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Abstract: We show that the use of the real effective exchange rate to test for purchasing power parity, as in Astorga (2012) and other studies, introduces a bias against finding evidence of PPP. The bias is illustrated using unit root tests applied to bilateral real rates.

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I. Introduction

In this paper we prove that the use of the real *effective* exchange rate (REER) introduces a bias against the purchasing power parity hypothesis into stationarity tests. Our argument is straightforward; the real effective exchange rate is constructed using bilateral real exchange rates (RER) weighted, typically, by trade shares of a country's major trading partners. If *N* bilateral real rates are used in the construction of the effective rate, then either *each of the N* real rates must be an *I(0)* process or those real rates that are not *I(0) must be* cointegrated to form an *I(0)* process for the REER to be stationary. If, by chance, evidence of PPP were found using the REER, it could mean that PPP holds for each of the bilateral rates used in the REER leading one to question the benefit from using the real effective exchange rate. Alternatively, it could mean that some of the bilateral real rates are integrated processes so that PPP and its underpinning, the law of one price, do not hold but (somehow) a cointegrating relationship exists among the integrated bilateral rates. If arbitrage to maintain the law of one price does not hold what would stationarity of the REER signify? It could not be evidence of purchasing power parity

In a recent study Astorga (2012) looks for evidence of purchasing power parity in annual real effective exchange rates (REER) of six Latin American countries for 1900-2000. Consistent with our contention, Astorga finds no evidence of stationarity in the real effective exchange rates of the six countries in his initial tests. Additional tests that include a trend and allow for structural breaks do reveal support for mean reversion of the REER, which he interprets as evidence of PPP. Our criticisms of employing REER in purchasing power parity studies are motivated by Astorga (2012) but he is not the only researcher using real effective exchange rates to test for PPP. A partial list of recent work includes Arize (2011), Bahmani-Oskooee, Hegerty, and Kutan (2009), and Bahmani-Oskooee, Kutan and Zhou (2008). In a widely cited paper, Taylor (2001) finds support for PPP when calculating real exchange rates relative to a world basket of currencies. Although Taylor's measure uses a simple average of real rates, rather than trade-weighted shares, our argument applies equally to his world basket measure.

The rest of the article is organized as follows: in Section II, we formally present our main argument. In Section III, we illustrate our argument empirically using the same dataset of Astorga (2012). Section IV concludes the paper.

II. Econometrics arguments

The REER is constructed as a weighted average of bilateral real rates.

$$\varepsilon_{jt} = \sum_{i \neq j} \alpha_{ijt}\left(e_{ijt} + p_{it} - p_{jt}\right) \tag{1}$$

Let N be the number of bilateral real rates used in construction of the real effective exchange rate and T be the sample size. Then $p_{jt}, p_{it}, e_{ijt}, \alpha_{ijt}$ for $i, j = 1,2, \dots, N$ and $t = 1,2, \dots, T$ are, respectively, the period t logarithms of the home country j price index, the price index of country i, the nominal exchange rate, and the trade share of country i relative to total trade of home country j. The nominal exchange rate is expressed as the country j price of a unit of country i currency. Note that the expression in parentheses corresponds to the bilateral real exchange rate between countries i and j in period t. Support for the PPP hypothesis is asserted if standard unit roots tests reject the null hypothesis of non-stationarity, i.e., when $\varepsilon_{jt} \sim I(0)$.[1]

Formally, cointegration means that the components of a vector x_t are cointegrated of order d, b [$x_t \sim CI(d,b)$], if (i) all components of x_t are $I(d)$, (ii) there exists a vector α ($\alpha \neq 0$) so that $u_t = \alpha' x_t \sim I(d-b)$, $b>0$[Engle and Granger (1987)]. When looking for evidence of stationarity between just three variables, as in the case of a unit root test applied to the bilateral real exchange rate, the practitioner is trying to infer whether there is a linear combination of the variables that cancels their stochastic trend components. If the practitioner decides to increase the number of variables to be included in the linear combination, as would occur if the REER is used instead of the RER, obtaining statistical

[1] Note that testing for PPP using this approach implies a restricted cointegration analysis between prices and nominal exchange rates because the elements of the cointegration vector are preset. Specifically, the coefficient associated with the domestic price index must be minus one, while those associated with the nominal exchange rate and foreign price indexes are equal to one.

evidence of such a linear combination entails a higher degree of difficulty for the simple reason that REER involves *N>1* trade-weighted RERs. A sufficient condition for nonstationarity of the REER is that just one of these RER series is integrated of order one (or higher). In other words, even if *N-1* RERs are stationary and the remaining one is *I(1)*, the weighted sum of all the RER would remain non-stationary. The proof is straightforward.

Proof:

Suppose there are *N-1* stationary random variables, RER_{it}~*I(0)* for *i=1,…N-1* and let $RER_{Nt} = \sum_{i=1}^{t} u_i$ be integrated of order 1, *I(1)*. Let a_i, for *i=1…N*, be positive constants such that $0<a_i<1$ for all i and $\sum_{i=1}^{N} a_i = 1$. For the sake of simplicity, but without any loss of generality, suppose $RER_{it} \sim iidN(0, \sigma_i^2)$ for *i=1,…,N-1* and $u_t \sim iidN(0, \sigma_u^2)$. Finally, assume $\varepsilon_t = \sum_{i=1}^{N} a_i RER_{it}$. The first two moments of ε_t are: (i) $E(\varepsilon_t)=0$, and $V(\varepsilon_t) = t\sigma_u^2 + \sum_{i=1}^{N-1} \sigma_i^2$. The resulting variable, ε_t (which corresponds exactly to the *REER*) is clearly not covariance-stationary and any test for stationarity of ε_t should not be able to reject the null hypothesis of a unit root.

Q.E.D.

Assuming no cointegration of the component series, extension of the proof to cases of a REER that is constructed from multiple, integrated bilateral real rates and to higher orders of integration of the RER components, is straightforward.

III. Empirical Illustration

Astorga (2012) tests for mean reversion of the REER of six Latin American countries; Argentina, Brazil, Chile, Colombia, Mexico and Venezuela; using annual data for 1900-2000. To calculate the REER series for a country he includes the bilateral RERs of the most important trading partners: US, UK, Germany, France, Japan, and one or two Latin American countries. He finds that the null hypothesis of a unit root in the REER series cannot be rejected for any country using the ADF and Phillips-Perron unit-root tests. In most cases de-trending each REER series still leads to failure to reject the null. He interprets the test results as indicating that the series do not revert to a constant mean possibly because of the presence of either a deterministic trend and/or structural shifts in the series.

In practice, does the bias against stationarity, inherent in the construction of the real effective exchange rate series, affect conclusions one can draw from empirical work regarding the validity of PPP? To answer this query we apply standard unit-root tests to the bilateral RER relative to the US dollar that Astorga used in constructing the real effective exchange rate measures. The *t*-statistics from the augmented Dickey-Fuller and Phillips-Perron tests (used by Astorga) applied to the bilateral rates are shown in Table 1. Test equations include an intercept but not a trend.

Table 1.UnitRoot*t*-Statistics for Bilateral Real Exchange Rates

Country	*ADF*	*PP*
Argentina	-3.24*	-3.43*
Brasil	-3.94**	-3.08*
Chile	-4.92**	-4.95**
Colombia	-1.13	-1.11
México	-2.45	-2.33
Venezuela	-2.50	-2.37

The symbols **, * denote rejection of the null hypothesis at 1% and 5%, levels, respectively.

Unlike Astorga's findings using the real effective exchange rate, the results display clear evidence of stationary bilateral real rates, hence evidence of PPP, for Argentina, Brazil and Chile. In contrast neither the ADF nor Phillips-Perron test reveals support for PPP in the real exchange rates of Colombia, Mexico, and Venezuela. These results suggest that PPP does hold for at least some of these countries and that the use of real effective exchange rates rather than bilateral real rates is unlikely to show evidence of purchasing power parity except under the exceptional circumstance of cointegration among the bilateral RERs.

IV. Conclusions

The main implication of our findings is that use of the real effective exchange rate to test for PPP makes it very unlikely that evidence of purchasing power parity will be found. We have illustrated the problem using two standard unit root tests and data from Astorga; but our arguments apply equally to any other tests for mean reversion of the REER such as cointegration methods and panel unit root tests.

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References

Andrews, D.W.K., 1993. Exactly median-unbiased estimation of first order autoregressive/unit root models, *Econometrica* 61, No 1 139–165.

Arize, A.C., 2011.Purchasing power parity in LDCs: An empirical investigation, *Global Finance Journal* 22, 56-71.

Astorga, P., 2012.Mean reversion in long-horizon real exchange rates: Evidence from Latin America*, Journal of International Money and Finance* 31, 1529–1550.

Bahmani-Oskooee, M., Hegerty S.W., and Kutan, A.M., 2009. Is PPP sensitive to time-varying trade weights in constructing real effective exchange rates? *Quarterly Review of Economics and Finance* 49, 1001-1008.

Bahmani-Oskooee, M.,Kutan, A.M., and Zhou S., 2008. Do real exchange rates follow a nonlinear mean reverting process in developing countries? *Southern Economic Journal* 74, 1049-1062.

Christiano, L., 1992.Searching for a break in GNP, *Journal of Business & Economic Statistics* 10, 237–250.

Dickey, D. Fuller, W., 1979.Distribution of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association* 74, 427–431.

Engle, R.F. and Granger, C.W.J, 1987. Co-integration and error correction: representation, estimation, and testing, *Econometrica* 55 (2), 251-276.

Kapetanios, G., 2005. Unit-root testing against the alternative hypothesis of up to m structural breaks, *Journal of Time Series Analysis* 26 (1), 123-133.

Lumsdaine, R.L. and Papell, D.H., 1997. Multiple trend breaks and the unit-root hypothesis, *Review of Economics and Statistics* 79, 212-218.

Perron, P., 1989. The great crash, the oil price shock and the unit root hypothesis, *Econometrica* 57, 1361–1401.

____________ , 1990.Testing for a unit root in a time series with a changing mean, *Journal of Business & Economic Statistics*8, 153–162.

Sollis, R.,Leybourne, S. and Newbold, P., 2002. Tests for symmetric and asymmetric nonlinear mean reversion in real exchange rates, *Journal of Money, Credit, and*

Banking 34, 686–700.

Taylor, A., 2002. A century of purchasing-power-parity, *Review of Economics and Statistics* 84, 139-150.

Zivot, E., and Andrews, D., 1992. Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis, *Journal of Business & Economic Statistics* 10, 251–270.