



Revisiting long-run purchasing power parity with asymmetric adjustment for G-7 countries

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ABSTRACT

In this study, we applied a threshold cointegration test advanced by Enders and Siklos (2001) to investigate the properties of asymmetric adjustment on long-run purchasing power parity (PPP) in G-7 countries between January 1994 and April 2010. Although there was strong evidence of long-run PPP for these G-7 countries, with the exception of Canada, the adjustment mechanism was asymmetric. These results have important policy implications for G-7 countries.

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1. Introduction

During the past several decades, considerable effort has been put into testing the validity of long-run purchasing power parity (PPP) hypothesis because it has important policy implications in international finance. Long-run PPP is indicative of a long-run relationship between the nominal exchange rate and the domestic and foreign prices of a particular economy.¹ When PPP exists, it can be used to determine the equilibrium exchange rate. When the PPP hypothesis does not hold, however, the use of any monetary approach to determine the exchange rate is invalid because a monetary approach necessitates that the PPP hypothesis holds true. According to Holmes (2001), PPP is important to policymakers for two reasons. First, it can be used to predict the exchange rate and determine whether a currency is over- or undervalued, which is particularly important for less developed countries and countries

experiencing large differences between domestic and foreign inflation rates. Secondly, the notion of PPP is used as the foundation on which many theories of exchange rate determination are built. Consequently, the validity is important to policymakers in developing countries who base their adjustments on PPP.

Although some empirical evidence of long-run PPP for both developed countries and less-developed countries seem convincing, nothing has currently been proved to be conclusive. As for methodology, recent studies of long-run PPP have primarily utilized conventional unit root tests for real exchange rates and cointegration tests for the relationships between various measures of domestic and foreign prices as well as nominal exchange rates. The conclusions drawn from these studies have primarily been based on linear tests of stationarity and/or cointegration. Because ample evidence in support of asymmetric reactions in key economic variables has been widely acknowledged in recent years, there is no reason to assume that the long-run PPP adjustment process toward equilibrium is always symmetric. Indeed, Madsen and Yang (1998) and Ramsey and Rothman (1996) have shown that economic variables, such as inflation rates, follow an asymmetric adjustment process. In addition, Balke and Fomby (1997) suggested that the power of linear cointegration tests was lower in an asymmetric adjustment process (i.e., the assumption of symmetric adjustments is likely to yield poor results when it comes to equilibrium relationships because conventional cointegration tests do not take asymmetric adjustments into account).

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¹ PPP can also be viewed as the international version of the "law of one price (LOOP)" (i.e., if two countries are engaging in free trade, arbitrage should make the purchasing powers of the two countries' currencies equivalent). Therefore, economists generally believe that PPP should hold in the long run. For example, Rogoff (1996) expressed his strong belief in PPP (see Taylor and Taylor, 2004). PPP has been one of the key building blocks of many international macroeconomic models. For the recent developments and debates in this area, see Taylor and Taylor (2004).

Furthermore, Enders and Granger (1998) showed that the standard tests for unit root and cointegration all have lower power in the presence of misspecified dynamics. This is important because the linear relationship is inappropriate if prices are sticky in the downward, but not in the upward, direction. Madsen and Yang (1998) have provided evidence that prices are sticky in the downward direction, which means that real exchange rate adjustments are asymmetric. Other reasons for the asymmetric adjustment are the presence of transactions costs, which inhibit international goods arbitrage, and official intervention in the foreign exchange market, which may make the nominal exchange rate movements asymmetric (Taylor, 2004; Taylor and Peel, 2000; Juvenal and Taylor, 2008).² Kilian and Taylor (2003) suggested that nonlinearity might arise from the heterogeneity of opinion in the foreign exchange market concerning the equilibrium level of the nominal exchange rate (i.e., as the nominal rate takes on more extreme values, a great degree of consensus develops concerning the appropriate direction of exchange rate movements, and traders act accordingly). All of these reports motivated us to use threshold (asymmetric) cointegration tests in our study. A number of studies have provided solid empirical evidence for the non-linear and/or asymmetric adjustment of the exchange rate in the developed countries (Baum et al., 2001; Enders and Dibooglu, 2001), the G-7 countries (Kilian and Taylor, 2003), the 17 OECD countries (Serletis and Gogas, 2000), the Middle East (Sarno, 2000), Asian economies (Enders and Chumrusphonlert, 2004), African countries (Chang et al., 2011), and oil-exporting countries (Chang and Liu, 2010).

We hope that our empirical study can significantly contribute to this field of research by using the threshold cointegration test of Enders and Siklos (2001) to determine whether long-run PPP exists in the G-7 countries. The present study filled a gap in the literature. What we find here is that long-run PPP held true in these G-7 countries, with the exception of Canada, but the adjustment mechanism was asymmetric. Our empirical results have important policy implications for G-7 countries under study.

The present empirical study was organized into several sections. Section 2 presents the data that we used in the study. Section 3 briefly describes the threshold cointegration test of Enders and Siklos (2001). Section 4 shows our empirical results and some of the policy implications from our findings. Section 5 concludes the paper.

2. Data

Our empirical analysis covers the G-7 countries: Canada, France, Germany, Italy, Japan, UK, and USA.³ Monthly data were

² According to Taylor and Sarno (2001), an intuitively appealing emerging theoretical literature on the nature of international goods arbitrage suggests that real exchange rate adjustment may arise in an inherently nonlinear fashion. At the simplest level, one can imagine arbitrage in a single, homogeneous traded good only becoming strong once arbitrage yielded sufficient profit to outweigh transport and other costs of arbitrage, such that deviations from the law of one price (LOOP) might be expected to switch abruptly from non-mean-reverting (when the deviation from the LOOP is smaller than the arbitrage costs) to mean-reverting (once the deviation is greater than the arbitrage costs). This would suggest that one might find evidence of threshold nonlinearity (i.e., a discrete switch from non-mean reversion to mean reversion at a certain distance from the equilibrium level)—when examining deviations from the LOOP using disaggregated data (Obstfeld and Taylor, 1997). The threshold autoregressive (TAR) model assumes that whenever the threshold is hit, instantaneous adjustment toward purchasing power parity occurs. Please see Balke and Fomby (1997) and, for an application, Obstfeld and Taylor (1997).

³ Recently, several papers (e.g., Zhou, 2008; Baharumshah et al., 2010) have raised concern about the choice of the numeraire currency in validating the parity condition. The available evidence on PPP depends to some extent on the base country. To demonstrate the robustness of our empirical results, we also considered the DM. We explored the hypothesis using the DM as the base currency against the same set of data. To the results on the DM-based real exchange rates (not reported here but are available from the authors upon request) also provided evidence favoring the long-run validity of PPP for G-7 countries under study. It is worth noting that our empirical evidence appears to be insensitive to the choice of numeraire currency in the model.

Table 1
Summary statistics (USD base).

	Canada	France	Germany	Italy	Japan	UK
Mean	0.267	1.691	0.465	7.409	4.614	-0.505
Median	0.273	1.665	0.442	7.385	4.640	-0.490
Maximum	0.463	2.020	0.793	7.729	4.879	-0.330
Minimum	0.004	1.451	0.214	7.131	4.164	-0.731
Std. Dev.	0.118	0.142	0.144	0.137	0.151	0.102
Skewness	-0.326	0.717	0.570	0.568	-0.782	-0.477
Kurtosis	2.233	2.664	2.608	2.761	3.141	2.368
Jarque-Bera	8.278 **	17.712 ***	11.872 ***	10.996 ***	20.161 ***	10.683 ***

Note: 1. The sample period is from January 1994 to April 2010.

2. $\ln(\text{real exchange rate}) = \ln(\text{nominal exchange rate}) + \ln(\text{foreign price level}) - \ln(\text{domestic price level})$; the US as the base country.

** Indicate significance at the 5% level.

*** Indicate significance at the 1% level.

employed in our empirical study, and the time span was from January 1994 to April 2010. All consumer price indices (CPI, based on 2005 = 100) and nominal exchange rates relative to the U.S. dollar data were taken from the International Monetary Fund's International Financial Statistics CD-ROM. Each of the consumer price indices and real exchange rate series was transformed into natural logarithms before the econometric analysis. Testing for PPP against the USA was based on the argument that internal foreign exchange markets are mostly dollar dominated.

A summary of the statistics of bilateral real exchange rate is given in Table 1. The Jarque-Bera test results indicate that for all six country pairs, the bilateral real exchange rate data sets are approximately non-normal. The Japan/USD with values varying from 4.164 to 4.879 and a standard deviation of 0.151 is the most volatile currency, whereas the UK/USD with values varying from -0.731 to -0.330 and a standard deviation of 0.102 is the less volatile currency.

Fig. 1 plots the real exchange rates series for these six country pairs. We do not find any significant upward or downward trend in the real exchange rate series. From these figures, for most of the series, there seem to exhibit some nonlinear adjustment patterns.

3. Threshold cointegration tests based on Enders and Siklos' (2001) approach

In the present study, we employed the threshold cointegration technique, which was advanced by Enders and Siklos (2001), to test for long-run PPP with asymmetric adjustments for G-7 countries. This test involves a two-stage process. In the first stage, we estimated a long-run equilibrium relationship using the following equation:

$$e_t = \alpha_0 + \alpha_1 p_t^* + \alpha_2 p_t + u_t \quad (1)$$

where e_t is the logarithm of the foreign exchange rate in the domestic currency, p_t^* and p_t represent the logarithm of foreign and domestic price levels, respectively, and u_t is the stochastic disturbance term. The second stage, which pertained to the OLS estimates of ρ_1 and ρ_2 was based on the following regression:

$$\Delta u_t = I_t \rho_1 u_{t-1} + (1 - I_t) \rho_2 u_{t-1} + \sum_{i=1}^l \gamma_i \Delta u_{t-i} + \varepsilon_t, \quad (2)$$

where μ_t in (1) is substituted into (2) and ε_t is a white-noise disturbance and the residuals. I_t is the Heaviside indicator function, such that $I_t = 1$ if $u_{t-1} \geq \tau$, and $I_t = 0$ if $u_{t-1} < \tau$, where τ is the threshold value. The necessary condition for $\{\mu_t\}$ to be stationary is $-2 < (\rho_1, \rho_2) < 0$. If the variance of ε_t is sufficiently large, it is also possible for one value of ρ_j to be between -2 and 0 and the other value to be equal to zero. Although there is no convergence in the

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