Are real exchange rates mean reverting? Evidence from a panel of OECD countries

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Are real exchange rates mean reverting? Evidence from a panel of OECD countries

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In our article we employ some contemporaneous panel unit root tests (Maddala and Wu, 1999; Im et al., 2003) to examine whether the real exchange rates are mean reverting. Considering a panel of 26 OECD countries from 1987 to 2006 both using monthly and quarterly observations, we find that assuming a panel framework significantly increases the power of unit root tests. As a result, we find that the nonstationarity of the real exchange rate has strongly been rejected in favour of giving support to the purchasing power parity.

I. Introduction

In international macroeconomics interested in the models of exchange rate determination, one of the main critical issues of interest for policy makers is to reveal whether the real exchange rates are mean reverting in the long run, that is, whether the purchasing power parity (PPP) holds. Such an analysis would enable researchers in a world of floating exchange rates to concern with the determinants of the short-run deviations from the course of the PPP and thus is able to make sense serious consequences in both theoretical considerations and policy implementations.[1]

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[1] Among many others, Froot and Rogoff (1995), Rogoff (1996), Taylor (1996), Taylor (2000), Sarno and Taylor (2002), Taylor and Taylor (2004), Taylor (2006) and a recent paper by Saatcioglu et al. (2007), of which the latter is constructed upon the Turkish economy, can be considered highly illuminating papers for the main theoretical issues related to the PPP relationship. Besides, Lothian and Taylor (1996) using a long period of two centuries data for dollar- and franc-sterling exchange rates considering also sub-divisions as to regime changes

The conventional unit root tests of the real exchange rates such as augmented Dickey–Fuller (ADF) (Dickey and Fuller, 1979) unit root test based on a univariate framework examining the nonstationarity of the bilateral real exchange rates and the approaches employing co-integration techniques such as the ADF co-integrating regression (Taylor, 1988) and Johansen maximum likelihood tests (Saatcioglu et al., 2007) trying to estimate stationary long-run relationships between relative prices and nominal exchange rates are recently subject to some criticism that is resulted from the low power of these tests in small samples in order to bring out the PPP relationship.

Considering such issues of estimation process and in line with the developments in the statistical tests, contemporaneous panel unit root framework proposed by e.g. Maddala and Wu (MW) (1999), Choi (2001), Levin et al. (LLC) (2002) and Im et al. (IPS) (2003) has recently been widely used in the economics literature to examine the validity of the mean-reverting characteristics of the real exchange rates by many researchers. More recent estimation results employing these panel unit root tests seem to be significantly improving the findings obtained by researchers in favour of the rejection of nonstationarity of the real exchange rates by increasing the observations when compared to the earlier nonpanel univariate time-series unit root tests, especially for the post-1980 periods of floating exchange rates and increasing openness to international trade all over the world.[2]

In this article, our aim is to give an essay on this issue employing a panel unit root framework of real exchange rates from 26 OECD countries. For this purpose, in Section II we provide a brief overview of some unit root tests constructed in the panel framework proposed by MW and IPS, while the third section is devoted to the empirical investigation. And the final section concludes.

II. Methodology

In this section, we try to examine the stationary characteristics of real exchange rates based on a panel framework of 26 OECD countries considering IPS and Fisher-ADF panel unit root tests proposed by Maddala and Wu (1999) and Choi (2001) using Fisher's (1932) results to

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yield a strong support to the mean-reverting characteristic of real exchange rates thus to the role of PPP as a long-run equilibrium condition.

[2] See Oh (1996), MacDonald (1996), Wu (1996), Lothian (1997), Papell (1997), Flôres et al. (1999), Heimonen (1999), Wu and Wu (2001), Chiu (2002), MacDonald et al. (2002), Alba and Park (2003) and a recent paper by Alba and Papell (2007) for the applications of panel unit root tests.

derive tests that combine the *p*-values from individual unit root tests. Following QMS (2004, pp. 518–25), let us assume unit root tests on the basis of whether there are restrictions on the autoregressive process across cross sections or series and consider an AR(1) process for panel data:

$$y_{it} = \gamma_i + \rho_i y_{it-1} + X_{it}\delta_i + \varepsilon_{it} \tag{1}$$

where $i = 1, 2, \ldots, N$ cross-section units or series, that are observed over periods $t = 1, 2, \ldots, T_i$.

The X_{it} represent the exogenous variables in the model, including any fixed effects or individual trends, ρ_i are the autoregressive coefficients, and the errors ε_{it} are assumed to be mutually independent idiosyncratic disturbance. If $|\rho_i| < 1$, y_i is said to be weakly (trend-) stationary. On the other hand, if $|\rho_i| = 1$ then y_i contains a unit root.

For purposes of testing, there are two natural assumptions that we can make about the ρ_i. First, one can assume that the persistence parameters are common across cross sections so that $\rho_i = \rho$ for all i. The LLC test employs this assumption. Alternatively, one can allow ρ_i to vary freely across cross sections, thus allowing for heterogeneity in the value of ρ_i. In our article, we follow the latter approaches of the IPS and Fisher-ADF tests which are of this form characterized by the combining of individual unit root tests to derive a panel-specific result.[3]

[3] However, some essential criticism dealing with considering the power of panel unit root tests come from Taylor and Sarno (1998). They emphasize that results from panel unit root tests should be appreciated by researchers in a cautious way, for they found through some Monte Carlo experiments that rejection of the null hypothesis of joint nonstationarity of a group of real exchange rates may be due to as few as one of the exchange rate series of interest tend to be generated by a stationary process. On the other hand, many other papers emphasize the importance of possible bias in panel tests due to the cross-sectional dependence as well. For instance, O'Connell (1998) reveals that standard practice of calculating all real exchange rates relative to the US dollar leads to cross-sectional dependence in panel data. Kuo and Mikkola (2001) also emphasize the possibility that real exchange rates may be highly dependent, since there exists economic dependence between the countries' price levels and exchange rates. Besides, dependence may be due to the construction of the real exchange rates with respect to some benchmark currencies so that any independent variation in the benchmark country's price level or the value of its currency shows up in all the real exchange rates. Following Koedijk et al. (1998), adjusting for this problem makes it much more difficult to reject the random walk in real exchange rates. We leave the investigation of such issues of theory to future papers and thus the rest of the panel tests considered here are built under the assumption of cross-sectional independence.

To briefly describe these tests, Im et al. (2003) begin by specifying a separate ADF regression for each cross section:[4]

$$\Delta y_{it} = \alpha y_{it-1} + \Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X_{it}^{\prime} \delta + \varepsilon_{it} \quad (2)$$

The null hypothesis may be written as:

$$H_0: \alpha_i = 0, \text{ for all } i \quad (3)$$

while the alternative hypothesis is given by:

$$\alpha_i = 0, \text{ for } i = 1, 2, \ldots, N_1$$
$$H_1: \alpha_i < 0, \text{ for } i = \text{N} + 1, \text{N}+2, \ldots, \text{N} \quad (4)$$

After estimating the separate ADF regressions, the average of the **t**-statistics for α_i from the individual ADF regressions, t_{iT}:

$$\psi_{NT} = N^{-1} \sum_{i=1}^{N} t_{iT} \quad (5)$$

is then adjusted to arrive at the desired test statistics. IPS show that a properly standardized ψ_{NT} has an asymptotic standard normal distribution:

[4] As suggested by most empirical studies and following Chiu (2002), time trend in real exchange rates is not consistent with the long-run PPP, and adding a trend in the specification may deteriorate the testing power due to a loss in degrees of freedom. Therefore, we exclude the time trend in our model specification.

$$W_{NT} = N^{1/2} \frac{(\psi_{NT} - N^{-1}\sum_{i=1}^{N} E(t_{iT})}{N^{-1}\sum_{i=1}^{N} Var(t_{iT})} \quad (6)$$

The expressions for the expected mean and variance of the ADF regression *t*-statistics, $E(t_{iT})$ and $Var(t_{iT})$, are provided by IPS.

An alternative approach to panel unit root tests uses Fisher's (1932) results to derive tests that combine the *p*-values from individual unit root tests. This idea has been proposed by Maddala and Wu (1999) and Choi (2001). If we define Π_i as the *p*-value from any individual unit root test for cross section *i*, then under the null of unit root for all *N* cross sections, we obtain the asymptotic result that:

$$2\sum_{i=1}^{N} \log(\pi_i) \quad (7)$$

where Π_i is the *p*-value of the test statistic in unit *i*, and is distributed as a $\chi^2(2N)$ under the assumption of cross-sectional independence. Eviews 5.1 used in this article for empirical papers reports asymptotic χ^2 statistics using ADF individual unit root tests. The null and alternative hypotheses are the same as for as the IPS.

III. Results

This section provides the results of panel unit root tests for chain-linked real effective exchange rates based on consumer prices with base period 2000 and employing IPS test and ADF-Fisher unit root test of MW and Choi for the 26 OECD countries. We use the data taken from the database of OECD Main Economic Indicators.[5] Considering the definitions used by the OECD, the calculation of real effective exchange rate uses a system of weights based on a double-weighting principle which, for each country, takes into account relative market shares held by its competitors on the common markets, as well as the importance of these markets

[5] The countries considered are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, UK and the US.

for the country in question. Percentage changes in the index are calculated by comparing the change in the index based on consumer prices for the country concerned (expressed in US dollars at market exchange rates) to a weighted average of changes in its competitors' indices (also expressed in US dollars), using the weighting matrix of the current year. The indices of real effective exchange rates are then calculated from a starting period by cumulating percentage changes.[6] All the series consider the time period of 1987 to 2006 employing both monthly and quarterly frequency data and are converted to logarithms. Tables 1 and 2 reports the IPS, MW and Choi test results without a linear time trend as expressed earlier.[7]

Table 1. IPS unit root test null hypothesis: unit root

	1987M01–2006M12		1987Q1–2006Q4	
Method	Statistic	Probability	Statistic	Probability
IPS W-stat	-2.80241	0.0025	-1.66735	0.0477
ADF-Fisher χ^2	71.8722	0.0353	56.3215	0.3165
ADF-Choi *Z*-stat	-2.84769	0.0022	-1.61039	0.0537

In Table 1 above we find that IPS, MW and Choi test statistics suggest that the unit root null can be rejected by all these tests for the panel as a whole considering 5% significant level and the monthly frequency data. For the quarterly observations, on the other hand, IPS and Choi tests reject the unit root null for the 5% and 10% significant levels respectively, but MW is now incapable of rejecting the null hypothesis. We also apply to LLC test and Breitung unit root test suggested by Breitung (2000) to examine the unit root null of real exchange rates. The *p*-values of the LLC test are 0.0385 and 0.3822 for monthly and quarterly data, and the *p*-values of Breitung unit root test are 0.0002 and 0.0022, respectively.[8] Obviously, we reject the unit root null of real exchange rates considering a panel data framework except the case of ADF-Fisher χ^2 test for the quarterly observations. Although in only 4 out of 26 cases for the monthly data and 2 out of 26 cases for the quarterly data are the individual ADF significant at

[6] For a more detailed exposition see OECD Main Economic Indicators.
[7] All the results are estimated in EViews 5.1.
[8] All these estimation results not reported here to save space are available from the authors upon request.

the 10% level, we see that the panel test has increased the power of the unit root tests in favour of stationarity of real exchange rates. Thus following Wu (1996) and Wu and Wu (2001), ADF test has low power against local stationary alternatives in small spans, but by pooling data and conducting a more powerful test the unit root null can be rejected. McCoskey and Seldon (1998) and MacDonald et al. (2002) give an example which helps to understand why similar results to those obtained in our article make sense.

Table 2. Intermediate ADF test results

	1987M01–2006M12			1987Q1–2006Q4		
Countries	*t*-Stat	Probability	lag	*t*-Stat	Probability	lag
Australia	-1.6174	0.4721	2	-1.6850	0.4349	0
Austria	-1.8499	0.3557	2	-1.9598	0.3038	0
Belgium	-2.3502	0.1573	1	-1.9595	0.3040	0
Canada	-1.0367	0.7404	1	-0.9489	0.7675	0
Denmark	-2.7382	0.0691	1	-2.5128	0.1163	0
Finland	-1.2223	0.6652	1	-1.1233	0.7030	0
France	-1.8868	0.3382	0	-1.9295	0.3174	0
Germany	-2.0118	0.2817	1	-1.8010	0.3776	0
Greece	-1.9476	0.3101	0	-1.5652	0.4955	0
Iceland	-2.3215	0.1660	1	-1.9411	0.3122	0
Ireland	-1.7938	0.3831	1	-1.4924	0.5323	0
Italy	-1.8335	0.3637	3	-1.6416	0.4568	0
Japan	-2.1142	0.2393	1	-1.5476	0.5045	0
Korea	-2.4664	0.1251	2	-2.2705	0.1840	0
Luxembourg	-1.6558	0.4524	7	-1.8324	0.3625	0
Mexico	-2.8137	0.0578	1	-2.8453	0.0566	0
Netherlands	-2.5268	0.1104	1	-2.2816	0.1814	0
New Zealand	-1.4528	0.5559	1	-1.2893	0.6310	0
Norway	-2.5054	0.1154	1	-2.1336	0.2323	0
Portugal	-1.7862	0.3868	1	-1.7169	0.4189	0
Spain	-1.8399	0.3606	1	-1.7486	0.4031	2
Sweden	-1.3626	0.6003	1	-1.2461	0.6506	0
Switzerland	-2.8530	0.0526	1	-2.5890	0.0995	0
Turkey	-2.5916	0.0961	1	-1.8522	0.3530	0
UK	-1.5763	0.4932	0	-1.4800	0.5385	1
US	-1.8669	0.3476	1	-1.5665	0.4949	0

IV. Concluding Remarks

Conventional unit root tests of the real exchange rates such as the ADF unit root test based on a univariate framework examining the nonstationarity of the bilateral real exchange rates are recently subject to some criticism resulted from the low power of these tests in small samples in order to bring out the PPP relationship. Considering these issues, we employ in our article some contemporaneous panel unit root tests to examine whether the real exchange rates are mean reverting.

Evidence from a panel of 26 OECD countries for the period 1987 to 2006 using both monthly and quarterly observations reveals that panel framework significantly improves the power of unit root tests in favour of the stationarity of the real exchange rates in a panel framework. As a result, we find that the nonstationarity of the real exchange rates has strongly been rejected supporting to the PPP. Future researches emphasizing the role of such findings found in this article upon the design and implementation of economic policies will be complementary to this article.

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