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Hiroyuki Taguchi, Harutaka Murofushi and Hironao Tsuboue

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内閣府経済社会総合研究所
Economic and Social Research Institute
Cabinet Office
Tokyo, Japan

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Hiroyuki Taguchi, Harutaka Murofushi, Hironao Tsuboue **

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** Hiroyuki Taguchi: Director of Department of Administrative Affairs, Economic and Social Research Institute, Cabinet Office

Harutaka Murofushi: Research Officer, Economic and Social Research Institute, Cabinet Office; Hironao Tsuboue: Research Officer, Economic and Social Research Institute, Cabinet Office;

Abstract

This paper examines exchange rate regimes from the viewpoint of the validity of purchasing power parity (PPP). Specifically, we analyze real exchange rate behavior (which is tantamount to the validity of PPP) under various classifications of exchange rate arrangement through panel unit root tests, and also investigate the adjustment speed of nominal exchange rate and relative prices separately through an error correction framework. The study's two main findings represent some contrasts between industrial countries and developing countries under the corner exchange rate arrangements. First, as a result of the panel unit root tests on real exchange rate behavior, industrial countries under "free float" reveal REER stability even though the test results show weak support for this speculation, while developing countries under "hard peg" definitely represent the REER stability, and have full support from the tests. Second, error correction analysis tells us that in industrial countries under "free float," the adjustment of nominal exchange rate was faster than that of relative prices, while in developing countries under "hard peg" the adjustment of relative prices is faster that that of the nominal exchange rate. We speculate that industrial countries under free float may render exchange rate movements sensitive to the inflation gap, and that developing countries under "hard peg" may produce nonlinear price adjustments toward the REER long-run equilibrium through an anchor-effect of peg on price stabilization.

Key words: real (effective) exchange rate, exchange rate arrangement, panel unit root tests, error correction analysis, nonlinear price adjustment

JEL Classification Codes: F31, F33, C23

1. Introduction

Exchange rate management is one of the central issues of macroeconomic policies. Since the postwar period, a lengthy debate has simmered over the merits of fixed versus floating exchange rates. The debate, which is typically framed in terms of the trade-off between credibility and flexibility, has gone through several swings of the pendulum (Frankel 1999, Frankel et al. 2000).

Recently, the debates on exchange rate regimes have become focused on whether the intermediate regimes that “soft peg” their currencies, by tactics such as target zones, crawling, and basket pegs, are vanishing. In other words, the question is whether exchange rate regimes are moving toward a corner solution with the “hard peg” approach or the “free float” one. The corner solutions hypothesis claims that, under the principle of the “impossible trinity,” countries will be increasingly forced toward more purely floating or more purely fixed regimes as capital market integration increases (Fischer 2001, Summers 1999). As a counter-argument against the corner solutions hypothesis, the “fear of floating” hypothesis justifies an intermediate exchange rate regime mainly from the viewpoint of establishing credibility in the financial markets so that the local currency will not lose value against foreign currencies, particularly among emerging market economies (Calvo and Reinhart 2000, Williamson 2000, Kawai 2002). So far, no clear consensus has been reached.

The 1997-98 Asian financial crisis has refocused attention on exchange rate management within the East Asian countries. Most views expressed criticize the pre-crisis US-dollar-pegged rate regime as one cause of the crisis. It is said that this regime induced short-term external over-borrowing and caused the appreciation of real exchange rates with the loss of competitiveness (Ito 2001, etc.). The question also arises as to whether, after the crisis, the East Asian countries are simply returning to the pre-crisis US dollar standard (McKinnon 2001), or whether they have learned a lesson from the crisis and are finding another path to follow (Kawai 2002, etc.).

The recent debates over the exchange rate regimes take it a step further, arguing that there must be coordination in selecting an exchange rate regime among countries in the region with similar trading structures and with high intra-regional trading shares (Ogawa and Ito 2000). The possibility of an optimal currency area in East Asia has also been discussed on an empirical basis (Bayoumi, Eichengreen, and Mauro 2000).

Among the literature on exchange rate regimes mentioned above, this paper examines exchange rate regimes from the viewpoint of the validity of purchasing power parity (PPP). The main questions are these: under which exchange rate regimes has PPP held? And, if some regimes allow PPP to hold, which adjustments of exchange rate or relative price have been effective in keeping PPP?

In the following sections we will first review previous studies and clarify this paper's position (Section 2). We will then present our own empirical study (Section 3), and end with some concluding remarks (Section 4).

2. Previous Studies, Our Position

There is now a vast body of literature on the validity of purchasing power parity (PPP). Within this immense body of work, professional opinion on both the short and long run appears to have shifted several times in the post-war period. Taylor (2003) provides a selective and critical review of the literature, with special reference to the literature of the past two decades. As Dornbusch and Krugman (1976) wrote: "Under the skin of any international economist lies a deep-seated belief in some variant of the PPP theory of exchange rate."

Subsequently, the flurry of empirical studies employing unit-root tests on real exchange rate data for verifying the validity of the PPP—which emerged toward the end of the 1980s—were unanimous in their failure to reject the unit-root hypothesis (e.g., Enders 1998, Taylor 1988, Mark 1990). Then, Frankel (1986, 1990) pointed out that the tests typically employed to examine the long-run stability of the real exchange rate—if based on data covering just 15 years or so—may have very limited power to reject the null hypothesis. A logical next phase of the analysis of long-run real exchange rates involved testing for mean reversion using *long spans* of data to increase the power of the tests. Using annual data from 1869 to 1984 for the dollar-sterling real exchange rate, Frankel (1986) estimated an AR(1) process for the real rate and was able to reject the random-walk hypothesis. An alternative approach to increase the power of the tests involved using a *panel* of data; i.e., data on more than one real exchange rate. Abuaf and Jorion (1990) examined a system of ten first-order autoregressive regressions for real dollar exchange rates over the period 1973–87 and indicated a rejection of the null hypothesis of joint non-mean reversion as evidence in favor of long-run PPP.

In the course of the literature above for verifying the validity of PPP, this paper can be classified into an empirical study that employs unit-root tests on a *panel* of real exchange rate data. The main contribution of this paper lies in the point where it conducts the panel unit-root tests on real exchange rates according to exchange rate regimes such as hard peg, soft peg, managed float, and free float, i.e. the empirical link between exchange rate regimes and behavior of real exchange rates using a large panel of countries in the world.

We find few studies in which the behavior of real exchange rate arrangement is examined under various exchange rate arrangements in a world-wide level, although these kinds of studies are often found on specific countries and areas. Among them, Parsley and Popper (2001) found important differences in real exchange rate behaviors across various official designations of exchange rate arrangement on a world-wide level, and showed notably that real exchange rate mean reversion is fastest when nominal exchange rates are officially pegged, and that nominal exchange rates, rather than prices, do most of the adjusting.

The new contributions of this study, which are different from Parsley and Popper (2001), are as follows. First, this study uses de facto exchange rate arrangements estimated by Reinhart and Ilzetzki (2009), while Parsley and Popper (2001) use the one reported in the International Monetary Fund (IMF). Second, the estimations in this study are based on monthly data of the International Financial Statistics of the IMF and monthly estimates of exchange rate arrangements by Reinhart and Ilzetzki (2009), while Parsley and Popper (2001) estimate on annual base. Third, a large panel of countries in the world is divided between industrial countries and developed ones in this study's estimation, although not in Parsley and Popper (2001). Fourth, this study adopts various types of the panel unit root tests with both common unit root process and individual unit root processes, while Parsley and Popper (2001) adopts only the tests with individual unit root processes of Im, Pesaran, and Shin (2003) and Maddala and Wu (1999).

3. Empirical Studies

We will now proceed to the empirical analysis, which we'll take in two steps. First, we will conduct the panel unit-root tests to examine the stationarity of the real exchange rate according to exchange rate arrangements during the post-Bretton Woods period on the member-countries of the International Monetary Fund. Second, we will use an error correction framework to examine separately the adjustment of the nominal exchange rate and of relative prices, in case the stationarity of the real exchange rate is identified under some of exchange rate arrangements. Before conducting this two-step analysis, we clarify the following three issues: the relationship between real exchange rates and purchasing power parity, the specification of the real exchange rate, and the classification of exchange rate arrangements.

3.1 Relationship between real exchange rates and purchasing power parity

We first refer to the relationship between real exchange rates and the purchasing power parity (PPP). The real exchange rate is an indicator of a country's international price competitiveness, specifically of a country's prices relative to those of other countries. It can also be expressed as the nominal exchange rate adjusted for relative national price level differences. We may formulate the real exchange rate, y_t, in logarithmic form as:

$$y_t = s_t - (p^*_t - p_t) \quad (1)$$

where s_t is the nominal exchange rate, p_t is the domestic price level, and p^*_t is the foreign price level. On the other hand, the PPP exchange rate is the exchange rate between two currencies that would equate the two relevant national price levels if expressed in a common currency at that rate, so that the purchasing power of a unit of one currency would be the same in both economies. It may be formulated as:

$$s_t = p^*_t - p_t \quad (2)$$

Comparing (1) and (2), we can see that, if the logarithm of the real exchange rate is identically equal to zero, PPP should hold. Thus, movements in the real exchange rate are tantamount to deviations from PPP. Further, an examination of the time-series properties of the real exchange rate may lead to the issue of whether the nominal exchange rate and relative national prices all settle down together at a level consistent with PPP over the long run. For the real exchange rate to settle down at any level whatsoever, it must display reversion toward its own mean. Hence, if the real exchange rate is mean-reverting, a necessary condition for long-run PPP to hold is satisfied. Generally, investigations into this issue have tested the null hypothesis of non-mean reversion (a unit root) against the alternative of mean reversion, in the process driving the real exchange rate.

3.2 Specification of the real exchange rate

We next discuss the issue of how to specify the real exchange rate defined above so as to calculate it. The real exchange rate is usually shown as a bilateral rate, like the nominal exchange rate. In general, the U.S. dollar is selected as the partner's currency. Then, Equation (1) may be rewritten as:

$$y_{t(US\ dollar\ /\ Local\ currency)} = s_{t(US\ dollar\ /\ Local\ currency)} - (p_{t\ US} - p_t) \quad (3)$$

Since a country has many trade partners and competitors in the world, the bilateral real exchange rates have to be unified to obtain a single indicator of a country's international price competitiveness. The real effective exchange rate (REER) is such an indicator. We can express the REER as the weighted average of the bilateral real exchange rates, as follows:

$$REER_t = W_{us} * y_{t(US\ dollar\ /\ Local\ currency)} + W_{JP} * y_{t(Japanese\ yen\ /\ Local\ currency)} + \ldots, (4)$$

where W_{us}, W_{JP}, … are the weights attached to each bilateral real exchange rate.

The International Monetary Fund has had its own Information Notice System since 1983, under which real and nominal effective exchange rate series are computed for almost all Fund members and published in the International Financial Statistics (IFS). The weighting scheme is based on trade data for manufactured goods, primary goods, and, where significant, tourism services, with the weights reflecting both the relative importance of a country's trading partners in its direct bilateral trade relations and that resulting from competition in third markets.[1]

We will thus take the data from IFS for REER of the IMF member-countries during the post-Bretton Woods period: the monthly data from March 1973[2] to December 2007. There are two kinds of REER: the one based on unit labor costs and the other based on consumer price indices. Since the former are computed only for 18 industrial countries and the euro area, we use the latter, which are computed for almost all Fund members.[3]

3.3 Classification of exchange rate arrangements

The IMF represents exchange rate arrangements of the Fund members. However, its classification is often criticized as the one that does not necessarily reflect actual

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1 Zanello and Desruelle (1997) provide background on the concepts and methodology underlying effective exchange rates.

2 The post-Bretton Woods period is said to have collapsed in March 1973, when most of the advanced nations in the world shifted their exchange rate arrangements to a floating system.

3 The REER data of 134 of the 227 Fund members are not available in the IFS because its publication needs their approval. As a measure of the real exchange rate, the use of the wholesale price index (WPI) is generally favored because, conceptually, the WPI is heavily weighted with tradable goods compared to the CPI, which measures price changes in both tradable and non-tradable items. Thus, it should be noticed that the usage of the CPI might provide some bias for the adjustment speed of mean-reverting of the REER.

exchange rate arrangements, since it is based on the Fund member's formally announced regime. Many economists, therefore, have often showed their own analysis of the de facto exchange rate regimes. One famous estimate on exchange rate arrangements is the chronologies of the exchange rate arrangements represented by Reinhart and Ilzetzki (2009), which reclassified exchange rate regimes by employing newly complied monthly data sets on market-determined exchange rates.

From their estimates, we will adopt four categories of "monthly coarse classification," which is composed of six categories of exchange rate arrangements. The first category consists of "no separate legal tender," "pre-announced peg or currency board arrangement," "pre-announced horizontal band that is narrower than or equal to +/-2%" and " de facto peg," which we will call "hard peg." The second one is "pre-announced crawling peg," "pre-announced crawling band that is narrower than or equal to +/-2%," "de factor crawling peg," and "de facto crawling band that is narrower than or equal to +/-2%," which we will call "soft peg." The third one is "pre-announced crawling band that is wider than or equal to +/-2%," "de facto crawling band that is narrower than or equal to +/-5%," "moving band that is narrower than or equal to +/-2% (i.e., allows for both appreciation and depreciation over time)," and "managed floating," all of which we will call "managed floating." The fourth one we will call "freely floating." We will take the data during the post-Bretton Woods period: the monthly data from March 1973 to December 2007. It is prudent, however, to draw strong conclusions by using the classification of Reinhart and Ilzetzki (2009), since the classification might not be always the best estimate, and since the test results in following sections might be subject to the selection of the classifications.

3.4 Panel unit root tests on the real exchange rate

We step into the panel unit root tests on the real exchange rate under various classifications of exchange rate arrangements during the post-Bretton Woods period from March 1973 to December 2007 on the Fund members, which we divide into industrial countries and developing countries in the analysis. We first clarify the procedures of panel unit root tests and then discuss the test results.

3.4.1 Procedures of the panel unit root tests

Recent literature suggests that panel-based unit root tests have higher power than unit root tests do, based on individual time series. We will adopt the following five types of panel unit root tests on the real exchange rate shown in the EViews 6 User's Guide: Levin, Lin and Chu (2002), Breitung (2000), Im, Pesaran and Shin (2003), and Fisher-type tests using ADF and PP tests (Maddala and Wu (1999) and Choi (2001)).[4]

We begin by classifying our panel unit root tests on the basis of whether there are restrictions on the autoregressive process across cross-sections or series. Consider a following AR(1) process for panel data:

$$y_{it} = \rho_i \, y_{it-1} + X_{it}\delta_i + \varepsilon_{it} \quad (5)$$

where i = 1, 2, …, N are cross-section units or series, that are observed over periods t = 1, 2, …, T_j. The X_{it} represents the exogenous variables in the model, including any fixed effects or individual trends, ρ_i are the autoregressive coefficients, and the errors ε_{it} are assumed to be mutually independent idiosyncratic disturbance. If $|\rho_i| < 1$, y_i is said to be stationary. On the other hand, if $|\rho_i| = 1$ then y_i contains a unit root. For purposes of testing, there are two natural assumptions that we can make about the ρ_i. First, one can assume that the persistence parameters are common across cross-sections so that $\rho_i = \rho$ for all i. The Levin, Lin, and Chu (LLC), and Breitung tests all employ this assumption. Alternatively, one can allow ρ_i to vary freely across cross-sections. The Im, Pesaran, and Shin, and Fisher-ADF and Fisher-PP tests are of this form.

Tests with common unit root process

LLC and Breitung both consider the following basic ADF specification:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X'_{it}\delta_i + \varepsilon_{it} \quad (6)$$

where we assume a common $\alpha = \rho - 1$, but allow the lag order for the difference terms, p_i, to vary across cross-sections. The null and alternative hypotheses for the tests may be written as:

$H_0: \alpha = 0$
$H_1: \alpha < 0$ (7)

[4] The description in this section is based on the EViews 6 User's Guide. The Guide includes one more test of Hadri (2000). This test is, however, said to over-reject the null of stationarity, and may yield results that directly contradict those obtained using alternative test statistics (see Hlouskova and Wagner (2006)). Therefore, we did not adopt the Hadri test here.

Under the null hypothesis, there is a unit root, while under the alternative, there is no unit root. The LLC and Breitung method elect to include individual constant terms (fixed effects), or to employ individual constants and trends.

Tests with individual unit root processes

The Im, Pesaran, and Shin, and the Fisher-ADF and PP tests all allow for individual unit root processes so that may vary across cross-sections. The tests are all characterized by the combining of individual unit root tests to derive a panel-specific result. The tests begin by specifying a separate ADF regression for each cross section. The specification is shown as the same equation as (6). The null hypothesis may be written as,

H_0: $\alpha_i = 0$, for i

while the alternative hypothesis is given by:

$$H1: \begin{cases} \alpha_i = 0 & \text{for } i = 1,2,\ldots, N_1 \\ \alpha_i < 0 & \text{for } i = N+1, N+2,\ldots, N \end{cases} \quad (8)$$

which may be interpreted as a non-zero fraction of the individual processes is stationary. This means that the null hypothesis is *joint* non-mean reversion of *all* of the real exchange rates considered. Hence, the null hypothesis will be violated even if only *one* of the real exchange rates exhibits mean-reverting behavior. Taylor (2003) criticizes the panel unit root tests with the null hypothesis of joint non-mean reversion in such a way that "if univariate unit-root tests applied to a set of real exchange rates lead to rejection of the null hypothesis of non-mean reversion for one or more of the rates, then the results of a panel unit-root test applied to the same group of exchange rates is completely uninformative." In this sense, it might be not appropriate if we depended only on the results of the tests with individual unit root processes. We therefore adopt both the tests with common unit root process and the ones with individual unit root processes. The method can choose to include individual constants, or to include individual constant and trend terms.

To sum up, we will conduct the five types of panel unit root tests of the LLC; Breitung; Im, Pesaran and Shin; and Fisher-type tests using ADF and PP tests, on the real effective exchange rate based on consumer price indices taken from the IFS, under the various kinds of the exchange rate arrangements represented by Reinhart and Ilzetzki (2009), in industrial and developing countries of the Fund members, during the post-Bretton Woods period.

3.4.2 Discussion of the test results

Table 1 shows the test results in the cases of full sample countries, industrial countries and developing countries. In the case of full samples, “hard peg” reveals the rejection of the null hypothesis of a unit root on REER in five types of tests with either intercept or trend and intercept at the significance level of one, to five and ten percent. “Free float” does it in four tests, whereas “soft peg” and “managed float” do it in only one test. These test results appear to be ambiguous in full samples because the corner arrangements of “hard peg” and “free float” show more definitely the REER stationarity than the intermediate arrangements of “soft peg” and “managed float.” We, therefore, divide full samples into industrial countries and developing countries.

In the case of industrial countries, “free float” gets the support of the REER stationarity from three tests, while the other arrangements get it from zero or only one test. In contrast, the case of developing countries shows that “hard peg” gets the support of the REER stationarity from all the tests, whereas the other arrangements get it from only one test.

We may interpret the results above in the following way. There seems to be some contrast in the real exchange rate behavior under the corner arrangements between industrial countries and developing countries: industrial countries may possibly keep the REER stability by rendering exchange rate sensitive to relative prices under “free float.” The test results, however, show weak support for this speculation because the REER stationarity is identified in the panel unit root test not with a common unit root process but with individual ones and also at the significance level of not a one percent level but a five and ten percent level. On the other hands, developing countries definitely present the REER stability under “hard peg,” getting full support from five types of tests. The results seem to be consistent with the previous study of Parsley and Popper (2001), which showed that real exchange rate mean reversion is fastest when nominal exchange rates are officially pegged. The REER stability under “hard peg” may tempt us to speculate that price adjustments have worked under the condition that the nominal exchange rate is rigidly pegged. However, there may also be the possibility that countries have often revised their pegs. We will then examine which adjustments of nominal exchange rate or relative prices have been dominated to keep the REER stability under the error correction framework in the case of industrial countries under "free float" and developing countries under "hard peg" in the following section.

3.5 Error correction analysis on rice and exchange rate adjustment

We now turn to error correction analysis to examine the adjustments of nominal exchange rate and relative prices towards the long-run REER stability. We first clarify the methodology of error correction model and then discuss the estimation result.

3.5.1 The methodology of error correction model

The real exchange rate can conceptually be divided into nominal exchange rate and relative prices. To be specific, y_t of real exchange rate in Equation (1) is divided into s_t of nominal exchange rate and $(p^*_t - p_t)$ of relative prices. We will then examine nominal exchange rate and relative prices separately by using error correction equations. Specifically, we estimate:

$$\Delta s_{it} = \beta_1 \Delta p_{it} + \beta_2 \, y_{it\text{-}1} + \varepsilon_{sit}$$
$$\Delta p_{it} = \gamma_1 \Delta s_{it} + \gamma_2 \, y_{it\text{-}1} + \varepsilon_{pit} \quad (9)$$

where p is relative prices of $(p^*_t - p_t)$. In the estimation, we take the data for both real and nominal effective exchange rates from IFS, and obtain relative prices by dividing nominal effective exchange rate by real effective exchange rate. Each data is converted into logarithmic form. Our estimation focuses on the case of industrial countries under "Free Float" and developing countries under "Hard Peg" where the stationarity of real effective exchange rate (REER) was identified in the previous section. In this case, since nominal exchange rate and relative prices have their cointegrating relationship, the cointegration term of real exchange rate, $\beta_2 \, y_{it\text{-}1}$ and $\gamma_2 \, y_{it\text{-}1}$ can be the *error correction* term. Then, the specification above can be interpreted in such a way that the long-run behavior of nominal exchange rate and relative prices converge to their cointegrating relationship of real exchange rate while their short-run adjustment dynamics are allowed; the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. The coefficient of interest, β_2 and γ_2 measures the speed of adjustment towards the long-run equilibrium of real exchange rate. A priori, we would expect negative sign in β_2 and positive one in γ_2. In case that $\beta_2 > \gamma_2$, the adjustment of nominal exchange rate is faster than that of relative prices toward the long-run equilibrium, and vice versa.

3.5.2 Discussion of estimation results

Table 2 reports the estimation results of the error correction model in the case of industrial countries under "free float" and of developing countries under "hard peg." In all the cases, the coefficients of β_2 and γ_2—the adjustment speeds of nominal exchange rate and relative prices—are of the correct sign and significant. In the case of industrial countries under "free float," the estimated response of nominal exchange rate is -0.0111, while that of relative prices is 0.0027. Thus, the adjustment of the nominal exchange rate is much faster that that of relative prices. On the contrary, in the case of developing countries under "hard peg," the estimated response of the nominal exchange rate is -0.0151, while that of relative prices is 0.0267. This means that the adjustment of relative prices is faster that that of nominal exchange rate.

The contrast in the estimation results above seems to be interpreted as follows. The estimation results for industrial countries under "free float," under which the exchange rate movement appears to be promptly responsive to the inflation gap. On the other hand, the estimation outcome for developing countries under "hard peg" may necessitate careful consideration because the outcome is different from that of Parsley and Popper (2001). This differing outcome revealed that the nominal exchange rate carries out the lion's share of the adjustment across all of the exchange rate arrangements, including those classified as maintaining a peg. Parsley and Popper (2001) argued that the exchange rate adjustment under the peg suggests that countries revise their pegs in such a way that purchasing power parity calculations underlie official currency adjustments. Our results do not deny that argument, because the exchange rate response *does* exist by -0.0151 against the relative price response of 0.0267. We do speculate, however, that there seems to be another effect of pegged exchange rate on prices. One alleged role of exchange rates is as an anchor of domestic price stability, which is based on the belief that pegging the exchange rate to a low-inflation currency would make domestic inflation come down rapidly through the restraint imposed on wage- and price-setting behavior (Aghevli et al., 1991). In fact, the exchange-rate-based stabilization programs were undertaken in high inflation developing countries, including, for example, Chile (1978), Uruguay (1978), Argentina (1991), and Mexico (1987). These programs are said to have achieved success in bringing down inflation, with the case of Mexico being a typical example in which inflation was brought down by over a third in the first year of the program from an annual rate close to 160 percent (IMF, 1997). Thus, one interpretation on our estimation result can be that the price adjustment through an anchor-effect of peg on price stabilization might exceed the adjustment of peg-revision suggested by Parsley and Popper (2001) in developing countries suffering from high inflation.[5]

The verification of nonlinearity in the price-adjustment processes may help support our interpretation. When the real exchange rate deviates greatly from the long-run equilibrium, the price adjustment might be fastest through the enforcement of the exchange-rate-based stabilization programs under a scenario of high inflation. On the other hand, a small deviation might prevent the price adjustment in the presence of transaction costs. We will then represent the nonlinearity by multiplying the lagged deviation by its absolute value, which preserves sign changes. The modified error correction equation (9) now becomes:

$$\Delta p_{it}' = \gamma_1' \Delta s_{it} + \gamma_2' y_{it-1} \mid y_{it-1} \mid + \varepsilon_{pit} \quad (10)$$

We can verify the nonlinearity in the price-adjustment, in case the coefficient of interest, γ_2' is significantly negative. Table 3 indicates that γ_2' is of the correct sign and significant, thereby suggesting that the nonlinear price adjustment is an important aspect of movements in real exchange rates.

4. Concluding Remarks

This article examined exchange rate regimes from the viewpoint of the validity of purchasing power parity (PPP). Specifically, we conducted the panel unit root tests to examine the stationarity of real exchange rates (which is tantamount to the validity of PPP) under various classifications of exchange rate arrangements during the post-Bretton Woods period on the member-countries of the International Monetary Fund. We further examined the adjustments of nominal exchange rate and relative prices separately by using an error correction framework.

Through this analysis, we found two contrasting results between industrial countries and developing countries under the corner exchange rate arrangements. First, as a result of the panel unit root tests on the real exchange rate behavior, industrial countries under "free float" reveal the REER stability, although the test results show weak support for

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5 As a reference, the average annual inflation rate from 1973 to 2007 in developing countries is around 25%, while that in industrial countries is around 5%.

this speculation. Developing countries under “hard peg,” in contrast, definitely represent the REER stability with full supports from the tests. Second, the error correction analysis tells us that in industrial countries under free float, the adjustment of nominal exchange rate was faster than that of relative prices, while in developing countries under hard peg the adjustment of relative prices is faster that that of nominal exchange rate. We speculate that industrial countries under free float may render exchange rate movements sensitive to the inflation gap, and that developing countries under hard peg may produce a nonlinear price adjustment toward the REER long-run equilibrium through an anchor-effect of peg on price stabilization.

The following issues still need further examination: First, this study has a problem regarding the REER data coverage: the IFS publishes the REER data of less than half of IMF members. For the purpose of getting more solid estimation results by covering most of the Fund members, it may be necessary to investigate the data availability from data sources other than the IFS or to estimate the REER by following the IFS method. Second, if the REER data coverage were expanded, it would be better to make the classification of countries more sophisticated. Developing countries might, for example, be divided according to their degree of inflation. This division may enable us to compare the speed of the REER mean reversion among developing countries with various degrees of inflation.

Table 1 Panel Unit Root Tests of Real Effective Exchange Rates

Full sample countires

		Hard Peg	Soft Peg	Managed Float	Free Float
Levin, Lin and Chu	Intercept	-2.21 **	-4.53 ***	-2.78 ***	-1.43 *
	Trend & Intercept	-0.99	-1.31 *	-1.61 *	2.52
Breitung	Intercept	-1.96 **	0.94	-0.36	0.32
	Trend & Intercept	1.53	2.79	0.85	-0.14
Im, Pesaran and Shin	Intercept	-1.28	0.70	0.40	-1.38 *
	Trend & Intercept	-2.52 ***	2.31	1.26	-0.28
Fisher - ADF	Intercept	151.14 ***	116.38	100.79	37.67 *
	Trend & Intercept	197.87 ***	84.00	85.72	25.29
Fisher - PP	Intercept	142.24 **	110.17	91.09	54.03 ***
	Trend & Intercept	160.30 ***	86.10	68.96	32.07
Sample		9,756	7,787	5,995	1,758

Industrial countires

		Hard Peg	Soft Peg	Managed Float	Free Float
Levin, Lin and Chu	Intercept	0.52	-0.27	-0.68	-1.10
	Trend & Intercept	-0.42	0.17	-0.81	-0.42
Breitung	Intercept	-1.80 **	-0.50	-2.13 **	0.07
	Trend & Intercept	2.46	-0.26	0.72	-0.50
Im, Pesaran and Shin	Intercept	1.09	0.06	-0.46	-1.86 **
	Trend & Intercept	1.37	2.04	-0.19	0.02
Fisher - ADF	Intercept	22.07	26.53	23.15	14.83 *
	Trend & Intercept	18.69	19.72	25.81	5.98
Fisher - PP	Intercept	20.26	23.81	20.27	15.09 *
	Trend & Intercept	16.70	16.77	21.76	6.39
Sample		2,880	2,606	1,727	1,223

Developing countires

		Hard Peg	Soft Peg	Managed Float	Free Float
Levin, Lin and Chu	Intercept	-3.00 ***	-4.72 ***	-2.74 ***	-0.77
	Trend & Intercept	-0.92	-1.65 **	-1.49 *	4.06
Breitung	Intercept	-1.32 *	1.12	0.25	0.79
	Trend & Intercept	-0.72	3.37	0.57	0.75
Im, Pesaran and Shin	Intercept	-2.10 **	0.78	0.73	-0.45
	Trend & Intercept	-3.52 ***	1.52	1.53	-0.33
Fisher - ADF	Intercept	129.07 ***	89.84	77.64	22.83
	Trend & Intercept	179.17 ***	64.28	59.91	19.30
Fisher - PP	Intercept	121.98 ***	86.36	70.82	38.94 ***
	Trend & Intercept	143.60 ***	69.33	47.20	25.68
Sample		6,876	5,181	4,268	535

2) ***, **, and * indicate rejection of the null of nonstationarity at the 1 percent, 5 percent, and 10 percent significance levels with critical values.

Table 2 Error Correction Estimates

$$\Delta s_{it} = \beta_1 \Delta p_{it} + \beta_2 y_{it-1} + \varepsilon_{sit}$$
$$\Delta p_{it} = \gamma_1 \Delta s_{it} + \gamma_2 y_{it-1} + \varepsilon$$

	Nominal Exchange		Relative Prices	
	Relative Prices	Error Correction Term	Nominal Exchange Rate	Error Correction Ter
	β1	β2	γ1	γ2
Developing Countries under "Hard				
Coefficient	0.4973	-0.0151	0.3825	0.0267
Standard Error	0.0125	0.0022	0.0096	0.0019
t-	39.8486	-6.7842	39.8486	13.8354
Wu-Hausman Test				
Chi-Sq.	16.0788		133.2636	
Chi-Sq. d.f.	2		2	
Prob.	0.0003		0.0000	
Type	Fixed		Fixed	
Industrial Countries under "Free				
Coefficient	0.1679	-0.0111	0.0155	0.0027
Standard Error	0.0940	0.0028	0.0085	0.0013
t-	1.7857	-3.9576	1.8199	2.0333
Wu-Hausman Test				
Chi-Sq.	2.7111		41.4386	
Chi-Sq. d.f.	2		2	
Prob.	0.2578		0.0000	
Type	Random		Fixed	

Table 3 Nonlinear Error Correction Estimates: Relative prices

$$\Delta p_{it}' = \gamma_1' \Delta s_{it} + \gamma_2' y_{it-1} |y_{it-1}| + \varepsilon_{pit}$$

	γ1'	γ2'
Developing Countries under "Hard Peg"		
Coefficient	0.3837	0.0028
Standard Error	0.0096	0.0002
t-statistic	39.9123	13.2157
Wu-Hausman Test		
Chi-Sq.	138.7967	
Chi-Sq. d.f.	2	
Prob.	0.0000	
Type	Fixed	

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