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Bayesian analysis of nonlinear exchange rate dynamics and the purchasing power parity persistence puzzle[☆]



Ming Chien Lo^{a, 1}, James Morley^{b, *}

^a Saint Cloud State University, USA

^b School of Economics, UNSW Business School, University of New South Wales, Sydney, NSW 2052, USA

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ABSTRACT

We investigate the persistence of real exchange rates using Bayesian methods. First, an algorithm for Bayesian estimation of nonlinear threshold models is developed. Unlike standard grid-based estimation, the Bayesian approach fully captures joint parameter uncertainty and uncertainty about complicated functions of the parameters, such as the half-life measure of persistence based on generalized impulse response functions. Second, model comparison is conducted via marginal likelihoods, which reflect the relative abilities of models to predict the data given prior beliefs about model parameters. This comparison is conducted for a range of linear and nonlinear models and provides a direct evaluation of the importance of nonlinear dynamics in modeling exchange rates. The marginal likelihoods also imply weights for a model-averaged measure of persistence. The empirical results for real exchange rate data from the G7 countries suggest general support for nonlinearity, with the strength of the evidence depending on which country pair is being considered. However, the model-averaged estimates of half-lives are almost

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* Corresponding author. Tel.: +61 2 9385 3366; fax: +61 2 9313 6337.

E-mail addresses: mclo@stcloudstate.edu (M.C. Lo), james.morley@unsw.edu.au (J. Morley).

¹ Department of Economics, Stewart Hall 380, St. Cloud State University, St. Cloud, MN 56301-4498, USA. Tel.: +1 320 308 0143; fax: +1 320 308 2228.

always as small or smaller than for the linear models alone, suggesting that the purchasing power parity persistence puzzle is less of a puzzle than previously thought.

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1. Introduction

Numerous studies, including [Michael et al. \(1997\)](#), [Obstfeld and Taylor \(1997\)](#), [Sarantis \(1999\)](#), [Sarno et al. \(2004\)](#), and [Bec et al. \(2010\)](#), have made use of nonlinear threshold-type autoregressive models to investigate the purchasing power parity (PPP) persistence puzzle, a notion initiated in a survey by [Rogoff \(1996\)](#). The motivation for using nonlinear models in this setting is that the original empirical findings used to establish the puzzle may have arisen due to model misspecification. Specifically, linear time series models restrict the degree of adjustment of real exchange rates to their PPP levels to be the same at all points of time. However, basic theory suggests that transaction costs can determine when the “law of one price” drives real exchange rates towards PPP and when it does not.² Hence, nonlinear models that allow for regime-switching behavior in real exchange rates may be more appropriate to study PPP. Indeed, the findings of many recent empirical studies imply that estimated PPP adjustments are faster for nonlinear models than those estimated for linear models, thus providing a potential resolution for the PPP persistence puzzle. [Sarno \(2003\)](#) and [Taylor and Sarno \(2003\)](#) provide detailed surveys of this literature.

In this paper, we adopt a Bayesian approach to investigate exchange rate nonlinearities and the PPP persistence puzzle. There are three reasons for doing this. First, standard frequentist estimation for nonlinear threshold models typically considered in the literature on exchange rates is cumbersome as it involves procedures to grid-search for the value of the parameters in nonlinear transition functions. Bayesian methods allow for joint estimation of all model parameters, as well as complicated functions of the parameters, such as the half-life measure of persistence based on generalized impulse response functions. Second, testing threshold-type nonlinearities in the frequentist setting is challenging due to the presence of nuisance parameters, with the concomitant problem that tests may be relatively uninformative in small samples due to weak power. In the Bayesian framework, model comparison via marginal likelihoods, which reflect the relative abilities of models to predict the data given prior beliefs about model parameters, is conceptually straight forward for any set of models and an inability to discriminate between models based on sample information will be evident in posterior odds ratios being close to even. Third, while frequentist inferences about exchange rate persistence can be highly sensitive to model specification, the Bayesian approach allows for model-averaged measures that address inherent uncertainty about model-specification issues such as lag order or the possible presence of nonlinear dynamics.

Our empirical findings can be summarized as follows. Based on our model comparison, there is general support for nonlinear threshold dynamics in real exchange rates for the G7 countries, although the strength of the evidence varies across country pairs. Meanwhile, our model-averaged measures of real exchange rate persistence are generally lower than for linear models alone. Thus, our analysis takes the resolution of the PPP persistence puzzle further than frequentist analysis based on nonlinear models. In the frequentist setting, the finding of lower persistence is a “knife-edge” results that depends crucially on the presence of nonlinear dynamics in real exchange rates, with tests for nonlinearity providing little support for nonlinearity across country pairs in practice. These “knife-edge” inferences are particularly worrisome given the fact that tests of nonlinearity can suffer from weak power in small samples. By contrast, our finding based on Bayesian analysis is that model-averaged measures of persistence are generally lower than those based on linear models, including in the cases where the evidence for nonlinearity is somewhat ambiguous. Specifically, we find that half-lives

² See, for example, [Heckscher \(1916\)](#), [Cassel \(1922\)](#), [Dumas \(1992\)](#) and [O’Connell \(1997\)](#).

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