right], C_1 = \left[\sum_{i=0}^{m} B_{ij}\right]$, and the long-run multiplier of the system is given by $C_0^{-1} C_1$.

Equation (2) is the particular formulation generally used as the “maintained hypothesis” of the specification search. The estimation procedure involves first estimating the unrestricted equation (2), and then progressively simplifying it by restricting statistically insignificant coefficients to zero and reformulating the lag patterns where appropriate in terms of levels and differences to achieve orthogonality. As part of the specification search, it is necessary to check rigorously at every stage even the more general of models for possible misspecification. Such checks will involve both a visual examination of the residual from the fitted version of the model; the use of tests for serial correlation, heteroskedasticity, and normality in the residual; and an examination of the appropriateness of the particular functional form used. In particular, any suggestion of autocorrelation in the residual should lead to a rethink about the form of the general model. Above all, theoretical consistency must be borne in mind throughout the testing procedure.

B. Results

The final parsimonious estimates of the export model, together with a set of commonly used diagnostic statistics and long-run elasticities computed from the steady-state solutions to the estimated equation are reported in Appendix 2. The estimated export equations are statistically significant at the 1% level in terms of the standard *F*-test and perform well in terms of standard diagnostic tests for serial correlation (LM), normality (JBN), heteroskedasticity (ARCH), and whiteness of the regression residuals. The Wu-Hausman test suggests no evidence of simultaneity for any of these variables. While all variables, except for FDI, are measured in natural logarithms, the regression coefficients can be interpreted as elasticities. Table 4 provides the summary results of RER coefficients in the eight East and Southeast Asian countries.

As expected, the positive relationship between the RER and export performance is revealed in all countries. This implies that other things being equal, a RER depreciation would bring about a higher level of export volume. However, RER coefficients vary across the eight economies. RER has the least impact on Singapore's exports while the impact is greatest in Indonesia. In Singapore, the long-run coefficient of RER is statistically insignificant while it would be around 4.3 for Indonesia. This is consistent with the fact that exports and imports in Singapore have been dominated by manufacturing parts and components over the past decade. In contrast, Indonesia has much greater product diversification in its export basket. In addition, Indonesia to date has been slow in joining international production networks of mobile network entities in the Standard International Trade Classification 7 category. The reliance on primary and traditional manufactured exports possibly makes Indonesian exports more sensitive to RER.

This result is also revealed by Jones and Kierzkowski (2001), Arndt and Huemer (2004), Athukorala (2004), and Jongwanich (2009), who find that importance of RER seems to be diluted for a country that has a high proportion of parts and components trade, especially in machinery and transport equipment (Standard International Trade Classification 7). Since parts and component exports involve a high proportion of imported parts and components, depreciation of a currency lowers the foreign currency price of exports and also increases the home-currency prices of component imports. To the extent that import content costs rise, this will offset any expansion in demand induced by depreciation.

In addition, it has been argued that international product fragmentation requires the establishment of “service links” in order to connect the various fragments of a production process in a seamless, rapid, and cost-efficient manner. Thus, the locational decisions of mobile network entities conducting assembly activities within an international production network are strongly influenced by the presence of other key variables such as infrastructure, logistic capabilities, availability of skilled operators, and modern technical and managerial skills as mentioned earlier. In these circumstances, RER changes are but one part of a far wider set of considerations about where to locate production facilities.

The negative relationship between RER misalignment and export volume is found in almost all countries. This negative relationship implies that RER misalignment could adversely affect export performance in addition to real appreciation. Meanwhile, a positive impact of RER depreciation on export performance could deteriorate when the real depreciation is associated with a significant misalignment of the RER. It is likely that when a country faces RER overvaluation, the RER tends to exhibit persistent RER appreciation. In addition, RER undervaluation is likely to be associated with persistent RER depreciation. However, it is possible that RER undervaluation could occur when a country is facing RER appreciation. This is evident in Thailand after the crisis as shown in Figure 1 where RER exhibited an appreciation trend but it was still undervalued from the equilibrium level.

Table 4: Coefficients of Real Exchange Rate and Real Exchange Rate Misalignment

	RER Misalignment (Absmis)		RER	
	Short-run Coefficient	Long-run Coefficient	Short-run Coefficient	Long-run Coefficient
PRC	—	–0.77**	0.66*	0.76*
Hong Kong, China	—	—	0.45**(–2)	0.75**
India	–3.23*	–2.76*	3.84*	0.55***
Indonesia	–0.22**	–1.34**	1.29*	4.28*
Korea	—	–0.71*	1.12*	1.13*
Malaysia	–0.28***	—	0.41*	1.37*
Singapore	–0.75***	—	0.81** 0.79***(-2)	—
Thailand	—	-0.96**	0.35*	0.92*

— means the estimated coefficient is statistically insignificant; * significant at the 5% level; ** significant at the 10% level; *** significant at 15% level.

Note: Values in parentheses show the lag period of the significance.

Source: Author’s estimates.

It is not surprising that RER misalignment in terms of real overvaluation could adversely affect export performance since real overvaluation reflects a loss in a country’s competitiveness and misallocations of resources toward the nontradable sector. Resources and incentives to produce tradable products are limited. Meanwhile, persistent real undervaluation could result in an economic overheating and higher import prices, thereby putting pressures on domestic prices and generating expected appreciation of currency in the future. This could also have a negative impact on export performance.

The estimation results point out that in the PRC, Korea, and Thailand, the negative relationship between RER misalignment and export performance is found only in the long run. A negative but insignificant impact is revealed in the short run. The negative impacts tend to be less for the PRC and Korea than Thailand. A 1% increase in the RER misalignment in the long run would lead to a 0.7–0.8% reduction in export volume while the reduction would be around 1% in Thailand. In India and Indonesia where the RER tends to play an important role in determining export performance, RER misalignment would have a negative impact on export performance in both the short run and long run and the negative impacts tend to be higher than other countries. In Singapore, the negative coefficient is statistically significant only in the short run, which is consistent with the role of RER that tends to determine Singapore's export activities only in the short run. In Hong Kong, China, a negative but statistically insignificant effect of RER misalignment on export performance is found. Such insignificance could result from the less variation of RER misalignment during the estimation period. In other words, the RER in Hong Kong, China tended to be kept close to the equilibrium level in 1995–2008.

World demand (WD) is also crucial in determining export performance. In the short run, it is statistically significant at 1% level in all countries while in the long run, it becomes statistically significant only in the PRC; Hong Kong, China; India; Korea and Thailand. These findings add weight to the observation that new emerging patterns of intraregional trade (i.e., an increasing importance of parts and components trade) do not necessarily indicate a weakening of integration with external markets outside of developing Asia.

Production capacity (PC) is another crucial factor affecting export performance of these eight economies. In particular, long-run estimates of PC are not only statistically significant but also large in absolute value. This tends to imply that supply-side factors, such as infrastructure, logistics capabilities, skills, and general business climate, are likely to be important in determining export performance. In addition to PC, FDI becomes statistically significant in determining export performance in all categories. The coefficient tends to be higher in the case of manufacturing exports. The importance of FDI in determining export performance, even using aggregate data, tends to support the hypothesis that multinational corporations are likely to be in a better position to overcome fixed costs induced by exports and have higher chances to successfully export. Multinational firms have knowledge and experience in operating in foreign markets and can benefit from network economies and know-how in managing the international marketing, distribution, and servicing of their products. Thus, they could cover sunk costs and access into foreign markets easier than domestically owned firms, thereby expanding a country's export performance. In addition, the presence of multinational corporations could indirectly encourage locally nonaffiliated firms to export, i.e., export spillovers through information externalities, demonstration, and imitation and competition (Aitken et al. 1997, Greenaway et al. 2004).

IX. Conclusions

This paper examines the equilibrium RER and RER misalignment in eight Asian economies—namely, PRC; Hong Kong, China; India; Indonesia; Korea; Malaysia; Singapore; and Thailand, during the period 1995–2008. The impact of RER misalignment on export performance is further examined. The absolute value of RER misalignment is included in the export model, together with the RER, WD, PC, and inflows of FDI.

In the lead-up to the 1997–1998 financial crisis, the RER exhibited persistent overvaluation in crisis-affected countries. Real overvaluation increased to around 10–15% in 1997 in Korea, Malaysia, and Thailand, and over 20% in Indonesia. For other countries, i.e., PRC; Hong Kong, China; and India, the RER tended to exhibit undervaluation in the lead-up to the crisis period. This reflects reduced vulnerability of the country in facing currency speculation and currency crisis. After the 1997–1998 crisis, RER deprecation in many Asian countries was associated with real undervaluation. This includes PRC, Malaysia, and Thailand. Although the RER depreciated in Hong Kong, China, the depreciation was so far consistent with economic fundamentals. In Indonesia and Korea, the RER tended to be kept well within the equilibrium level although real appreciation was found in these two countries. However, the slight real overvaluation in the PRC and Singapore resulting from appreciation of their nominal effective exchange rate and a decline in domestic prices of their trading partners during the global financial crisis period (in 2008) would need close monitoring to ensure that real appreciation (overvaluation) would not worsen the slumping world demand affecting export and economic performance in developing Asia.

Real exchange rate misalignment could have a negative impact on export performance in developing Asia. This implies that the negative impacts of RER appreciation on export activities could become even more significant when such appreciation is associated with RER misalignment. In other words, the positive effects of RER depreciation on exports could be reduced when such depreciation is not consistent with economic fundamentals. RER misalignment in terms of real overvaluation could adversely affect export performance since real overvaluation reflects a loss in a country's competitiveness. Meanwhile, persistent real undervaluation could result in an economic overheating thereby putting pressure on inflation and generating expected currency appreciation. This could also have a negative implication on export performance.

These results show that RER misalignment could be regarded as one of the key indicators in measuring the level of a country's vulnerability to currency speculation and crisis. In particular, the significant misalignment of the RER provides a benchmark for assessing misalignment of currencies, which has an implication for export performance. Thus, monitoring RER equilibrium and misalignments would become a useful tool for governments/central banks to ensure balance in the economy.

Appendix 1: Cointegration Tests

1. PRC

Ho: r	Trace	Trace95	Trace99
None*	224.20	146.76	158.49
At most 1	105.37	114.90	124.75
At most 2	62.03	87.31	96.58

2. Hong Kong, China

Ho: r	Trace	Trace95	Trace99
None*	153.26	87.31	96.58
At most 1	53.58	62.99	70.05
At most 2	26.24	42.44	48.45

3. India

Ho: r	Trace	Trace95	Trace99
None*	111.11	87.31	96.58
At most 1	46.95	62.99	70.05
At most 2	19.64	42.44	48.45

4. Indonesia

Ho: r	Trace	Trace95	Trace99
None*	114.84	87.31	96.58
At most 1	66.06	62.99	70.05
At most 2	33.04	42.44	48.45

5. Korea

Ho: r	Trace	Trace95	Trace99
None*	153.00	87.31	96.58
At most 1	67.52	62.99	70.05
At most 2	20.08	42.44	48.45

6. Malaysia

Ho: r	Trace	Trace95	Trace99
None*	76.58	62.99	70.05
At most 1	29.18	42.44	48.45
At most 2	9.09	25.32	30.45

7. Singapore

Ho: r	Trace	Trace95	Trace99
None*	148.54	87.31	96.58
At most 1	85.94	62.99	70.05
At most 2	33.23	42.44	48.45

8. Thailand

Ho: r	Trace	Trace95	Trace99
None*	166.13	114.90	124.75
At most 1	89.43	87.31	96.58
At most 2	46.15	62.99	70.05

Note: * denotes rejection of the hypothesis at the 0.01 level. The Trace95 and Trace99 columns are the 95% and 99% significance level from Osterwald-Lenum (1992).

Appendix 2: Regression Results: Export Performance

1. PRC

$$\Delta X = -5.31 + 0.76\Delta RER + 4.26\Delta PC + 0.09\Delta FDI + 0.02\Delta FDI(-1) - 0.81X(-1) + 0.47WD(-1)$$

(-4.38)* (2.70)* (2.41)* (9.16)* (2.23)* (-6.19)* (1.94)*

$$+1.14PC(-1) + 0.54RER(-1) - 0.63Absmis(-1)$$

(6.28)* (2.18)* (-1.78)**

Adj-R2 = 0.92; S.E. of regression = 0.04; LM(1) = 0.01 (p=0.92); LM(2) = 0.77 (p=0.47); ARCH = 0.002 (p=0.97); J-B = 0.83 (p=0.66)

2. Hong Kong, China

$$\Delta X = 0.16 + 0.45\Delta RER(-2) + 0.32\Delta WD + 6.28\Delta PC(-1) + 0.02\Delta Absmis - 0.45X(-1) + 0.34RER(-1)$$

(0.15) (1.54)*** (13.71)* (2.07)* (0.06) (-5.89)* (1.75)**

$$+ 0.09WD(-2) + 0.28PC(-1) + 0.25Absmis(-1)$$

(2.53)* (1.77)** (0.99)

Adj-R2 = 0.96; S.E. of regression = 0.02; LM(1) = 0.001 (p=0.97); LM(2) = 0.39 (p=0.68); ARCH = 2.49 (p=0.12); J-B = 1.52 (p=0.47)

3. India

$$\Delta X = -19.92 + 3.84\Delta RER + 0.77\Delta WD(-1) - 3.23\Delta Absmis - 0.89X(-1) + 0.49RER(-1) + 0.20WD(-1)$$

(-4.32)* (5.61)* (4.96)* (-2.97)* (-8.66)* (0.94) (1.27)***

$$-2.47Absmis(-1) + 1.84PC(-1) + 0.02FDI(-1)$$

(-1.90)** (6.61)* (0.82)

Adj-R2 = 0.86; S.E. of regression = 0.07; LM(1) = 0.86 (p=0.36); LM(2) = 1.11 (p=0.34); ARCH = 2.88 (p=0.10); J-B = 2.26 (p=0.32)

4. Indonesia

$$\Delta X = -4.89 + 1.29\Delta RER + 0.31\Delta WD + 0.18\Delta WD(-3) + 0.02\Delta FDI(-2) - 0.22\Delta Absmis - 0.08X(-1) + 0.35RER(-1)$$

(-1.82)** (11.24)* (2.84)* (1.73)** (2.63)* (-1.67)*** (-2.11)* (4.85)*

$$+0.33PC(-1) + 0.02FDI(-1) - 0.11Absmis(-1)$$

(1.48)*** (1.65)** (-1.50)***

Adj-R2 = 0.90; S.E. of regression = 0.05; LM(1) = 2.01 (p=0.16); LM(2) = 1.88 (p=0.17); ARCH = 3.50 (p=0.07); J-B = 1.45 (p=0.48)

5. Korea

$$\Delta X = 1.84 + 1.12\Delta RER + 0.15\Delta WD + 0.002\Delta FDI(-1) - 0.48X(-1) + 0.54RER(-1) + 0.19WD(-1) - 0.34Absmis(-1)$$

(2.13)* (13.06)* (4.98)* (0.51) (-3.62)* (2.71)* (4.55)* (-3.05)*

Adj-R2 = 0.87; S.E. of regression = 0.04; LM(1) = 0.07 (p=0.79); LM(2) = 0.58 (p=0.56); ARCH = 0.94 (p=0.34); J-B = 0.15 (p=0.93)

6. Malaysia

$$\Delta X = 0.22 + 0.41\Delta RER + 0.47\Delta WD + 0.15\Delta WD(-3) + 0.002\Delta FDI(-2) - 0.28\Delta Absmis - 0.29X(-1) + 0.40RER(-1)$$

(0.69) (2.22)* (6.43)* (2.29)* (1.16)*** (-1.12)*** (-3.27)* (3.41)*

$$+0.29PC(-1) + 0.002FDI(-1) + 0.13Absmis(-1)$$

(2.55)* (0.99) (0.58)

Adj-R2 = 0.69; S.E. of regression = 0.03; LM(1) = 0.13 (p=0.71); LM(2) = 0.25 (p=0.77); ARCH = 0.99 (p=0.32); J-B = 2.64 (p=0.27)

7. Singapore

$$\Delta X = -0.62 + 1.30\Delta RER + 1.15\Delta RER(-2) + 0.50\Delta WD + 0.008\Delta FDI(-1) - 0.68\Delta Absmis - 0.23X(-1) + 0.37PC(-1)$$

(-1.43)*** (2.34)* (1.92)* (0.50) (2.67)* (-1.30)*** (-2.20)* (1.68)**

$$+ 0.05WD(-1)$$

(0.75)

Adj-R2 = 0.56; S.E. of regression = 0.04; LM(1) = 0.49 (p=0.49); LM(2) = 0.29 (p=0.60); ARCH = 0.37 (p=0.69); J-B = 0.004 (p=0.99)

8. Thailand

$$\Delta X = 0.76 + 0.35\Delta RER + 0.49\Delta WD + 4.72\Delta PC - 0.13\Delta Absmis - 0.31X(-1) + 0.28RER(-1) + 0.29WD(-1) + 0.03FDI(-1)$$

(0.99) (2.87)* (5.30)* (1.92)* (-0.71) (-3.41)* (-2.23)* (2.40)* (2.62)*

$$- 0.29Absmis(-1)$$

(-1.79)*

Adj-R2 = 0.62; S.E. of regression = 0.04; LM(1) = 1,21 (p=0.28); LM(2) = 0.63 (p=0.54); ARCH = 3.76 (p=0.06); J-B = 0.31 (p=0.86)

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About the Paper

Juthathip Jongwanich examines real exchange rate misalignment and its impacts on export performance in eight East and Southeast Asian economies during 1995–2008. The results show that in the lead-up to the 1997–1998 financial crisis, the real exchange rate exhibited persistent overvaluation in the crisis-affected countries. After 1997–1998 crisis, real exchange rate undervaluation was evident in many Asian countries such as People's Republic of China, Malaysia, and Thailand. This study shows that real exchange rate misalignment could have a negative impact on export performance in developing Asia.

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