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A nonparametric study of real exchange rate persistence over a century ☆

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ABSTRACT

This paper estimates the degree of persistence of 16 long-horizon real exchange rates relative to the US dollar. We use nonparametric operational algorithms by El-Gamal and Ryu (2006) for general nonlinear models based on two statistical notions: the short memory in mean (SMM) and the short memory in distribution (SMD). We found substantially shorter maximum half-life (MHL) estimates than the counterpart from linear models. Our results are robust to the choice of bandwidth with a few exceptions.

1. Introduction

This paper measures the persistence of the real exchange rate using a nonlinear nonparametric approach developed by El-Gamal and Ryu (2006) for 16 long-horizon real exchange rates of developed countries relative to the US dollar.

Taylor (2002) constructed over a hundred-year long real exchange rates for 20 countries. Implementing an array of *linear* unit root tests, he reported very strong evidence in favor of purchasing power parity (PPP), which was later questioned by Lopez, Murray, and Papell (2005) who pointed out that his results were not robust to the choice of lag selection methods. Kim and Moh (2010), however, employed a nonlinear unit root test by Park and Shintani (2005, 2010) that allowed an array of transition functions for Taylor's (2002) data, finding very strong evidence of nonlinear PPP.

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Even though the current literature finds fairly strong evidence for PPP from long-horizon real exchange rates, the profession fails to find persuasive answers to the so-called PPP puzzle (Rogoff, 1996), which states that the 3- to 5-year consensus half-life, based on *linear* models, seems too large to be reconciled by highly volatile short-run exchange rate dynamics.

Furthermore, Murray and Papell (2002) and Rossi (2005), among others, report half-lives with wide confidence intervals that extend to positive infinity. Panel estimations often provide substantially shorter half-lives than the consensus half-life, however, Murray and Papell (2005a, 2005b) reported similarly long half-life estimates from panel models correcting for small-sample bias.[2]

One promising approach to understand the PPP puzzle is to employ nonlinear models of the exchange rate. As shown by Taylor (2001), half-life estimates from linear models tend to be biased upward when the true data generating process (DGP) is nonlinear. Therefore, removing the bias by adopting nonlinear models may yield reasonably short half-life estimates.

Nonlinear models have been widely used in the study of financial data including exchange rates, which are mostly motivated by market friction arguments such as transaction costs (see Dumas, 1992).[3] Examples include Sercu, Uppal, and Van Hulle (1995), Michael, Nobay, and Peel (1997), Obstfeld and Taylor (1997), Sarantis (1999), Taylor, Peel, and Sarno (2001), Kilian and Taylor (2003), Sarno, Taylor, and Chowdhury (2004), Kim and Moh (2010), and Lee and Chou (2013).

However, it is not straightforward how to measure the persistence from nonlinear models, because exchange rates in these researches obey state-dependent stochastic processes. That is, the half-life from these models depends upon the current state and the size of the shock.

One may estimate the persistence of the real exchange rate only in regimes outside the inaction band, that is, subsets of the full sample, which is not fully comparable to half-life measures from linear models based on the full sample. Rigorous methods include Gallant, Rossi, and Tauchen (1993), Koop, Pesaran, and Potter (1996), and Potter (2000) who proposed nonlinear analogs of impulse-response functions. See, among others, Baum, Barkoulas, and Caglayan (2001) and Lothian and Taylor (2008) for research work that employ such methods. Shintani (2006) also proposed a nonparametric method based on the largest Lyapunov exponent of the series to evaluate the speed of adjustment in the presence of nonlinearities, finding fairly shorter half-lives than the consensus half-life.

This paper uses a nonlinear nonparametric approach proposed by El-Gamal and Ryu (2006) that employs more general time series notions of the convergence toward the long-run equilibrium: short-memory-in-mean (SMM) and short-memory-in-distribution (SMD) as an alternative to the stationarity in linear model framework (Granger, 1995; Granger & Teräsvirta, 1993). SMM and SMD nest linear models as a special case.

Our nonparametric approach does not require the knowledge on the parametric representation of transition functions nor any distributional assumptions, so our results are less likely to be influenced by specification errors. In what follows, we provide straightforward algorithms to measure the persistence not only for the first moment (SMM), but also for the entire distribution (SMD). That is, after estimating conditional and unconditional densities by kernel methods, we measure the rate of convergence by using metrics for SMM and SMD based on a worst-case scenario.

Using long-horizon real exchange rates for 16 currencies *vis-à-vis* the US dollar, we find reasonably short half-lives using notions of SMM and SMD with exceptions of Canada, Japan, and Switzerland. Especially, our maximum half-life estimates for SMM with asymptotically optimal bandwidth are substantially shorter than those from linear models (e.g., Murray & Papell, 2002, 2005a, 2005b; Rossi, 2005), which confirms the issue of an upward bias suggested by Taylor (2001). Our estimates for SMD add new insights to the current literature in favor of a century-long PPP, which is valid even when first moments are not well-defined. We also report maximum quarter-life estimates (Steinsson, 2008) to study monotonicity of convergence over time.

We also note that our results provide interesting contrast compared with those of El-Gamal and Ryu (2006) who used five short-horizon current float (post Bretton Woods) exchange rates relative to the US dollar. Their estimates tend to exhibit very slow convergence rates as the bandwidth parameter increases, which may imply indefinitely long half-lives, even though their half-life estimates are similar to ours when fairly wide bandwidth window is used. This may indicate that utilizing long-horizon data might be crucially important to help understand the PPP puzzle.

The remainder of the paper is organized as follows. Section 2 presents our baseline methodologies and operational algorithms for estimating convergence rates using our key statistical notions. In Section 3, we describe the data and report major empirical findings. Section 4 concludes.

2. The econometric model

This section presents some useful definitions for our nonparametric model as an alternative to conventional linear models that are often employed in the current empirical international economics literature. We also provide our nonparametric measures of persistence for a general Markovian univariate time series models.

Let e_t be the natural logarithm nominal exchange rate as the domestic currency (US dollar) price of the foreign currency. p_t and p_t^* denote the price level in the home (US) and the foreign country, respectively, in natural logarithms. When e_t, p_t^*, and p_t are individually

[2] One related issue of aggregation bias was raised by Imbs, Mumtaz, Ravn, and Rey (2005), who point out that PPP puzzle might be caused by aggregation bias which neglects sectoral heterogeneity in convergence rates, while Chen and Engel (2005), Parsley and Wei (2007), Crucini and Shintani (2008), and Broda and Weinstein (2008) have found negligible aggregation biases.

[3] Prohibitively large transaction costs may discourage economic agents from engaging in arbitrage. That is, adjustments toward the long-run equilibrium take place only when deviations from the equilibrium are big enough.