The purchasing power parity in Australia: Evidence from unit root tests with structural breaks

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Abstract

The unit root tests with structural break developed by Perron and Rodriguez (Journal of Econometrics, 2003, 115, 1-27) are used to study the purchasing power parity in Australia for the period 1977:1 to 2004:4. The results indicate that there is a break in 1985:2 which coincides with the exchange rate crisis in 1985, occurring after the establishment of the dirty flexible exchange rate system. We also show that there is no tendency to the purchasing power parity in Australia to hold in the long run during this period.

Keywords: Purchasing power parity; Structural breaks; Unit root; Real exchange rate.

JEL Classification: F31.

1 Introduction

Purchasing power parity [PPP] states that national price levels should be equal when expressed in a common currency. Therefore, variations in the real exchange rate, defined as the nominal exchange rate adjusted for relative national price levels, represent deviations from PPP\(^1\). Formally, the real exchange rate may be defined in logarithmic form as \(q_t = s_t - p_t + p_t^*\), where \(s_t\) is the logarithms of the nominal exchange rate (domestic price of foreign currency), and \(p_t\) and \(p_t^*\) denote the logarithms of the domestic and foreign price levels, respectively. The real exchange rate may thus be interpreted as a measure of the deviation from PPP: when PPP holds, the real exchange rate is a constant so that movements in the real exchange rate represent deviations from PPP. Research on long-run PPP hypothesis can be in the

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\(^1\)For a survey of PPP literature, see Froot and Rogoff (1995), Sarno and Taylor (2002), and Taylor and Taylor (2004).
form of testing the stationarity of real exchange rates. Indeed, PPP requires that the
deviations of the actual real exchange rate from a constant long run exchange rate is
transitory, which implies that the real exchange rate must be a stationary time-series
process. In others words, if the real exchange rate series follows a random walk (that
is, have unit roots), and so is generated by a stochastic trend, then there is no evidence
that the real exchange rate returns to a long run equilibrium and therefore no evidence
in favor of long run PPP. Sarno and Taylor (2002) listed three reasons why we should
care if the real exchange rate has a unit root. First, the degree of persistence can be used
to infer the principal impulses driving real exchange rate movements, high persistence
indicating principally supply side shocks. Second, nonstationarity questions a large
part of open economy macroeconomic theory that assumes PPP. Third, economic
policies based on estimates of PPP exchange rates may be flawed if the real exchange
rate contains a unit root. Research on PPP has therefore focused on the credibility of
the unit root finding and on why deviations from PPP exist.

However, despite a decade of multiple applications of the unit root tests in
analyzing PPP, we are still unable to draw homogeneous conclusions. One explanation
of the lack of consensus is the low power of unit root tests. Consequently, a number
of researchers have sought to increase the power of unit root tests by increasing the
span of the data (Lothian and Taylor, 1996). Another explanation, which we examine
in this paper, is that standard unit root tests can be biased by the presence of structural
breaks (e.g., Perron, 1989; Leybourne, Mills and Newbold, 1998; Leybourne and
Newbold, 2000) and outliers (e.g., Franses and Haldrup, 1994; Vogelsang, 1999) real
exchange rates. Recently, Perron and Rodriguez (2003) proposed an unit root tests with
structural break which are robust to the presence of additive outliers (Darné, 2005).

The purpose of this paper is to determine whether the PPP relationship holds as a long
run equilibrium relationship in Australia by implementing the Perron and Rodriguez
tests. Testing long run PPP for Australia is really interesting given that others studies
using Australian data have reached mixed conclusions (Olekalns and Wilkins (1998),
Corbae and Ouliaris (1998), Henry and Olekalns (2002)).

The outline of the paper is as follows. Section 2 presents the data and explains
the structural breaks and outliers identified. Section 3 describes the unit root tests of
Perron and Rodriguez (2003). Section 4 displays the results. Section 5 concludes.

2 The Australian Exchange Rate Data

The real exchange rate data used in this article consist of quarterly observations of
the Australian real Trade Weighted Index [TWI] constructed by the Reserve Bank of
Australia over the period 1977:1–2004:4. The use of the real TWI for Australia, rather
than a bilateral real exchange rate, is appropriate because of the strong diversification
of Australian trade, especially since the beginning of 1980s.

Before to apply the unit root test we employ an automatic outlier detection procedure
available in the computer program TRAMO to determine whether or not the presence

2 The Perron and Rodriguez (2003) test is an extension of the Ng and Perron (2001) unit root test to
the case where a change in the trend function is allowed to occur at unknown time. Vogelsang (1999)
showed that the Ng-Perron test is robust to the presence of additive outliers.

3 TRAMO: Time Series Regression with ARIMA Noise, Missing Observations, and Outliers.
of additive outliers [AO] and structural breaks [LS] in the time series. The results presented in Table 1 show the presence of one structural break in 1985:2 and one additive outlier in 1986:3.

These special points can be explained in an economic way by the exchange rate crises of the Australian dollar ($AUS) in 1985 and 1986 (Blundell-Wignall, Fahrer and Heath, 1993). In December 1983, Australia decides to give up the crawling peg against the American dollar ($US) and implements a dirty flexible exchange rate system. One year later, the $AUS experiences an historical deep crisis. Indeed, from January to the end of April 1985 the $AUS depreciated by over 20 per cent against both the $US dollar and the TWI. While relative stability in these exchange rates was regained for a time and the $AUS actually appreciated until July, this was followed by further depreciation which gathered pace in the middle of 1986. The $AUS fell 17 per cent from May to the end of August 1986. Overall, the TWI depreciated by more than one-third from its level at the end of 1984, to its lowest point at the end of July 1986.

Blundell-Wignall, Fahrer and Heath (1993) found four reasons\(^4\) that explain these large downward adjustments. Nevertheless, in our point of view, the misalignment situation of the local currency was the most important one. This latter had become overvalued in the early 1980s, and this had not been corrected by early 1985. Moreover, at that time, commodity prices began to weaken, leading to a 13 per cent decline in the terms of trade in 1985 and 1986. This caused an increase in the current account deficit. These circumstances required real exchange rate depreciation in an underlying equilibrium sense. So, correction to overvaluation in circumstances where the equilibrium rate itself is declining was bound to require large nominal and real depreciation.

<table>
<thead>
<tr>
<th>Date</th>
<th>Type</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985:2</td>
<td>LS</td>
<td>-4.03</td>
</tr>
<tr>
<td>1986:3</td>
<td>AO</td>
<td>-4.60</td>
</tr>
</tbody>
</table>

Therefore, the finding of one structural break and one additive outliers in the Australian real exchange rate implies using the endogenous break unit root test of Perron and Rodriguez (2003) which takes into account a structural break and is robust to the additive outlier.

### 3 Perron-Rodriguez Tests

Perron and Rodriguez (2003) [PR] extended the class of GLS-tests and M-GLS-tests for a unit root developed by Elliott, Rothenberg and Stock (1996) [ERS] and Ng and Perron (2001) [NP], respectively, to the case where a change in the trend function is

\(^4\)These ones are (i) the overvaluation situation of the dollar, (ii) the monetary policy behavior, (iii) the perceived riskiness of investing in Australia due to the sharp rise in external debt, and (iv) the presence of destabilising speculative cycles.
allowed to occur at unknown time. The ERS tests adopt the GLS (Generalized Least Squared) detrending approach to improve the power of the Dickey-Fuller test whereas the NP tests are modified versions of the tests of Phillips and Perron (1988) that are more robust with regard to size distortions when the residuals have negative serial correlation.

Perron and Rodriguez (2003) consider the following data generating process:

\[ y_t = \psi' z_t + u_t \quad u_t = \alpha u_{t-1} + \nu_t \]  

(1)

where \( \nu_t \) is an unobserved stationary mean-zero process, and \( z_t \) is a set of deterministic components.

As proposed by Elliott et al. (1996), PR consider local to unity GLS detrending of the data to improve power. They define the transformed data \( \tilde{y}_t \) and \( \tilde{z}_t \) as follows:

\[ \tilde{y}_t = (y_0, (1 - \bar{\alpha}B)y_t), \quad \tilde{z}_t = (z_0, (1 - \bar{\alpha}B)z_t), \quad t = 0, \ldots, T. \]

for some chosen \( \bar{\alpha} = 1 + \bar{c}/T \). The GLS detrended series is defined as:

\[ \tilde{y}_t = y_t - \hat{\psi}' z_t \]  

(2)

where \( \hat{\psi} \) minimizes \( S(\psi, \bar{\alpha}, \delta) = \sum_{t=0}^{T} (\tilde{y}_t - \psi' \tilde{z}_t)^2 \), and \( \delta \) related to the breakpoint \( T_B \) according to \( T_B = \delta T \) with the break fraction \( \delta \in (0,1) \). They consider a point optimal test of the unit root null hypothesis \( \alpha = 1 \) against the alternative \( \alpha = \bar{\alpha} \) given by:

\[ P_T = [S(\bar{\alpha}, \delta) - \alpha S(1, \delta)]/s^2 \]  

(3)

The value of \( \bar{c} \) is chosen such that the asymptotic power of test is 50% against the local alternative (\( \bar{\alpha} = 1 + \bar{c}/T \)). PR obtained \( \bar{c} = -22.5 \) by simulations. They also employ the Dickey-Fuller-GLS statistic [DF-GLS] as the \( t \)-statistic for testing \( \hat{b}_0 = 0 \) from the following regression:

\[ \Delta \tilde{y}_t = \hat{b}_0 \tilde{y}_{t-1} + \sum_{j=1}^{k} \hat{b}_j \Delta \tilde{y}_{t-j} + \epsilon_t \]  

(4)

Perron and Rodriguez (2003) also recommend the M-GLS-tests proposed by Ng and Perron (2001), defined by:

\[ MZ_{\alpha} = (T^{-1} \hat{s}_T^2 - s^2) \left( 2T^{-2} \sum_{i=1}^{T} \hat{s}_{T-1}^2 \right)^{-1} \]  

(5)

\[ MZ_t = (T^{-1} \hat{s}_T^2 - s^2) \left( 4s^2 T^{-2} \sum_{i=1}^{T} \hat{s}_{T-1}^2 \right)^{-1/2} \]  

(6)

where \( s^2 \) is the autoregressive estimate of the spectral density at frequency zero of \( v_t \), defined as \( s^2 = \hat{s}_{k}^2/(1 - \hat{b}(1))^2 \) with \( \hat{s}_{k}^2 = (T - k)^{-1} \sum_{t=k+1}^{T} e_{t,k}^2 \), \( \hat{b}(1) = \sum_{j=1}^{T} \hat{b}_j \), and \( \hat{b}_j \) and \( \{e_{it}\} \) are obtained from the regression (4).
As suggested by Zivot and Andrews (1992), PR assume no shift in the trend function under the null hypothesis whereas the alternative allows a break in both the intercept and slope, defined by:

$$z_t = \{1, 1(t > T_B), t, 1(t > T_B)(t - T_B)\}$$

where $1(.)$ is the indicator function and $T_B$ is the time of the change. In this case, $\psi(\delta) = (\hat{\mu}_1, \hat{\mu}_2, \hat{\beta}_1, \hat{\beta}_2)$ is the vector of estimates that minimizes $S(\psi, \alpha, \delta)$. The differences $(\mu_2 - \mu_1)$ and $(\beta_2 - \beta_1)$ represent the magnitude of the change in the intercept and in the slope of the trend function occurring at time $T_B$, respectively.

The break point is estimated by minimizing the statistics:

$$J[\delta_{\text{inf}}] = \inf_\delta J(\delta)$$

where $J = MZ_{\alpha, t}, MZ_t, DF - GLS, P_T$.

For each choice of $T_B$, Perron and Rodriguez (2003) advise to use the Modified Akaike Information Criteria (MAIC) proposed by Ng and Perron (2001) to select\(^5\) the value of augmented lags $k$.

### 4 Unit Root Tests with Structural Break

The results of unit root tests are displayed in Table 2. The selected lag order in the regression is $k = 1$, using the modified Akaike information criteria. All the test statistics of the efficient unit root tests do not reject the unit root null hypothesis at the 5% level. Therefore, the Australian exchange rate data spanning the period 1977:1 to 2004:4 has no mean-reversion property, in which case all deviations from purchasing power parity are permanent. This implies that there is no tendency for purchasing power parity in Australia to hold in the long run.

Note that all the tests determine the break point at 1985:1. This result is not surprising because Lee and Strazicich (2001) showed that the endogenous break unit root tests tend to estimate the structural break incorrectly at $T_B - 1$ instead of at the true break $T_B$.

Moreover, it is interesting to note that, from the PPP viewpoint, this study reaches the same conclusion found by Henry and Olekalns (2002), that is, the rejection of the PPP hypothesis in the Australian real exchange rate. However, our outcomes differ on the estimated break date. These authors found a break in 1984:1 and 1984:3 from the Zivot-Andrews (1992) and Perron (1997) endogenous break unit root tests, respectively. This difference can be explained by the low power of Zivot-Andrews and Perron tests to date the break. Nevertheless, the robustness of the methodology implemented in this study and the economic events occurred in 1985 and 1986 seem to corroborate our finding.

\(^5\)Perron and Rodriguez (2003) also considered two others data dependent methods to select $k$: the standard Bayesian Information Criteria (BIC) and the sequential $t$-test proposed by Ng and Perron (1995). They showed that the use of the MAIC to select $k$ leads to tests with better overall properties.
Table 2: Unit Root Test with Structural Break for Australian Exchange Rate.

<table>
<thead>
<tr>
<th></th>
<th>MZ_α</th>
<th>MZ_t</th>
<th>DF-GLS</th>
<th>PT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test statistic</td>
<td>-16.23</td>
<td>-2.83</td>
<td>-2.93</td>
<td>17.43</td>
</tr>
<tr>
<td>(k)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(T_b)</td>
<td>1985:1</td>
<td>1985:1</td>
<td>1985:3</td>
<td>1985:1</td>
</tr>
<tr>
<td>Critical value</td>
<td>-25.9</td>
<td>-3.56</td>
<td>-4.14</td>
<td>12.04</td>
</tr>
</tbody>
</table>

MZ_α/MZ_t and DF-GLS/PT denote M-GLS-tests and GLS-tests, respectively. \(k\) represents the lag order in the Ng-Perron regression, and is selected by using the modified Akaike information criteria proposed by Ng and Perron (2001). \(T_b\) is the time of the structural break.

5 Conclusion

The paper studied the purchasing power parity in Australia using the endogenous break unit root test proposed by Perron and Rodriguez (2003). The results obtained show that there is no tendency for purchasing power parity in Australia to hold in the long run during the period 1977:1 to 2004:4. Furthermore, a break point is detected which coincides with the exchange rate crisis in 1985, occurring after the establishment of the dirty flexible exchange rate system.

References


