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Real exchange rate dynamics: Evidence from India

Natalie D. Hegwood, Hiranya K. Nath *

Department of Economics and International Business, Sam Houston State University, Huntsville, TX 77341-2118, USA

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ABSTRACT

This paper examines the dynamic behavior of bilateral real exchange rates between India and 16 of its trading partner countries using annual data from 1960 to 2010. We use panel unit root test procedures, with and without structural breaks, to investigate if there is any evidence in India's bilateral real exchange rates data to support the Purchasing Power Parity (PPP) hypothesis. While the unit root null is rejected in all three cases – with no structural break, one structural break, and two structural breaks – at least at the 5% level of significance, the evidence is much stronger in the cases with structural breaks. Furthermore, we correct for small sample bias and time aggregation bias to obtain unbiased estimates of half-life. However, in the case with no structural break, although we find evidence of mean reversion, an unbiased half-life estimate of about 8 years implies an extremely slow speed of mean-reversion. When we consider the cases with structural breaks, the unbiased half-life estimates are greatly reduced. With two structural breaks, the unbiased half-life estimate is about one year.

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1. Introduction

The dynamics of real exchange rate has been an important and widely researched topic in economics. The purchasing power parity (PPP) hypothesis, based on the law of one price, is at the core of this literature. PPP implies that, "once converted to a common currency, national price levels should be equal" (Rogoff, 1996). The test of this hypothesis essentially involves testing for mean-reversion in real exchange rate. This is important for several reasons. *First*, in most models of exchange rate determination, PPP is regarded as a long-run equilibrium or an arbitrage condition in goods and assets markets. *Second*, real exchange rate movement plays an important role in inter-temporal smoothing of traded goods consumption (Rogoff, 1992) and in cross-country redistribution and transfer of wealth (Obstfeld and Rogoff, 1995). *Finally*, evidence of mean-reversion or a lack of it helps identify the shocks that characterize real exchange rate dynamics. For example, evidence of mean-reversion implies that nominal disturbances have only transitory impact on real exchange rate while a lack of such evidence implies that permanent real shocks are behind the real exchange rate movements.

Numerous empirical studies on the PPP hypothesis have been conducted and published over last several decades.[1] The results have been mixed. While some studies find evidence of mean reversion, others do not. The rejection of the PPP hypothesis has been broadly termed as the "PPP puzzle" (*a la* Rogoff, 1996) and tremendous time and efforts have been expended on resolving this puzzle. A variety of datasets and empirical methods have been employed in this endeavor. Some

* Corresponding author. Tel.: +1 936 294 4760; fax: +1 936 294 3488.
E-mail address: eco_hkn@shsu.edu (H.K. Nath).

[1] Although the PPP theory has been around for several centuries, the empirical studies to test the theory started appearing in the late 1970s. With the development of new and sophisticated econometric techniques and ever-increasing computing power, there has been a flurry of empirical studies over last three decades or so. Rogoff (1996) provides a review of the earlier studies. Taylor and Taylor (2004) survey the literature for the preceding three decades.

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studies have explored probable causes for the breakdown of the PPP hypothesis and have suggested a number of plausible explanations. They include: (i) tariff and non-tariff trade barriers; (ii) transportation costs associated with moving goods from one country to another; (iii) the failure of nominal exchange rates to adjust to relative price-level shocks; (iv) the presence of nontraded goods prices in the calculation of general price levels; (v) existence of segmented markets.

On the methodological side, there have been several important developments with regard to the procedures employed to test for mean-reversion. Primarily after the publication of Perron's seminal work on structural break in (Perron, 1989), adding shifts in the mean (that represent structural breaks) of a real exchange rate series has been used as a solution to the inability to reject the unit root.[2] Dornbusch and Vogelsang (1991), Perron and Vogelsang (1992), Culver and Papell (1995), and Hegwood and Papell (1998, 2002) are some of the notable early examples along this line of research. However, these studies include only one structural break. Lumsdaine and Papell (1997) and Papell and Prodan (2006) extend this analysis by adding a second break into the unit root test framework. There have been a number of recent studies (e.g, Dimitriou and Simos, 2013) that include one or more structural breaks in the investigation of the PPP hypothesis.[3]

Incorporating structural breaks in the panel context represents the next development. For example, using several panels of between 11 and 20 real exchange rates, Papell (2002) conducts unit root tests with multiple structural breaks that correspond to specific major depreciations and appreciations of the US dollar. While the results are mixed, there is some evidence of PPP when those breaks are included in some of the panels. Im et al. (2005) also incorporate structural breaks in several panels and are able to reject the unit root null for each of them. Narayan (2008) tests a panel of 16 OECD countries. While incorporating a single break does not allow a unit root rejection, adding a second break does. More recently, Lin and Lee (2010) are able to reject the unit root in a panel of G7 real exchange rates by incorporating multiple structural breaks.

In this paper, we examine the dynamic properties of bilateral real exchange rates between India and 16 of its trading partner countries using annual data for a period between 1960 and 2010. During this period, India has moved from a low growth trajectory to a high growth trajectory. In 1991, India carried out major market-oriented reforms and trade liberalization. As part of the economic liberalization, India moved to a market-determined floating exchange rate regime in 1993.[4] In last two decades, the GDP share of trade has increased from about 16% in 1990 to 46% in 2010. The flow of international capital has increased manifold. Thus, it is important to investigate the dynamic behavior of India's real exchange rates.[5]

We use panel unit root tests with and without structural breaks to examine if there is evidence in India's bilateral real exchange rates data to support the PPP hypothesis.[6] While the unit root null is rejected in all three cases – with no structural break, one structural break, and two structural breaks – at least at the 5% level of significance, the evidence is much stronger in the cases with structural breaks. We further report unbiased estimates of half-life. We correct for small sample bias and time aggregation bias to obtain these unbiased half-life estimates. In the case with no structural break, although we find evidence of mean reversion, an unbiased half-life estimate of about 8 years implies extremely slow speed of mean reversion. However, when we consider the cases with structural breaks, the unbiased half-life estimates are greatly reduced. With two structural breaks, the unbiased half-life estimate is about one year.

The rest of the paper is organized as follows. Section 2 describes the data. In Section 3, we present the results of panel unit root test procedures. We first report the results with no structural break and we then report the test results with structural breaks. Section 4 presents the unbiased estimates of half-life. Section 5 includes our concluding remarks.

2. Data

We obtain annual data on nominal exchange rates and consumer price indices (CPIs) for India and 16 countries in our sample for the period between 1960 and 2010 from four different sources: *International Financial Statistics* (IFS) compiled and published by International Monetary Fund (IMF); *Penn World Table Version* 7.0 (Heston et al., 2011); *Office for National Statistics*, UK (statistics.gov.uk); and Measuring Worth.com (Officer, 2011).[7] The base year for CPI was 2005. The sample of

[2] A rejection of the unit root null has been interpreted as evidence in support of PPP in the literature.

[3] There are other studies that examine nonlinear adjustment to PPP. For example, see Baum et al. (2001); Sollis et al. (2002); Sollis (2009); Chang et al. (2012). Tiwari and Shahbaz (2014) use threshold cointegration and nonlinear unit root test to examine the PPP hypothesis in the context of India.

[4] Between 1950 and 1973, India followed an exchange rate regime with Indian Rupee (INR) linked to British Pound Sterling (GBP). When GBP floated in 1972, INR's link to the British currency was maintained. In 1975, INR's ties to GBP were broken. India conducted a managed float exchange regime with INR's effective rate placed on a controlled, floating basis and linked to a "basket of currencies" of India's major trading partners. This regime continued until the early 1990s.

[5] Previous studies (e.g. Baghestani, 1997; Kohli, 2002; Narayan, 2006) have examined exchange rate behavior in India. The current study is more akin to Narayan (2006) in its coverage and focus.

[6] The methods used in the current study are similar to those used by Hegwood and Nath (2013) and Nath and Sarkar (2014). However, these studies examine city relative price convergence within the US and Australia respectively.

[7] One reviewer suggests that we should use high frequency (daily, weekly, monthly) exchange rate data. Since we are examining real exchange rate, we will also need high frequency data on CPI. To the best of our knowledge, there are no daily and weekly CPI data even for the developed countries where data collection practices are most advanced. For most developing countries (our sample includes a few), it is not available even at monthly frequency. Even high frequency nominal exchange rate data are not available for our entire sample period that begins in 1960. For developing countries, high frequency data are available only for last few years. Besides, the PPP hypothesis is about long-run behavior. Therefore, we believe that it would not be appropriate to test this hypothesis about the long-run behavior of real exchange rate with only a few years of noisy daily data.

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