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# Nonlinearities or outliers in real exchange rates? ☆

Antonia López Villavicencio *

*EconomiX, Universite de Paris X-Nanterre, France*

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**Abstract**

Long-lasting misalignments in the real exchange rates are sometimes explained by the presence of a nonlinear adjustment process towards the long-run equilibrium. However, while it is possible that evidence of nonlinearity exists for some real exchange rates, outliers and nonlinearity may easily be confused. This paper uses robust methods to examine and compare the behaviour of Smooth Transition Autoregressive [STAR] models for the real exchange rates of 14 countries. The results show that the evidence for nonlinearity is reduced when considering outliers. Nonlinearity is also more common among developing economies.
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## 1. Introduction

The purchasing power parity (PPP) is a simple concept of long-run or equilibrium exchange rate in the literature that implies a constant equilibrium exchange rate.[1] In other words, the PPP maintains that there exists a deterministic steady state level of real exchange rate (the equilibrium real exchange rate) towards which the current value converges in the long run. Yet, even though its popularity, many studies that test PPP during the recent float cannot reject the random walk hypothesis for the real exchange rates of the currencies of all the major industrialized countries against one another, suggesting that deviations from PPP are permanent (for example, Engle, 2000).

Therefore, failure to provide evidence for the PPP has motivated several justifications. For instance, recently, a number of studies (Michael et al., 1997; Sarantis, 1999; Taylor et al., 2001) have explained the persistent misalignments in the real exchange rates during the post-Bretton Woods period by the presence of a nonlinear adjustment process

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* Departament d'Economia Aplicada, Universitat Autonoma de Barcelona, Spain.
*E-mail address:* alopezv@selene.uab.es.

[1] Other concepts of equilibrium exchange rates, as the Fundamental Equilibrium Exchange Rate (FEER) by Williamson (1985), the Behavioral Equilibrium Exchange Rate (BEER) by Clark and MacDonald (1998) and the Natural Real Exchange Rate (NATREX), introduced by Stein (1994), have also been suggested in the literature.

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towards the PPP.[2] While the most common causes for nonlinearity are the existence of transactions costs, mainly due to the cost of transportation (Dumas, 1992), other arguments, such as the heterogeneity of opinions in the foreign exchange market concerning the equilibrium level of the nominal exchange rate (see Taylor and Allen, 1992; Kilian and Taylor, 2003), the speculative attacks on currencies (Flood and Marion, 1998), the presence of target zones (Krugman, 1991), noise traders (De Long et al., 1990) or the heterogeneity of the interventions of central banks (Dominguez, 1998) have also been advanced.[3]

In general terms, the idea of nonlinearities in the adjustment process implies that there exists a band for the real exchange rate (RER) within which the marginal cost of arbitrage exceeds the marginal benefit. The thresholds then not only reflect shipping costs and trade barriers *per* se, but also they are the result of the sunk cost of international arbitrage and the resulting tendency for traders to wait for sufficiently large arbitrage opportunities to open up before entering the market. That is, the profits from commodity arbitrage, which is generally thought to be the ultimate force behind maintaining the PPP, do not make up for the cost involved in the necessary transactions for small deviations from the equilibrium real exchange rate. This implies the existence of a band around the equilibrium rate in which there is no tendency of the real exchange rate to revert to its equilibrium value. Outside this band, commodity arbitrage becomes profitable, forcing the real exchange rate towards the band.

To capture the phase-dependent properties, most of the empirical studies on real exchange rates specify the switch between regimes as a function of past values of the real exchange rate by means of smooth transition autoregressive (STAR) models, as suggested by Terasvirta and Anderson (1992), Granger and Terasvirta (1993) and Terasvirta (1994). Based on this approaches, these studies conclude that the RER in industrialized countries behave more like a unit root process the closer they are to long-run equilibrium and, conversely, become more mean reverting the further they are from it.[4]

However, even if STAR characterizations may be useful to explain deviations from the Purchasing Power Parity (PPP) in some cases, it is possible that this apparent nonlinearity is due to outlier observations in the series.[5] Indeed, many linear economic time series are contaminated by occasional outliers. In particular, given the changes in exchange rate regimes, financial or political crisis and other sharp disturbances, real exchange rates are subject to substantial variations. These turbulent histories appear as structural shifts or as outliers in the real exchange rates. In the presence of some aberrant observations, nonlinearity tests may incorrectly point towards nonlinear structures.

Yet, it is also possible that the nonlinear properties of the series are reflected in a few observations. One may be tempted to view these nonlinear data points as aberrant observations and remove them dramatically, thus destroying intrinsic nonlinearity (van Dijk, 1999). Indeed, it may be the case that the presence of these outliers allows one to detect the way and speed of adjustment towards equilibrium. Therefore, eliminating outliers can sometimes lead to the omission of valuable information about the equilibrium.

In this context, the aim of this paper is to analyze whether the characteristics of the adjustment process of the real effective exchange rates for a group of 14 countries can be explained by STAR-type models and, if so, to investigate non-linearities in real effective exchange rates. Our study differs from most of the earlier literature on nonlinear exchange rate modeling at least in two important ways. First, in contrast to previous investigations, we adopt a robust test for STAR type nonlinearity. The main advantage of this robust procedure is that it automatically guards the test against outliers and does not require a priori knowledge concerning their presence and timing (Escribano et al., 1998).[6]

[2] While there are various ways to think about equilibrium exchange rates, our paper centers on the most popular concept of equilibrium in applied exchange rate analysis which is the PPP. The interest for this concept of equilibrium is that its validity as an exchange rate benchmark is still a subject of heated controversy. Yet, it can also be the case that the concept of equilibrium is richer than PPP. For an application of nonlinear adjustment of European exchange rates using a BEER approach see Dufrénot et al. (2006).

[3] It can also be the case that persistent misalignments of the exchange rates from their equilibrium value (i.e., the Purchasing Power Parity or an equilibrium value according to the fundamentals) are due to the long-memory property of the adjustment process towards equilibrium. In this case it would be more natural to study the RER misalignment using fractional cointegration models (see, for example, Dufrénot et al., 2006). This is a relevant point since it is well known that long-memory and nonlinearity can easily be confused.

[4] See Michael et al. (1997), Sarantis (1999), Taylor et al. (2001) who investigate nonlinear adjustment dynamics of exchange rates in major industrial countries.

[5] Although it is not a formal definition, an outlier can be described as an observation (or a subset of observations) which appears to be inconsistent with the remaining of that set of data (Barnett and Lewis, 1994).

[6] Several papers consider testing for unit roots in the presence of structural changes and outliers (for instance, Hegwood and Papell, 1998; Lothian and Taylor, 1996). They argue that shifts in the intercept and/or slope of the trend function of a stationary time series biases standard unit-root tests toward non rejection. However, to our knowledge, no previous investigation exists that tests for a nonlinear mean reversion in real exchange rates in the presence of outliers.

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