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Nonlinear adjustment of the real exchange rate towards its equilibrium value: A panel smooth transition error correction modelling

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ABSTRACT

We study the nonlinear dynamics of the real exchange rate towards its behavioral equilibrium value (BEER) using a Panel Smooth Transition Regression model framework. We show that the real exchange rate convergence process in the long-run is characterized by nonlinearities for emerging economies, whereas industrialized countries exhibit a linear pattern. Moreover, there exists an asymmetric behavior of the real exchange rate when facing an over- or an undervaluation of the domestic currency. Finally, our results suggest that the real exchange rate may be unable to unwind alone global imbalances.

1. Introduction

The assessment of equilibrium values for the real exchange rate has always been an important issue in international macroeconomics, especially in the current context of global imbalances. Between the short-run market view and the PPP attractor supposed to hold at a remote time horizon, a wide range of intermediate approaches have been developed.[1] Among them, there is the BEER or "Behavioral Equilibrium Exchange Rate" model which has been introduced by Clark and MacDonald (1998) and has proved to be a consistent framework to derive equilibrium exchange rate values.[2] This approach consists in the estimation of a long-run (cointegrating) relationship between the real effective exchange rate and a set of economic fundamentals. The BEER value is then calculated by predicting the real effective exchange rate from the estimated long-run equation. Vector error correction models (VECM) are subsequently perfectly accurate to assess the speed at which the real exchange rate converges towards its equilibrium value.[3]

In this context, according to the standard macroeconomic view, any deviation from the equilibrium level is considered as temporary since there are forces ensuring quickly mean-reverting dynamics. However, in many countries, the experience of real exchange rates over the last two decades has been characterized by substantial misalignments, with time lengths much higher than suggested by the theoretical models (Dufrénot et al., 2008). The fact that exchange rates can spend long periods away from their fundamental values implied a revival of interest in the study of exchange rate misalignments. Our aim is to contribute to this literature by investigating the dynamics of the adjustment process of the exchange rate towards its equilibrium value in a nonlinear panel framework.

The nonlinear cointegration support allows us to investigate the slowness of the adjustment process towards the long-run equilibrium. Numerous factors may explain such a nonlinear dynamics: transaction costs (Dumas, 1992; Sercu et al., 1995; O'Connell & Wei, 1997; Obstfeld & Taylor, 1997; Imbs et al., 2003), heterogeneity of buyers and sellers (Taylor & Allen, 1992), speculative attacks on currencies (Flood & Marion, 1999), presence of target zones (Krugman, 1991; Tronzano et al., 2003), noisy traders causing abrupt changes (De Long

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[1] For recent surveys, see MacDonald (2000), Driver and Westaway (2004) and MacDonald and Dias (2007).

[2] See Bénassy-Quéré et al. (2009) for a detailed study on the robustness of the BEER approach.

[3] An interesting study on this topic is provided by MacDonald and Dias (2007) who investigate exchange rate adjustments which are necessary to achieve equilibrium values, corresponding to Williamson (2006)'s scenarios.

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et al., 1988), heterogeneity of central banks' interventions (Dominguez, 1998). All these factors imply, either a nonlinear relationship between the exchange rates and the economic fundamentals, or a nonlinear adjustment mechanism with time-dependence properties. We consider here a smooth transition model for the adjustment process which can be viewed as a reduced form of structural models of fundamental exchange rate accounting for nonlinearities such as transaction costs, changing-regimes fluctuations,... Moreover, such models help at modelling asymmetries inherent to the adjustment process. This is particularly interesting since these asymmetries may explain, for instance, the unequal durations of under-valuations and over-valuations.

While numerous contributions have applied this nonlinear cointegration methodology in time series[4], this has not been done so far in the panel context. This constitutes a lack since we think that, to derive consistent equilibrium values of exchange rates, it seems important to work with a large panel of countries. Indeed, as noticed by Bénassy-Quéré, Duran-Vigneron, Lahrèche-Révil and Mignon (2004) among others, the large literature on equilibrium exchange rates has typically focused on country-by-country estimations of equilibrium exchange rates (Clark & MacDonald, 1998) or on consistent estimations of equilibrium exchange rates for a set of industrial economies (Williamson, 1994; Wren-Lewis & Driver, 1998). Until the mid-1990s, this approach was in line with a two-tier international monetary system, the first tier consisting in a small number of key currencies (the dollar, the Deutschemark, the yen and the British pound) and the second tier consisting in all other currencies. Since the mid-1990s, the rising share of emerging countries in global imbalances has made such divide no longer adequate and calls for the estimation of consistent sets of equilibrium exchange rates for a large number of currencies. To account for this evolution, we consider the G-20 in deriving our estimates of equilibrium exchange rates, a group that covers both industrial and emerging economies.

To sum up, the goal of this paper is to investigate the nonlinear behavior of the real exchange rate adjustment process towards its equilibrium value in a panel framework by estimating a Panel Smooth Transition Error Correction Model. To this end, the rest of the paper is organized as follows. Section 2 briefly sketches out methodological aspects relating to panel nonlinear models. Section 3 discusses our approach, data and their properties. Section 4 contains the estimation results and related comments, as well as robustness checks. Section 5 concludes.

2. Panel nonlinear models

2.1. PTR and PSTR models

In his seminal paper, Hansen (1999) introduced the panel threshold regression (PTR) model to allow regression coefficients to vary over time.

Let $\{y_{i,t}, s_{i,t}, x_{i,t};\ t=1, ..., T;\ i=1, \ldots, N\}$ be a balanced panel with t denoting time and i the individual. Denoting $y_{i,t}$ the dependent variable, μ_i the individual fixed effects, $s_{i,t}$ the threshold variable and $x_{i,t}$ a vector of k exogenous variables, the PTR model can be written as follows:

$$y_{i,t} = \begin{Bmatrix} \mu_i + \beta_1' x_{i,t} + \varepsilon_{i,t}, & s_{i,t} \le c \\ \mu_i + \beta_2' x_{i,t} + \varepsilon_{i,t}, & s_{i,t} > c \end{Bmatrix}. \tag{1}$$

In this model, the observations in the panel are divided into two regimes depending on whether the threshold variable is lower or larger than the threshold c. The error term $\varepsilon_{i,t}$ is independent and identically distributed. As in the time series context, the transition from one regime to another is abrupt and the model implicitly assumes that the two groups of observations are clearly identified and distinguished, which is not always feasible in practice.

To account for possible smooth and gradual transitions, González, Teräsvirta and van Dijk (2005) have introduced the panel smooth transition regression (PSTR) model, which is given by:[5]

$$y_{i,t} = \mu_i + \beta_0' x_{i,t} + \sum_{j=1}^{r} \beta_j' x_{i,t} g_j(s_{i,t}^{(j)}; \gamma_j, c_j) + \varepsilon_{i,t} \tag{2}$$

where $r+1$ is the number of regimes, the $g_j(s_{i,t}^{(j)}; \gamma_j, c_j), j=1, ..., r$, are the transition functions, normalized and bounded between 0 and 1, $s_{i,t}^{(j)}$ the threshold variables which may be exogenous variables or a combination of the lagged endogenous one[6] (see van Dijk et al., 2002), γ_j the speeds of transition and c_j the threshold parameters. Following Granger and Teräsvirta (1993) and Teräsvirta (1994) in the time series context or González et al. (2005) in a panel framework, the logistic specification can be used for the transition function:[7]

$$g(s_{i,t}; \gamma, c) = \left[1 + exp\left(-\gamma \prod_{l=1}^{m} (s_{i,t} - c_l)\right)\right]^{-1} \tag{3}$$

with $\gamma > 0$ and $c_1 \le c_2 \le ... \le c_m$. When $m=1$ and $\gamma \to \infty$, the PSTR model reduces to a PTR model. González et al. (2005) mention that from an empirical point of view, it is sufficient to consider only the cases of $m=1$ or $m=2$ to capture the nonlinearities due to regime switching.[8]

2.2. Methodology

Following the methodology used in the time series context, González et al. (2005) suggest a three step strategy to apply PSTR models: (i) specification, (ii) estimation, (iii) evaluation and choice of the number of regimes (choice of r). Let us give some explanations about each of these steps.

The aim of the *identification* step is to test for homogeneity against the PSTR alternative. This can be done by testing the null hypothesis $\gamma=0$. Due to the presence of unidentified nuisance parameters under the null, a first-order Taylor expansion around zero is used for the function g (see Lüükkonen, Saikkonen and Teräsvirta, 1988, or González et al., 2005):

$$y_{i,t} = \mu_i + \beta_0'^{*} x_{i,t} + \beta_1'^{*} x_{i,t} s_{i,t} + ... + \beta_m'^{*} x_{i,t} s_{i,t}^{m} + \varepsilon_{i,t}^{*} \tag{4}$$

where $\beta_1'^{*}, ...\beta_m'^{*}$ are multiple of γ and $\varepsilon_{i,t}^{*} = \varepsilon_{i,t} + r_m \beta_1' x_{i,t}$, r_m being the remainder of the Taylor expansion. Testing the null hypothesis of linearity is then equivalent to test $\beta_1'^{*} = ... = \beta_m'^{*} = 0$ in Eq. (4). To this end, González et al. (2005) provide a LM-test statistic that is asymptotically distributed as a $\chi^2(mk)$ under the null.

As in the time series context, this test can be used to select (i) the appropriate transition variable as the one that minimizes the associated p-value and (ii) the appropriate order m in Eq. (3) in a sequential manner.

Turning to the *estimation* step, nonlinear least squares are used to obtain the parameter estimates, once the data have been demeaned. It should be noted that demeaning the data is not straightforward in a panel context (see Hansen, 1999, and González et al., 2005 for details).

[4] See, for instance, Michael et al. (1997); Ma & Kanas (2000); Chen and Wu (2000); Taylor et al. (2001); Baum, Barkoulas and Caglayan (2001); Dufrénot and Mignon (2002); Dufrénot, Mathieu, Mignon and Péguin-Feissolle (2006); Dufrénot et al. (2008); López Villavicencio (2008).

[5] See also He and Sandberg (2004) and Fok, van Dijk and Franses (2005) who have introduced dynamic nonlinear panel models through the development of PLSTAR (panel logistic smooth transition autoregressive) models.

[6] As Fouquau (2008) reminds us, the endogenous variable must be lagged to avoid simultaneity problems.

[7] To simplify notations, we drop the j in the equation.

[8] Note that the case $m=1$ corresponds to a logistic PSTR model and $m=2$ refers to a logistic quadratic PSTR specification.