Economic Modelling 27 (2010) 605–612

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Do real exchange rates really follow threshold autoregressive or exponential smooth transition autoregressive models?

Gawon Yoon *

School of Economics, Kookmin University, Seoul, 136-702, Republic of Korea

ARTICLE INFO

Article history:
Accepted 27 November 2009

JEL classification:
C22
F31

Keywords:
Entropy
Nonlinear serial dependence
Purchasing power parity
Threshold autoregression
Exponential smooth transition autoregression
Nonlinearity

ABSTRACT

Nonlinear models, especially threshold autoregressive [TAR] and exponential smooth transition autoregressive [ESTAR] classes, are widely applied for modeling real exchange rates in order to examine the validity of purchasing power parity [PPP]. Even though the nonlinear models are theoretically well-motivated, some of the recent findings cast doubts on their relevance for real exchange rates. In particular, the nonlinear models do not necessarily yield improved out-of-sample forecasts over linear models and add little value in resolving the well-documented PPP puzzle. Utilizing a nonparametric entropy measure of dependence proposed by Granger et al. (2004), we show, in this study, that the real exchange rates from four major countries had exhibited quite strong *nonlinear* serial dependence, which linear autoregressive models fail to replicate. Furthermore, the nonlinear TAR and ESTAR models estimated for the real exchange rates also have some difficulty in generating significant serial dependence structure actually observed in the data. Overall, other nonlinear models than the currently entertained TAR and ESTAR should be considered to study the dynamics of the real exchange rates.

© 2009 Elsevier B.V. All rights reserved.

1. Introduction

Linear autoregressive models are popular for modeling the dynamics of real exchange rates to examine the validity of purchasing power parity [PPP]. See e.g. Rogoff (1996), Sarno and Taylor (2002), Taylor and Taylor (2004), and Taylor (2006, 2003) for recent surveys on the vast literature on PPP. The linear models usually yield, however, the unappealing finding that the real exchange rates are nonstationary, or I(1), and that PPP does not hold. Even when the models are stationary, the estimated half-lives of the shocks to real exchange rates are quite long, ranging from 3 to 5 years, thereby yielding the so-called PPP puzzle, see e.g. Rogoff (1996).

To resolve the difficulties associated with linear models, various nonlinear models are entertained recently. For instance, Obstfeld and Taylor (1997) apply band-threshold autoregressive [TAR] models, where the real exchange rates are random walks inside bands of inaction, because transaction costs prevent arbitrage from correcting the deviations from PPP, whereas they are mean-reverting outside the bands. Taylor et al. (2001) employ exponential smooth transition autoregressive [ESTAR] models, in which the speed of mean reversion increases as the real exchange rates move away from their long-run equilibrium values. Other applications of the nonlinear models to PPP include Michael et al. (1997), Taylor (2001), Sollis et al. (2002), Kilian and Taylor (2003), Sarno et al. (2004), Bec et al. (2004), and Paya and Peel (2004, 2005, 2006), among many others. In fact, the TAR and ESTAR models are quite popular in modeling other economic variables as well. Additionally, other nonlinear models are also proposed for modeling real exchange rates; see e.g. Markov regime switching models in Kanas (2006), GARCH models in Brooks (1997), and stochastic unit root processes in Bleaney and Leybourne (2003).

Because the TAR and ESTAR models specified in Obstfeld and Taylor (1997) and Taylor et al. (2001) are stationary and ergodic, it is assumed that PPP holds from the beginning. Additionally, theoretical arguments based on the presence of international transaction costs dictate that the nonlinear models should be relevant for real exchange rates; see e.g. Dumas (1992), Sercu et al. (1995), and Sarno and Taylor (2002). Taylor et al. (2001) also show via Monte Carlo simulations that the half-lives of the large shocks to real exchange rates become substantially lower in their ESTAR models, and that the PPP puzzle is easily resolved. In summary, the nonlinear models turn out to be quite useful in overcoming some of the difficulties associated with linear models.

While the nonlinear models are routinely applied to various economic variables and new inference procedures are developed, see e.g. Granger and Teräsvirta (1993), Kapetanios et al. (2003), Kapetanios and Shin (2006), and Park and Shintani (2005), recent evaluation of the models casts some doubts on their relevance for modeling real exchange rates. For example, via quite an extensive evaluation of the forecasting performance of the TAR models estimated in Obstfeld and Taylor (1997) and the ESTAR models in Taylor et al. (2001), Rapach and Wohar (2006) show that the nonlinear models do not necessarily yield improved out-of-sample

* Tel.: +82 2 9104532; fax: +82 2 9104519.
E-mail address: gyoon@kookmin.ac.kr.

0264-9993/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.econmod.2009.11.015

forecasts over linear autoregressive ones. Boero and Marrocu (2002), Bubcic (2009), and Enders and Falk (1998) also report similar findings.[1] Additionally, Rapach and Wohar (2006) find that the fitted nonlinear models are not very different from linear autoregressive ones. Furthermore, El-Gamal and Ryu (2006) show that the half-lives of shocks in linear autoregressive models are actually less than 3 years, such that there is no PPP puzzle, and claim that the added value of the nonlinear ESTAR models is not significant.

In this study, we show that there is a subtle, interesting nonlinear serial dependence in the real exchange rates from four major countries. It turns out that the data series had exhibited quite different serial dependence from that of linear (non)stationary autoregressive models. Our finding is from the nonparametric entropy measure of dependence recently devised by Granger et al. (2004). They show that their new entropy measure has a very good power in detecting serial dependence in various linear and nonlinear time series models. To explain the serial dependence structure actually observed in the real exchange rates, therefore, it seems that we have to apply nonlinear models, and the claim, for instance, in El-Gamal and Ryu (2006) that the nonlinear models are not useful in modeling real exchange rates seems to be premature. Furthermore, for the four real exchange rates studied in this paper, their nonlinear dependence structure is not similar, and it is doubtful that a single nonlinear TAR or ESTAR model would fit all of them. We show also that the TAR and ESTAR models estimated in Obstfeld and Taylor (1997) and Taylor et al. (2001) fail to yield significant serial dependence similar to that is actually observed in the real exchange rate data, and that the nonlinear models are not really adequate to capture their serial dependence structure. Overall, other nonlinear models than TAR or ESTAR should be considered. Or, at least different specifications of the nonlinear models should be employed for the real exchange rates. Even though it is not clear yet what nonlinear models would be proper for the real exchange rates examined in this study, we also provide a brief discussion on a possible new approach.

2. Nonparametric entropy measure of dependence: S_ρ

To identify the serial dependence in an economic variable, (partial) autocorrelation functions are routinely applied. For instance, Taylor et al. (2001) find that an autoregressive model of order 1 is appropriate for the data series depicted in Fig. 1B below. The (partial) autocorrelation functions are, however, appropriate only for linear, continuous Gaussian models, and might not capture the full dynamics of the data, as discussed in Hong (2006).

In this paper, we employ a nonparametric entropy metric of dependence, recently suggested in Granger et al. (2004), to measure the degree of nonlinear serial persistence in the real exchange rates. The new measure is only briefly reviewed here. The metric is based on a normalized Bhattacharya–Matusita–Hellinger measure and is given by

$$S_\rho = \frac{1}{2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}(f_1^{1/2}-f_2^{1/2})^2 dxdy, \tag{1}$$

where $f_1 = f(x,y)$ is the joint density and $f_2 = g(x)\cdot h(y)$ is the product of the marginal densities of the random variables X and Y. The null hypothesis of independence is

$$H_0 : f_1 = f_2 \quad \text{or} \quad S_\rho = 0.$$

Otherwise, $S_\rho > 0$, under the alternative hypothesis.

In the present study, we are interested in the nonlinear dependence structure of a first differenced real exchange rate, Δq_t, over time. Therefore, in Eq. (1), $x = \Delta q_t$ and $y = \Delta q_{t-k}$ for $k = 1, 2, \ldots$, and we apply S_ρ separately to each real exchange rate.

The nonparametric entropy measure S_ρ is a special case of the symmetric *k-class* measure, I_k, at $k = 1/2$:

$$S_\rho = I_{1/2} = I_{1/2}(f_2, f_1) + I_{1/2}(f_1, f_2),$$

where $I_k(f_2, f_1) = \frac{1}{k-1}\left[\int (f_1^k / f_2^k) dF_2 - 1\right]$, $k \neq 1$, is the asymmetric (with respect to f_2) *k-class* entropy divergence measure, such that $\lim_{k\to 1} I_k(\bullet) = I_1(\bullet)$, the Shannon cross-entropy (divergence) measure, and $F_\bullet$ denotes a probability distribution function corresponding to $f_\bullet$. Hence, a symmetric measure I_k is obtained by averaging the divergence of f_1 and f_2, wherein I_1 is the Kullback–Leibler measure. It also follows that $S_\rho = I_{1/2} = 2\,M(f_1, f_2) = 4B(f_1, f_2)$, where $M(\bullet) = \int (f_1^{1/2} - f_2^{1/2})^2 dx$ is the Matusita or Hellinger distance, and $B(\bullet) = 1 - \rho^*$ is the Bhattacharya distance with $0 \le \rho^* = \int (f_1, f_2)^{1/2} \le 1$.

The entropy measure of dependence S_ρ for random variables X and Y has the following desirable properties:

1. It is well-defined for both continuous and discrete variables.
2. It lies between 0 and 1, and is equal to 0 if X and Y are independent.
3. The modulus of the measure is equal to 1 if there is a measurable exact (nonlinear) relationship, $Y = m(X)$, between the random variables.
4. It has a simple relationship with the linear correlation coefficient in the case of a bivariate normal distribution.
5. It is a metric, that is, it is a true measure of distance and not just of divergence.
6. The measure is invariant under continuous and strictly increasing transformations.
7. It is symmetric with respect to variables X and Y.

The nonparametric entropy measure of dependence has been already applied to some economic problems with interesting results. For instance, Maasoumi and Racine (2002), Racine and Maasoumi (2007), and Maasoumi and Racine (2009) employ the metric to measure the goodness-of-fit of nonlinear models, to evaluate model specifications, and to detect asymmetry in economic data, respectively.[2] Additionally, Maasoumi et al. (2007) apply the measure to examine the world distribution of per capita GDP growth rates in the context of growth regressions.

Granger et al. (2004) estimate S_ρ by kernel density estimation. For the bivariate density of the random variables A and B, evaluated at the point (a, b) with n observations, the kernel density estimator is

$$\hat{f}_1(a, b) = \frac{1}{nh_a h_b}\sum_{j=1}^{n} K\left(\frac{a-a_j}{h_a}, \frac{b-b_j}{h_b}\right),$$

where $K(\bullet)$ is a pth order univariate kernel function, and h_a and h_b are the bandwidths. For the marginal densities evaluated at a and b, the estimators are $\hat{g}(a) = \frac{1}{nh_a}\sum_{j=1}^{n} K\left(\frac{a-a_j}{h_a}\right)$ and $\hat{h}(b) = \frac{1}{nh_b}\sum_{j=1}^{n} K\left(\frac{b-b_j}{h_b}\right)$, respectively. For instance, the estimated S_ρ will be

$$\hat{S}_\rho = \frac{1}{2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\left(\sqrt{\hat{f}_1(a,b)} - \sqrt{\hat{g}(a)}\sqrt{\hat{h}(b)}\right)^2 dadb. \tag{2}$$

No inference procedure is yet available for $\hat{S}_\rho$ and the results in the current paper should be treated with care.[3]

[1] Teräsvirta et al. (2005) find, however, that STAR models outperform linear autoregressive ones in forecasting some macroeconomic variables. A similar finding is also reported in Pavlidis et al. (2009).

[2] For instance, to test for symmetry, assume that a strictly stationary series $\{W_t\}$ has a density function $f(w)$ with a mean μ_w. $\{W_t\}$ is symmetric about its mean if $f(w) = f(\tilde{w})$ almost everywhere, where $W = -W + 2\mu_w$ and $f(\tilde{w})$ is the density function. W is a rotation of W about its mean. If we set $f_1 = f(w)$ and $f_2 = f(\tilde{w})$ in (1), S_ρ can be employed to test for symmetry in $\{W_t\}$.

[3] In a working paper version of Granger et al. (2004), it was proved, invoking the results in Hong and White (2005), that an approximated $\hat{S}_\rho$ follows a normal distribution asymptotically under suitable conditions, even though asymptotic inference could be quite unreliable.

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات