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Empirical conditional quantile test for purchasing power parity: Evidence from East Asian countries☆

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ABSTRACT

This paper develops empirical tests for the purchasing power parity (PPP) hypothesis for China, Japan and South Korea by using the quantile unit root and quantile cointegrating regression method. Unlike the conventional unit root and cointegration methods, we test for the validity of the PPP hypothesis at both the quantile interval and the single quantile level. While conventional nonlinear models could also capture the regime switching behaviour, the quantile approach enables us to avoid choosing the appropriate form of nonlinearity, and therefore, avoid the misspecification risk. When conventional methods are used, the PPP hypothesis is not strongly supported for all three countries. However, when the quantile-based approach is used, the PPP hypothesis holds for China at some quantile levels when producer price index (PPI) is used as price variable, and it also holds for Japan over the lower and upper quantile levels. Interestingly, the PPP hypothesis for South Korea holds over all quantile levels when the consumer price index (CPI) is used as the price variable.

1. Introduction

The purchasing power parity (PPP) theory states that the national price levels expressed in a common currency should be equal. PPP has great importance both in theory and practice. For example, the validity of the PPP theory is an indication of whether two countries are financially integrated or not. And, more importantly, PPP is considered as the long-run equilibrium value of the currency. Empirical tests for PPP have been widely studied. The studies testing the PPP hypothesis can be divided into two types, one for testing the stationarity of the real exchange rate, and the other for testing whether the nominal exchange rate and the price difference between two countries are cointegrated. Empirical researches have not reached a consensus view on whether or not PPP holds by using the conventional unit root and cointegration tests. For example, Mark (1990); Doganlar (1999), Grilli and Kaminsky (1991), and Coe and Serletis (2002) showed that PPP did not hold; in contrast, Cheung and Lai (1998), MacDonald (1993), and Lothian and Taylor (1996) supported the PPP theory. These mixed results might be attributed to the low power of the traditional unit root and cointegration test. As Taylor and Taylar (2004) pointed out that, traditional unit root tests had low power to reject the null hypothesis of a unit root even it is indeed false, and the power of the test only has a marginal increase even with a century of data.

Several studies do not support the PPP theory, possibly because the real exchange rates are nonlinear mean-reverting processes or non-normal, or the cointegration relationship is nonlinear, time varying, or quantile dependent. Therefore, when one uses nonlinear unit root tests, nonlinear cointegration tests, or time-varying cointegration tests, the empirical test findings support the PPP theory.

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For example, Taylor and Sarno (1998) and NikoLaou (2008) found the real exchange rates nonlinear mean-reverting processes; Haug and Basher (2011) found the nominal exchange rates and price differences nonlinear cointegrated; and Kim et al. (2009) found the cointegrating relationship time varying. Lee and Chou (2013) argued that PPP was valid for all in the G20 by considering the nonlinearity and structural change in the real exchange rates. Another studies used the panel unit root and cointegration test to improve the power performance of the conventional unit root and cointegration, such as, Frankel and Rose (1996); Papell and Theodoridis (1998), Taylor and Sarno (1998), Pedroni (2001); Chiu (2002); Murray and Papell (2005); Alba and Papell (2007); Nagayasu and Inakura (2009), and Huang and Yang (2015).

The parametric nonlinear models, such as, the (Self-Exciting) Threshold Autoregressive ((SE)TAR) model, the Smooth Transition Autoregressive (STAR) model, the Markov Regime Switching Autoregressive model, have been supported by some empirical studies on the mean reversion of the real exchange rate. For example, Kanas (2006) examined the stationarity of the real exchange rate by using the Markov regime switching ADF unit root test, Chang (2002) employed the unit root test against the smooth transitional nonlinear alternative, and Chang et al. (2011) used the threshold cointegration approach. Even though some economic theory suggests a special nonlinear model, it is still an important and unsolved problem to choose an appropriate model. Moreover, Taylor and Taylor (2004) also re-emphasized an important warning of Taylor and Sarno (1998) in interpreting the findings of panel data unit root tests: the researchers always tend to draw a conclusion that all the real exchange rates in the studies panel are stationary, however, at most that we can conclude is that at least one of the exchange rates is mean reverting. And, Chang (2002) also noted that, commonly used panel unit root tests, such as the test proposed by Im et al. (2003), assumed cross-sectional independence, are likely to yield biased results when the panel is actually cross-sectional dependent.

In this paper, we apply Koenker and Xiao's (2004) quantile unit root test and Xiao (2009) quantile cointegrating regression model to analyze the PPP theory. In contrast with some special nonlinear models, the conditional quantile approach provides a complete picture so that one can obtain useful information for the behavior of variables of interest. Moreover, the conditional quantile approach is robust to the non-normal error which is a stylized fact for the exchange rate series. In the literature, the non-normal behaviors of the exchange rate returns have been noted by Falk and Wang (2003), who tested the PPP hypothesis in the presence of heavy tails with infinite variance by using Caner (1998)'s robust procedure.

In a quantile cointegrating regression model, the cointegrating coefficient is quantile dependent and, therefore, time-varying. Furthermore, the model includes the conventional cointegration model of Engle and Granger (1987) as a special case. In the literature, Papell (2006) noted the importance to incorporates PPP restricted structural change, Papell and Prodan (2006) tested PPP in the presence of a structural change, and Kim et al. (2009) found the cointegrating relationship time varying. To the best of our knowledge, this paper is the first to apply the quantile cointegration approach to the study of PPP theory. However, this paper is a complement to the PPP literature rather than a substitution.

In the literature, there are two kinds of tests to check the validity of the PPP theory. One is the unit root test, and the other is the cointegration test. As pointed out by Pedroni (2001) and Robertson et al. (2014), the unit root test on the real exchange rate actually imposes a unit value for the implied cointegrating vector between nominal exchange rate and aggregate price ratio. Therefore, the unit root test checks the validity of the strong-form PPP. Rejection of strong-form PPP based upon the unit root tests gives little clarity about the existence of the weak-form PPP. For the weak-form PPP, although the nominal exchange rate and the price difference have a tendency to move together in equilibrium over long periods, the relationship need not necessarily be one-for-one. The cointegration tests allow for straightforward testing for the weak-form PPP. Therefore, our paper actually tests both the strong-form and weak-form PPP.

The quantile unit root and cointegration approaches have three advantages. First, the quantile unit root and cointegration approaches provide a robust test for unit root and cointegration because they are robust toward non-normal errors. Second, the quantile unit root (cointegration) approach enables us to test whether a unit root (cointegration) relationship exists at both the quantile interval and each single quantile level. The quantile levels for conditional distribution of economic variables can indicate the states of an economy. For the study of the PPP theory, the dependent variable is the nominal exchange rate. The different quantile levels refer to the conditional quantiles of the nominal exchange rate: low quantile levels indicate the appreciation states and high quantile levels indicate depreciation states. Therefore, the quantile unit root and cointegration tests can show whether the PPP theory is valid at various economic situations. Finally, the quantile cointegrating regression model can also show whether the cointegrating coefficients vary over the quantiles. As pointed out by Xiao (2009), it allows the values of cointegrating coefficients to be influenced by the shock received in each period, and therefore, they might vary over different innovation quantiles. Moreover, it might be regarded as a stochastic cointegration model which includes the conventional counterpart as a special case. Specifically, instead of focusing on the average relationship between nominal exchange rate and price level difference through conditional mean function, the quantile cointegration model investigates their long-run equilibrium relationship in a range of quantiles of a shock. In the literature, Tsong and Lee (2013) examined the long-run relationship between nominal interest rates and inflation by using the quantile cointegration approach, and found that the long-run relationship is quantile dependent.

This study tests whether the PPP theory holds for three East Asian countries, China, Japan and South Korea. While it is supported in industrialized economies, conclusions on the validity of long-run PPP for East Asian economies is mixed (see, e.g., Wu et al., 2004; Enders and Chumrusphonlert, 2004; Baharumshah, Liew, and Chowdhury, 2010). Moreover, these countries experienced different states of economic development and situation. Thus it is of particular interest to test PPP hypothesis by considering these countries. Exchange rate of Chinese currency Yuan recently becomes the focus of the world economy with the development of Chinese economy, and China has been under considerable pressure with many callings for the government to intervene in the exchange rate market to appreciate Chinese Yuan. The Chinese government changed the exchange rate system into a managed floating exchange rate regime based on market supply and demand with reference to a basket of other major foreign currencies. As a result, Chinese Yuan has