

# Symmetry, proportionality and the purchasing power parity: Evidence from panel cointegration tests

Mario Cerrato\*, Nicholas Sarantis

*Centre for International Capital Markets, Department of Economics, Finance and International Business, London Metropolitan University,  
84 Moorgate, London EC2M 6SQ, UK*

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## Abstract

This paper investigates the long-run Purchasing Power Parity hypothesis in a dynamic panel of twenty OECD countries, using recently developed heterogeneous panel cointegration tests. An important contribution of the paper is that it investigates the symmetry and proportionality conditions in PPP using likelihood-based inference as suggested by Johansen [Johansen S., 1995, Likelihood inference in cointegrated vector auto-regression models, Oxford University Press.], but with likelihood ratio tests extended to a panel context. We find empirical support for the weak form of the long-run PPP relationship, with the assumptions of symmetry and proportionality being strongly rejected.

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## 1. Introduction

Purchasing Power Parity (PPP) remains one of the key components of a number of theoretical models such as flexible-price monetary exchange rate models, asset pricing models and open economy macroeconomic models. As a result the PPP hypothesis has been subjected to extensive empirical investigation, particularly for the post Bretton Woods floating period. Economists have accepted the idea that PPP performs poorly in the short run and as a consequence have looked at PPP as a long run issue.

Most of the studies examining long-run PPP are based on unit root tests of the real exchange rates. The empirical evidence from time series unit root tests for individual countries generally rejects PPP.<sup>1</sup> On the other hand, evidence from panel unit root tests tends to be more mixed, with some studies finding mean reversion – though with a high degree of persistence – in real exchange rates (e.g. Frankel & Rose, 1996; Oh, 1996; Wu, 1996; Wu & Wu, 2001), while others fail to find strong evidence supporting long-run PPP (e.g. Coakley, Kellard, & Snaith, 2005; Cerrato & Sarantis, 2002; O’Connell, 1998; Papell, 1997). Another strand of the literature examining PPP has focused on testing for cointegration between the nominal exchange rate and domestic and foreign prices, though the number of studies is

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\* Corresponding author. Tel.: +44 20 7320 1551.

E-mail address: m.cerrato@londonmet.ac.uk (M. Cerrato).

<sup>1</sup> For excellent surveys of the empirical literature on PPP, see Taylor (2003), Sarno and Taylor (2002), and Rogoff (1996).

more limited.<sup>2</sup> Time series cointegration tests for individual countries provide conflicting evidence (e.g. Coakley & Fuertes, 2000; Enders & Falk, 1998; Sarantis & Stewart, 1993; Mark, 1990; Cheung & Lai, 1993; Taylor, 1988). But studies applying panel cointegration tests, which exploit both the time series and cross section information and have been shown to be more powerful than conventional time series tests, are scarce. To our knowledge, Pedroni (1997) and Canzoneri, Cumby, and Diba (1999) are only few studies that apply panel cointegration tests (but only the Pedroni tests) to PPP, though their evidence for PPP is mixed.

Another important issue when testing for long-run PPP is the validity of the symmetry and proportionality restrictions. In fact, unit root tests for mean reversion in real exchange rates are based on the assumption that these restrictions hold. Consequently, the failure of unit root tests to find evidence supporting PPP may well be due to the failure of the symmetry and proportionality restrictions.

An important contribution of this paper is that we employ some recently developed heterogeneous panel cointegration tests of PPP (i.e. McCoskey & Kao, 1998; Pedroni, 1997). Another contribution is that we investigate symmetry and proportionality conditions using likelihood-based inference as suggested by Johansen (1995), but with likelihood ratio tests extended to a panel context.

The paper is organised as follows. Section 2 outlines the specification of the long-run PPP relationship. Section 3 explains the panel cointegration tests employed in the econometric investigation. Section 4 analyses the empirical results obtained from panel unit root and panel cointegration tests. Section 5 examines the symmetry and proportionality conditions, while the final section summarises the empirical findings.

## 2. The PPP relationship

The PPP hypothesis suggests that the exchange rate depends on relative price levels:

$$s_t = \alpha + \beta_1 p_t - \beta_2 p_t^* \quad (1)$$

where  $s_t$  is the log of the nominal exchange rate (domestic price of foreign currency), and are, respectively, the logs of domestic and foreign prices.

Eq. (1), assuming that there is evidence of cointegration among  $s_t, p_t, p_t^*$ , represents the weak PPP relationship. Let us now impose the symmetry condition  $\beta_1 = -\beta_2$ , on prices. This restriction implies a new PPP relationship:

$$s_t = \alpha + \beta(p_t - p_t^*) \quad (2)$$

If we also impose the proportionality condition on the relative price coefficient in Eq. (2), then we have. This yields the strong PPP relationship.<sup>3</sup> Eq. (2) can only have one single cointegrating vector and this result from the symmetry condition. In the present paper we examine these two assumptions (i.e. symmetry and joint symmetry and proportionality) because of their empirical relevance. Rejection of these conditions can be explained by reference to measurement errors in prices, common trend in the relative prices of traded/non traded goods (Froot & Rogoff, 1995), barriers to trade, transaction costs and other economically unimportant factors (see Sarno & Taylor, 2002).

## 3. Panel cointegration tests for testing PPP

Before presenting the empirical results, we present, in this section, the panel cointegration tests we are going to use to test for PPP. Let  $\{y_t, x_t\}$  be  $I(1)$  variables and consider the following model:

$$y_t = \alpha + \beta x_t' + e_t \quad (3)$$

where  $x_t'$  is a vector of  $I(1)$  variables, and the cointegrating vector is  $(1, -\beta')$ .

<sup>2</sup> A major advantage of the cointegration approach to PPP is that it relaxes the restrictive conditions of symmetry and proportionality imposed by unit root tests of the real exchange rate (Sarno & Taylor, 2002).

<sup>3</sup> The assumptions of symmetry and proportionality are also relevant for the application of unit root tests to PPP. In fact, only if we are ready to assume that the proportionality and symmetry conditions hold, we can justify the use of unit root tests to test for PPP, otherwise PPP tests based on real exchange rates might be biased.

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