

The Persistence in Real Exchange Rate: Evidence from East Asian Countries

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Abstract

In this article, we examine the degree of persistence in monthly real exchange rates (RER) for East Asian countries to study the validity of PPP for the 1974:01-2007:09 period. These countries were affected by the financial crisis of the fall 1997. We use the grid-bootstrap procedure developed by Hansen (1999) to construct the confidence intervals for the measure of persistence and half-lives. We have two findings: First, we find evidence for high persistency in real exchange rate and hence no evidence for PPP for the full and pre-crisis sample periods. Second, the presence of low persistency in real exchange rate supports PPP for post-crisis period, except South Korea. These findings indicate that real exchange rate series of four East Asian countries are mean-revert based on their exchange rate policies.

Key words: PPP; Real exchange rates; Unit Root; Persistence.

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1. Introduction

As discussed in Taylor (2003; 2006), since the breakdown of the Bretton Woods system of fixed exchange rates in 1971, there has been an ongoing debate among economists regarding the stability of real exchange rate (RER) and purchasing power parity (PPP), which states that nominal exchange rates adjust to reflect difference in price levels across countries. The validity of PPP even as a long-run equilibrium condition has been disappeared among economists during the last three decades. To overcome that problem, there have been many studies to test the validity of long-run PPP on the basis of linear, non-linear and panel unit root tests in the RER literature. For example; Diebold et al. (1991), Lothian and Taylor (1996), Mollick (1999), Taylor (2002) applied univariate techniques to long horizon RER to overcome the PPP puzzle. Panel unit roots have been used to test PPP in the post-1973 period producing no strong evidence for PPP (Wu, 1996; Papell, 1997; O'Connell, 1998) as they imply long half lives in developed countries. On the other hand, median-unbiased estimation (Murray and Papell, 2002) has produced evidence contradicting the earlier findings on the half-lives summarized in Rogoff (1996). Moreover, with extending the median-unbiased estimation to the more powerful unit root test, Lopez et al. (2005) finds more evidence in favour of PPP hypothesis. Interestingly, the studies using panel unit root tests find different and some mixed results than the conventional stationarity tests.

There are fairly recent studies considered RER for East Asian countries (e.g. Hsing, 2008; Narayan, 2008; Bhandari and Upadhyaya, 2008; Chinn, 2000) and for developed countries (e.g. Panopoulou, 2007; Lau, 2008; Kalyoncu and Kalyoncu, 2008; Narayan et al., 2007) using different econometric techniques produced mixed results. For instance, Narayan

(2008) reports evidence for PPP for East Asian countries using the Lagrange multiplier panel structural break cointegration test for yearly data from 1967 to 2002, but cannot find any evidence using Pedroni's panel cointegration test. Baharumshah et al. (2008) cannot find strong evidence PPP for East-Asian countries from 1976 to 2002 by using autoregressive distributed lag cointegration procedure, but strong evidence in the post-Asian crisis period. Liew et al. (2004) using a nonlinear unit root test find considerable evidence for RER stationarity for Asian exchange rates. Cushman (2008), who uses Johansen approach finding out no evidence for PPP for the extended data of Sideris, finds evidence for PPP. Also, Nusair (2008) uses Johansen et al. (2000) procedure that allows for up to two pre-determined structural breaks and finds support for long run PPP for most Asian countries. Cerrato et al. (2008) construct bootstrap confidence intervals for the half-lives to analyse the PPP puzzle for 36 emerging economies and find the puzzle still exists for most emerging market countries.

In this study, examining the papers' of Taylor (2003; 2006) and the paper of Lothian and Taylor (2008) on PPP and persistency of RER, we investigate the degree of persistence in RER for five East Asian countries, namely Indonesia, Malaysia, Philippines, South Korea and Thailand– vis-a`-vis the Japanese yen for the 1974:01 – 2007:09 period including the Asian financial crisis. We intend to investigate whether the sharp fall in the currencies of these countries following the financial crisis has had a significant impact on the persistence of RER. Previous research, using conventional unit root tests, provides limited information on the degree of persistence in RER. Unit root tests focus on testing the null hypothesis that the sum of the autoregressive (AR) coefficients is unity in an AR representation of a series against the alternative hypothesis that the sum of the AR coefficients is less than unity. On the contrary, a confidence interval for the sum of the AR coefficients provides a

more informative statistical description of a variable's persistence. In this paper, we employ recently developed econometric procedures by Hansen (1999) in order to estimate 95% confidence intervals for the sum of the AR coefficients in AR representations of RER of the countries. Unlike the conventional bootstrap, the procedure of Hansen (1999) generates confidence intervals for nearly integrated variables with correct first-order asymptotic coverage for the sum of the AR coefficients. These procedures also have good coverage in finite samples (Rapach and Wohar, 2004).

Considering the effects of financial crisis on the degree of persistence in RER, the data was truncated into two sub-periods. First is the January 1974 – June 1997, pre-crisis, period that covers the era of financial regulation and the fast growing period of the East Asian countries. Second is the July 1997 – September 2007, post-crisis, period that the major structural and financial reforms were undertaken. Our results indicate a high degree of persistence in monthly RER for five East Asian countries for full-sample, pre-crisis sample, and post-crisis sample periods. Regardless of the sample periods, RER is persistent for all countries, except Malaysia for the post-crisis sample period. For the full-sample and pre-crisis sample periods, the lower bound for the 95% confidence interval for the sum of the AR coefficients is often greater than 0.92, while the upper bound is almost always greater than unity, for the countries considered. Grid-bootstrap 95% confidence intervals for the half-lives have lower bounds ranging from approximately 1.5 to 8 years (with the exceptions of Indonesia and Malaysia), while the upper bound is 8 for countries included in the sample, with the exception of Malaysia. The lower bounds for the 95% confidence intervals for the sum of the AR coefficients and the half-lives indicate that real exchange rate series included in the sample are highly persistent.

The rest of the article is organized as follows. Section II outlines the construction of the confidence intervals for measures of persistence. Section III discusses the data and the empirical results of the sum of the AR coefficients and half-lives for monthly RER for East Asian countries, while the final section provides some concluding remarks.

2. Econometric Methodology

In order to explain the persistence in the RER series, consider the following AR(p) process for the variable y_t :

$$y_t = \gamma + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \dots + \alpha_p y_{t-p} + \varepsilon_t \quad (1)$$

for $t = 1, 2, \dots, T$. It is argued by Andrews and Chen (1994) that an informative scalar measure of persistence in the AR process is the sum of the AR coefficients, $\alpha = \sum_{i=1}^p \alpha_i$, as the cumulative impulse response (CIR) is associated with α by $\text{CIR} = 1/(1 - \alpha)$. Given that two AR(p) models with identical largest roots can have very different persistence properties, they consider α as more informative than the largest root of the AR(p) model.

The variable y_t is a unit-root process if $\alpha = 1$, while y_t is stationary, or mean-reverting, if $|\alpha| < 1$. Focusing on the case where $\alpha > 0$, as this is an appropriate range for RER data that is considered, a point estimate can be obtained by re-writing equation (1) and by means of OLS to estimate the well-known augmented Dickey and Fuller (1979, ADF) and Said and Dickey (1984) regression model:

$$\Delta y_t = \gamma' + \alpha y_{t-1} + \sum_{j=1}^k \beta_j \Delta y_{t-j} + \varepsilon_t \quad (2)$$

Here, $\Delta y_t = y_t - y_{t-1}$. Since the asymptotic distribution of the OLS estimator is different in the stationary and unit-root cases, the obtaining of confidence intervals for α is problematic. If α is near unity, the conventional asymptotic procedure is poor in finite samples. If the near unit-root case is formalized in a local-to-unity framework, then the conventional t -statistic used to form asymptotic confidence intervals for α has a non-standard distribution. Therefore, the conventional confidence interval is not valid asymptotically. At the same time, in finite samples, the conventional confidence interval will likely perform very poorly. This problem cannot be solved by a conventional bootstrap procedure, since the confidence intervals with correct first-order asymptotic coverage will be failed to be generated by the conventional bootstrap (Basawa et al., 1991). Therefore, we use the grid-bootstrap procedure by Hansen (1999), an alternative procedure to the conventional percentile-t bootstrap that provides correct first-order asymptotic coverage in a local-to-unity framework, for constructing confidence intervals for α with correct first-order asymptotic coverage.²

The half-life is also considered as a measure of persistence. The half-life is calculated from the impulse response function for an AR(p) in levels and is defined as the number of periods required for a unit shock to dissipate by 0.5: $\sup_{t \in L} \partial y_{t+i} / \partial \varepsilon_t \geq 0.5$, as in Cheung and Lai (2000). The persistence of the process over different horizons can be analyzed by studying the moving average representation for y_t :

$$y_t = C(L)\varepsilon_t \tag{3}$$

where $C(L) = 1 + c_1L + c_2L^2 + \dots$, obtained from $C(L) = (1 - \alpha_1L - \alpha_2L^2 - \dots - \alpha_pL^p)^{-1}$. The moving average coefficients, (c_1, c_2, \dots) , are referred to as impulse responses. In general,

² See Rapach and Wohar (2004) for the detailed information about the procedure.

c_j tracks the impact of a unit shock at time t on the level of y at time $t+j$. For a stationary process, which contains no unit root, $C_\infty = 0$; the process thus has zero long-run persistence. Over time horizons much shorter than infinity, nonetheless, $c_j \neq 0$ and sizable persistence may still exist (Cheung and Lai, 2000). As it is explained in Rapach and Wohar (2004); and Inoue and Kilian (2002), the conventional bootstrap confidence intervals are not valid for the sum of the AR coefficients, α , while they are valid asymptotically for the individual slope coefficients of the AR(p) model, equation (1), and some functions of these coefficients - including the impulse response function - even in a local-to-unity framework, as long as $p > 1$. We compute percentile grid-bootstrap 95% confidence intervals for the half-life of the impulse response function using the procedure outlined in Gospodinov (2004) in order to eliminate to have poor coverage in finite samples for persistent series of conventional bootstrap confidence intervals for the half-life when $p > 1$.

3. Data and Empirical Analysis

The data under study are monthly RER constructed from nominal exchange rates and consumer price indices obtained from the International Monetary Fund's *International Financial Statistics* in CD-ROM. The RER of five East Asian countries – Indonesia, Malaysia, Philippines, South Korea and Thailand – vis-a-vis the Japanese yen are investigated. The data are seasonally non-adjusted monthly observations for the period January 1974 to September 2007. The real exchange rate, z_t , is defined as: $z_t = s_t - p_t + p_t^*$, where s_t is the log of the nominal exchange rate defined as the price of foreign currency in terms of home currency, p_t is the log of the domestic price level, and p_t^* is the log of the price level of the foreign country.

In this study, the main aim is to examine the persistency of RER in East Asian countries for three different periods considering the financial crisis in 1997. The periods covered are 1974:01 – 2007:09, 1974:01 – 1997:06 and 1997:07 – 2007:09, respectively. For all three different periods, the OLS estimation results for coefficient α , in equation (2), are given in the third column of Table 1 for all countries. The lag length k in equation (2) is determined by the modified AIC (MAIC) criterion of Ng and Perron (2001). The lag length, k , found by MAIC, is given in the second column of Table 1. The OLS point estimates of coefficient α are greater than 0.9 for all countries for full-period, pre-crisis period, and post-crisis period, according to the results reported in Table 1. These point estimates are biased downwards and are of limited value. For the three considered periods, the grid-bootstrap of Hansen (1999) is calculated at 95% confidence intervals for α for every country to give more informative measure of persistence. These confidence intervals for α for every country are given in column (4) of Table 1.³

Table 1. Point estimates and 95% confidence intervals for measures of real exchange rate persistence

Country	k	$\hat{\alpha}_{OLS}$	Grid-bootstrap 95% CI for $\hat{\alpha}_{OLS}$	HL_{IRF}	Grid-bootstrap 95% CI for HL_{IRF}
Sample 1974:01-2007:09					
Indonesia	16	0.991	[0.983, 1.003]	6.271	[3.263, 8.333]
Malaysia	3	0.991	[0.986, 0.994]	7.394	[4.394, 8.333]
Philippines	0	0.984	[0.977, 1.002]	3.648	[2.515, 8.333]
South Korea	0	0.982	[0.974, 1.002]	3.237	[2.253, 8.333]
Thailand	0	0.988	[0.983, 1.002]	5.217	[3.517, 8.333]
Sample 1974:01-1997:06					
Indonesia	0	0.995	[0.990, 1.003]	8.333	[5.835, 8.333]
Malaysia	3	0.993	[0.985, 0.995]	8.333	[4.344, 8.333]
Philippines	0	0.983	[0.975, 1.003]	3.454	[2.285, 8.333]
South Korea	0	0.984	[0.976, 1.003]	3.618	[2.472, 8.333]
Thailand	1	0.990	[0.985, 1.002]	6.597	[4.107, 8.333]

³ We generated the Hansen (1999) grid-bootstrap confidence intervals using the GAUSS program available from Bruce E. Hansen's home page at <http://www.ssc.wisc.edu/~bhansen/>

Sample 1997:07-2007:09

Indonesia	3	0.954	[0.923, 1.006]	0.838	[0.523, 8.333]
Malaysia	0	0.907	[0.897, 0.918]	0.597	[0.536, 0.676]
Philippines	1	0.964	[0.944, 1.007]	1.562	[1.005, 8.333]
South Korea	4	0.990	[0.977, 1.006]	5.291	[2.328, 8.333]
Thailand	4	0.962	[0.933, 1.009]	1.489	[0.864, 8.333]

^a Lag length k in equation (2) selected using the Ng and Perron (2001) modified MAIC criterion.

^b OLS estimate for the sum of the AR coefficients in equation (2).

^c Estimate of the half-life (measured in years) based on the impulse response function.

Column (4) of Table 1 reports that the lower bound of the grid-bootstrap confidence interval is greater than 0.92 for every country, with the exception of Malaysia for the 1997:07-2007:09 period. For 1997:07-2007:09 (post-crisis) period, the lower bound is equal to 0.896 for Malaysia. On the other hand, for the same period, the upper bound of the 95% confidence interval of α for Malaysia is 0.918. However, for the three periods, the upper bound of the 95% confidence interval of α for all other countries is between 0.99 and 1.1. As it can be seen from Table 1, the upper bound of the 95% confidence interval for α is less than 1 for Malaysia for three periods, but it is greater than 1 for the other countries for all periods. Therefore, the data for the countries in that study are not inconsistent with a unit root in the RER, except Malaysia. Based on grid-bootstrap of Hansen (1999) at 95% confidence intervals for α , the lower bounds for the 95% confidence intervals indicate that RER display a high degree of persistence (with the exception of Malaysia), although it is expected that RER are stationary (so that $\alpha < 1$). We also report the impulse response function figures for all countries in Figure 1, 2 and 3 for the full sample period, the pre-crisis sample period and the post-crisis sample periods, respectively.

Fig. 1. Impulse response function of Yen based Real Exchange Rate Series for the 1974:01-2007:09 period

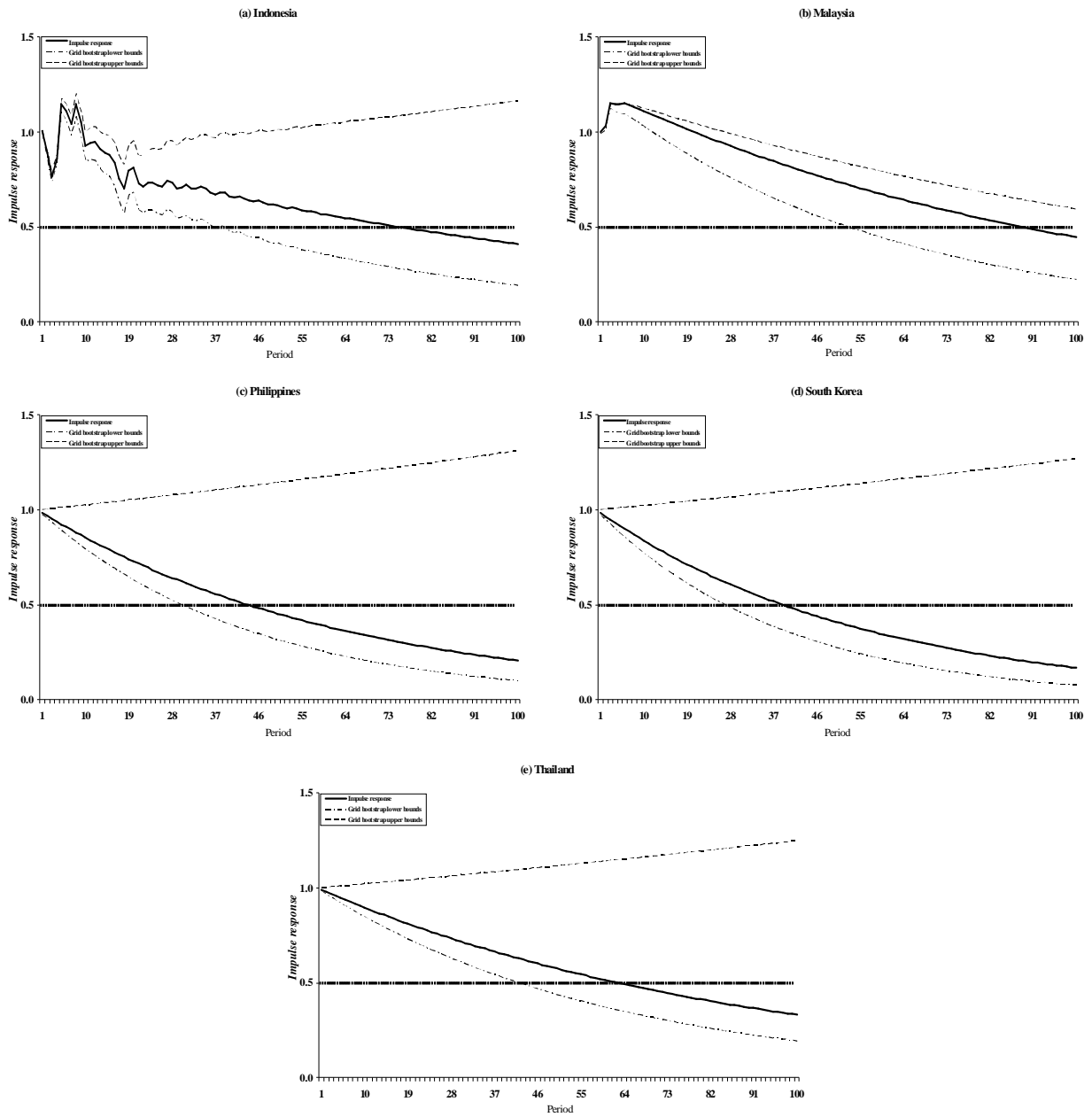


Fig. 2. Impulse response function of Yen based Real Exchange Rate Series for the 1974:01-1997:06 period

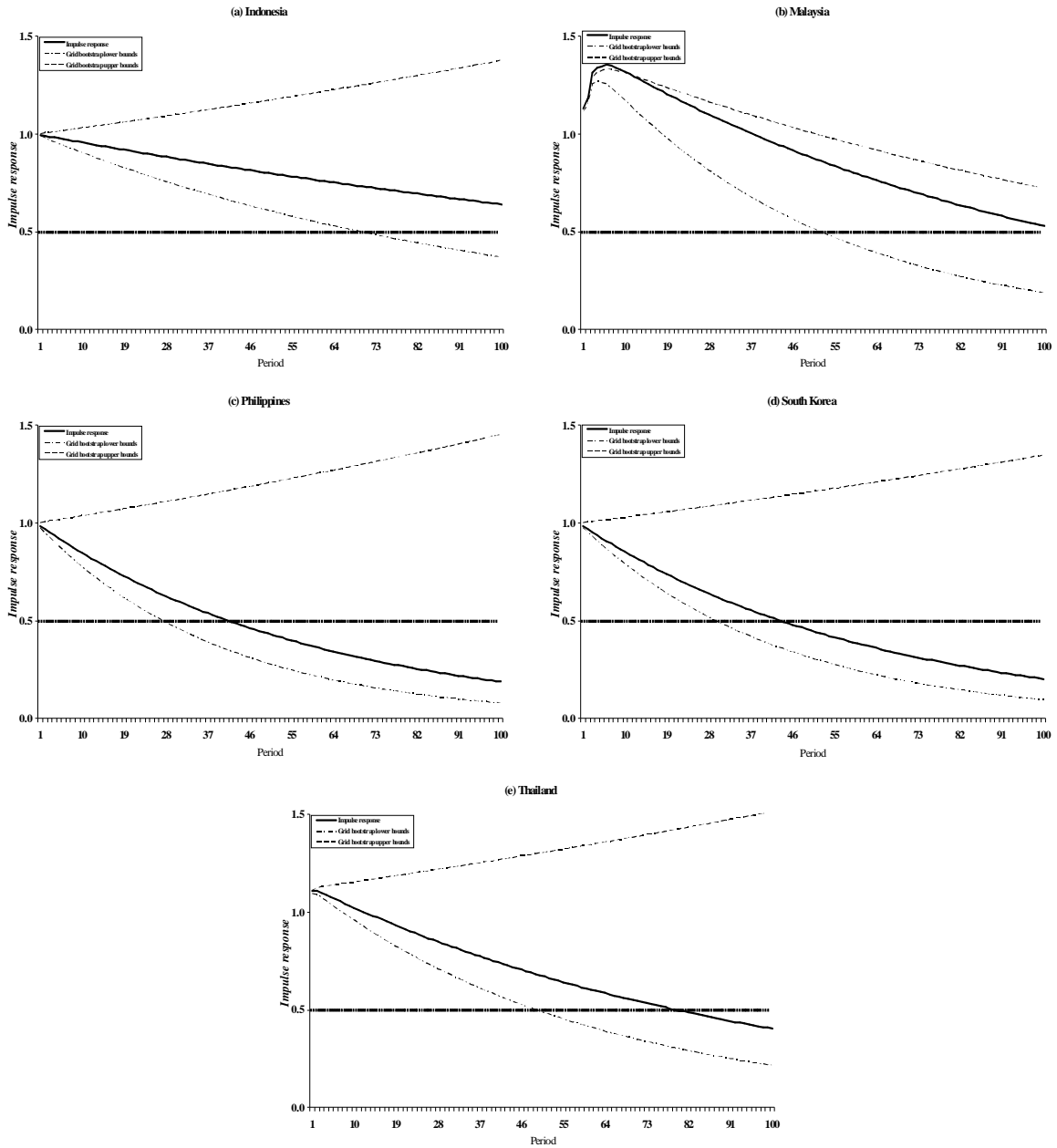
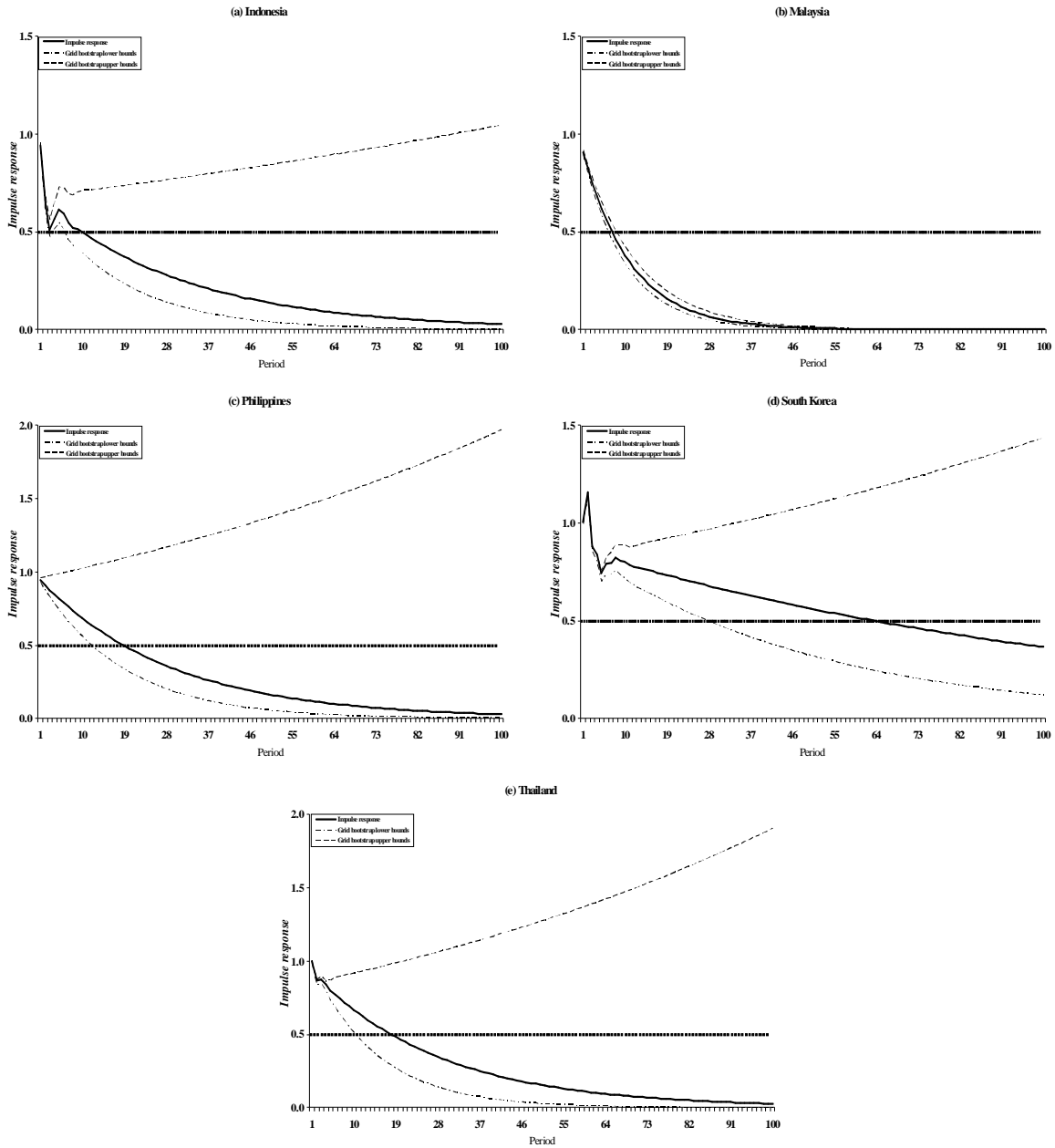


Fig. 3. Impulse response function of Yen based Real Exchange Rate Series for the 1997:06-2007:09 period



The half-life based on the impulse response function as a measure of persistence is reported in column (5) of Table 1. The half-lives are measured in years in Table 1. Column (6) of Table 1 reports the grid-bootstrap 95% confidence interval (measured in years) for

the half-life for the three sample periods.⁴ For the full-sample and pre-crisis sample periods, measure of half-life for all countries is quite large, around 3.2 to 8.3 years. However, the measure of half-life for all countries for the post-crisis sample period is very small in comparison with other two periods, and in most cases are 18 months, the only exception being South Korea with approximately 5.2 years. Those findings provide strong evidence for very low persistence of RER deviations from their PPP value in the post-1997 period. The results obtained from post-crisis period indicate that the strong evidence for mean reversion of RER may be explained by the change in the exchange rate regime chosen by the affected countries. The grid-bootstrap 95% confidence interval of the half-lives, [0.536, 0.676], is extremely narrow only for Malaysia for the post-crisis sample period, but the confidence intervals of the other half-lives are quite wide for RER of all countries for full, the pre- and post-crisis periods. Most of those countries peg their exchange rate against the US dollar during pre-crisis period. Since those countries were challenged to maintain their currencies in the pre-crisis period, they loss most of foreign exchange reserves. Therefore, they preferred to follow a more market-oriented exchange rate policy after pre-1997 period. Consequently, our results support to mean reversion to the long-run PPP for the all countries for post-crisis period, with the exception for South Korea.

4. Conclusion

In this paper, we investigate the degree of persistence in monthly RER of five East Asian countries – Indonesia, Malaysia, Philippines, South Korea and Thailand– vis-a`-vis the Japanese yen for the January 1974 - September 2007, the January 1974 – June 1997, and

⁴ We generated the grid-bootstrap confidence intervals for the half-lives reported in column (6) of Table 1 using the GAUSS program available from Nikolay Gospodinov's home page at http://alcor.concordia.ca/_gospodin/.

the July 1997 – September 2007 periods using the recently developed the grid-bootstrap procedures by Hansen (1999) to construct the confidence intervals for the measure of persistence and half-lives. Our findings indicate that there is evidence for high persistency in real exchange rate and hence no evidence for PPP for the full and pre-crisis sample periods. Another finding of this paper is that there is low persistency in real exchange rate, indicating long-run RER mean-reversion, supporting PPP for post-crisis period, except South Korea. These findings are consistent with the flexible exchange rate regime that the monetary authorities pursue after the 1997 crisis. The last finding of PPP for the panel of four East Asian countries can be used as a supportive result for a consideration of an Asian monetary union.

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