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ARGENTINEAN REAL EXCHANGE RATE 1900-2006: TESTING PURCHASING POWER PARITY THEORY

TIPO DE CAMBIO REAL DE ARGENTINA 1900-2006: TESTEANDO LA TEORÍA DE LA PARIDAD DE PODER ADQUISITIVO

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Abstract

This paper tests the Purchasing Power Parity Theory of Exchange Rates dealing with Argentinean data for the period 1900-2006. This is equivalent to testing if the Real Exchange Rate is a stationary variable or if its components (the nominal exchange rate and the relative prices) are cointegrated. Since most works study developed countries or developing countries but with short span data, this paper aims to fill a gap in the wide PPP literature by studding a developing country with a long-run approach. This country is particularly interesting since during 20th century "Argentine economic performance tells a story of decline unparalleled in modern times" (Taylor 1992). The downfall of this once developed country has probably affected the behavior of its RER and the validity of PPP. To check this, we use a wide set of econometric techniques and found that the PPP theory is not verified in Argentina, since its RER appears as a non-stationary variable, and there is no evidence of cointegration between the nominal exchange rate and the relative prices. In particular, the Argentinean RER appears to be trend-stationary under structural breaks with a continuous real depreciation of the Argentinean currency, especially in the first half of XX century, which is consistent with theories that relate the secular impoverishment of a country with the depreciation of its RER, as the Balassa-Samuelson effect.

Key words: *Purchasing power parity, real exchange rate, stationarity, unit root tests, cointegration, structural breaks.*

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Resumen

Este trabajo testea la Teoría de la Paridad de Poder Adquisitivo de los tipos de cambio utilizando datos de Argentina para el período 1900-2006. Esto es equivalente a testear si el Tipo de Cambio Real es una variable estacionaria o si sus componentes (el tipo de cambio nominal y los precios relativos) están cointegrados. Dado que la mayoría de los estudios se focalizan en países desarrollados o en países en vías de desarrollo pero utilizando series que abarcan pocos años, este trabajo busca llenar una brecha en la literatura estudiando un país en desarrollo con un enfoque de largo plazo. Este país es particularmente interesante dado que durante el siglo XX Argentina tuvo un desempeño económico muy negativo. La caída de este país otrora desarrollado probablemente afectó al comportamiento de su TCR y la validez de la PPA. Para testearlo, utilizamos un amplio abanico de técnicas econométricas, y encontramos que la PPA no se verifica en Argentina, dado que el tipo de cambio real aparece como no estacionario y no hay evidencia de cointegración entre el tipo de cambio nominal y los precios relativos. En particular, el tipo de cambio real aparece como estacionario pero alrededor de una tendencia y bajo cambios estructurales, con una continua depreciación real de la moneda argentina, especialmente en la primera mitad del siglo XX, lo que es consistente con teorías que relacionan el secular empobrecimiento de un país con la depreciación de su TCR, como el efecto Balassa-Samuelson.

Palabras clave: *Paridad poder adquisitivo, tipo de cambio real, estacionario, test de raíz unitaria, cambios estructurales.*

JEL Classification: *C12, C22, C29, F31, F41.*

> "Under the skin of any international economist lies a deep-stated belief in some variant of the purchasing power parity theory of the exchange rate." Dornbusch and Krugman (1976, p. 540).
> "Simplified views based on the purchasing power parity theory have suggested that the equilibrium real exchange rate is a constant that does not vary through time. Speaking rigorously, however, there is no reason why the value of the RER required to attain internal and external equilibrium should be a constant number; it would indeed be an extraordinary coincidence if it was". Edwards (1989, p. 15).

1. Introduction

The Real Exchange Rate (henceforth RER) is the relative price of domestic to foreign goods and is a key relative price for any open economy since it is an indicator of the incentives to economic agents regarding investment and consumption decisions between domestic and international goods. As such, the RER plays a central role in economic development, growth strategies and stabilization policies and its movements have great effects on the economy (Bleaney, 1997;

Bagellaa, *et al*. 2006). The "Purchasing Power Parity Theory" of exchange rates that states that national prices must be the same once converted to the same currency is one of the most important theories of exchange rate determination (and certainly the most tested) and has a clear prediction for the RER: if the Purchasing Power Parity (PPP) holds then the RER is a stationary variable.

The PPP has been widely refuted as a short-run relation but there is an extended belief that it is valid in the long run being a sort of "anchor for long-run real exchange rates" (Rogoff, 1996, p. 647). In this view, the Nominal Exchange Rate (NER) varies in the short run due to changes in the interest rates or due to monetary shocks but in the long run the *economic forces* behind the PPP explain its movements. The central place occupied by PPP in international economics is revealed by the fact that most models of open economies impose it as a long-run equilibrium condition (Obstfeld and Rogoff, 1996).

Regarding the long-run validity of PPP, recent empirical evidence, in many cases using long-span data to capture slow adjustment towards the parity, appears to sustain that it is a valid long-run international parity condition but mainly among developed countries. The evidence for developing countries is scarcer and less conclusive, as it is based mostly in short-span data. For Argentina, and to the best of our knowledge, the only long time series PPP study is Taylor (2002) that finds empirical support to PPP for the 1884-1996 years, while the other works that study this country use short-span data and obtain mixed results[1]. In line with Taylor (2002) but using a wide array of econometric techniques this paper tests PPP in Argentina using annual data for the 1900-2006 years. Therefore, this paper aims to fill a gap in the wide PPP literature by studying a relatively big developing country using long-span data.

Studying PPP in Argentina during the 20th century is very interesting as in this period "Argentine economic performance tells a story of decline unparalleled in modern times" (Taylor, 1992, p. 907). Our guess is that the downfall of this once developed country has probably affected the behavior of the RER. Besides, the country experienced in the last century big changes in the terms of trade, several balance of payments and banking crises and hyperinflations. These events may have caused shifts in the equilibrium RER and/or trend behavior in the RER that are contrary to the mean reversion to a stable mean postulated by the PPP theory. The use of long-span data is hence crucial since we can only detect long-run trends using long-span data.

The results found here are contrary to the PPP theory. In particular, the Argentinean RER appears as a non-stationary variable and there is no evidence of cointegration among the NER and the prices of Argentina and USA. This has important implications, among other things, for economic policy. For example, it is relevant for the debate on how long a country can obtain benefits by maintaining appreciated or depreciated its RER. These policies would be more effective and last longer the smaller the connection between the NER and the relative prices. When PPP holds, any real currency appreciation/depreciation generates

[1] For other Latin American countries, besides Taylor (2002) that also studies Brazil and Mexico the only two long-span PPP studies that we have found are Calderón and Duncan (2003) which tested PPP dealing with 193 years of data from Chile; and Fernandes Guimaraes-Filho (1999) that study PPP in Brazil over the period 1855-1990.

trade flows that drive the RER to a rate consistent with the PPP but such a reversal would not occur if the PPP does not hold. In addition, economic policies grounded on models that are based on the PPP are not suitable for Argentina, or at least should be taken with caution. Moreover, the validity of the PPP is relevant in practical matters since the PPP exchange rate is commonly used as a benchmark rate for policymakers, and a guide for arbitragers to judge whether a currency is overvalued or undervalued.

This work continues as follows: in Section 2 we briefly summarize the PPP theory and the empirical literature that has tested it[2]. In Section 3 we perform the econometric study for Argentina, and in Section 4 we conclude.

2. Purchasing Power Parity: Conceptual Framework and Review of Empirical Literature

The PPP is one of the oldest theories of exchange rate determination[3]. In its modern form, it was first formulated and tested by Gustav Cassel (1916, 1917 and 1918) who created the expression "Purchasing Power Parity" to name the theory he was proposing. Enunciated as a theorem, absolute PPP states that prices in a country must be the same as prices of other countries if expressed in the same currency so the NER between national and foreign currency must be equal to the ratio of domestic and foreign prices (Krueger, 1983, p. 24). The less restrictive relative PPP, stressing arbitrage across time rather than space, claims that variations in the NER must offset the changes in the relative prices.

The conceptual base of PPP is the "Law of One Price" (LOP), which states that in absence of all frictions identical goods sold in integrated and competitive markets, should have the same price in all countries when quoted in the same currency. It implies, in logarithm forms:

$$p_{i,t} = s_t + p_{i,t}^* \tag{1}$$

Where p_i is the logarithm of the home price of good i expressed in local currency, p_i^* is the logarithm of the foreign price of good i expressed in foreign currency, and s is the logarithm of the NER expressed as the domestic price of foreign currency.

However, various econometric studies reject the LOP for a wide number of tradable goods, except for a few standardized goods strongly exposed to international trade like gold[4]. The reasons for this rejection are: (1) national and foreign goods are not perfect or even close substitutes; the existence of (2) tariff and non-tariff trade barriers, and of (3) transaction costs; (4) the absence

[2] See Dornbusch (1987), Breuer (1994), Froot and Rogoff (1995) and Sarno and Taylor (2002) for superb surveys on PPP literature, from which we borrow extensively.

[3] Rogoff (1996) shows that the first formulations of the PPP theory have been made by scholars of Salamanca University in the XV and XVI Centuries whilst Frenkel (1978) shows advances of the theory in the writings of John Wheatley and David Ricardo in the XIX Century.

[4] See Isard (1977), Giovannini (1988), Knetter (1989, 1993) and Rogoff *et al*. (2001) for empirical studies of LOP.

of competitive markets; and (5) variations of non-tradable components of goods across countries. In spite of the contrary evidence, the LOP is an important base of most models of open economies in general, and of PPP in particular. To see this, consider the log of domestic and foreign price levels, $p_t = f(p_{1t}, ..., p_{it}, ..., p_{nt})$ and $p_t^* = g\left(p_{1t}^*, \ldots, p_{it}^*, \ldots, p_{nt}^*\right)$ respectively. If the LOP is valid for all goods and f and g functions are the same, then PPP holds since at all t:

$$s_t = p_t - p_t^* \tag{2}$$

This theoretically solid proposition is empirically disputable because: (i) those factors that inhibit the LOP also affect the PPP; (ii) the national and foreign baskets of goods are required to be equal, but national price indices used to test the PPP typically have different weights for the same good. In this case it is needed for the PPP to hold to have a high degree of substitution in international trade so monetary shocks will not have real effects and deviations from the PPP caused by monetary events will be transitory (Dornbusch, 1987, pp. 1076-7). (iii) Besides these temporary deviations there can be permanent departures caused by real events that affect the equilibrium relative prices, due to productivity differentials across sectors as the "Balassa-Samuelson" effect[5] (BS; Balassa, 1964; Samuelson, 1964), differences in factor endowments and rewards across countries (Kravis and Lipsey, 1983; Bhagwati, 1984), economic openness, etc.

The validity of the PPP has important implications for the RER. Since the log of RER, r_t, is:

$$r_t = s_t - p_t + p_t^* \tag{3}$$

If the PPP holds as stated in (2), r_t should be equal to zero or if we use price *indices* instead of *levels* should be equal to an arbitrary constant. In any case, the RER is a measure of deviations from the PPP. If the RER is a (weakly) stationary variable that tends to return to a constant mean, hence deviations from PPP are transitory and PPP holds in the long-run; while if the RER is non-stationary then PPP does not hold.

Since the 1970's empirical testing of the PPP theory has grown exponentially but mainly using developed countries data. Rogoff (1996) affirms that two stylized facts emanate from this literature: (a) the real exchange rates converge to the PPP in the long-run, but at very slow pace, and (b) short-run deviations from PPP are huge and very volatile. In this sense, Sarno and Taylor (2002, p. 65) conclude that: "Purchasing power parity might be viewed as a valid long-run international parity condition when applied to bilateral exchange rates among major industrialized countries." For developing countries, data availability problems generate that most works use short-span data and hence the evidence is less conclusive. For example, Holmes (2002a) found for thirty developing countries

[5] The first formulations of the BS effect were done by Ricardo (1821) and Harrod (1933). Because of that, some authors call the effect "Ricardo-Harrod-Balassa-Samuelson" or alternative combinations of those four surnames.

no compelling evidence in favor of the PPP, while Anoruo *et al*. (2002) studying eleven developing countries concludes that the PPP holds in their sample[6].

The econometric works that have tested the PPP theory have used an array of techniques that for the purpose of this work can be divided in three groups. First, since the PPP requires at minimum that the RER fluctuates around a stable mean, several works test the theory by studying if the RER is a stationary process, basically checking for the existence of a unit root (UR) in the RER series[7]. If the existence of a unit root is rejected then the RER appears as a stationary process and the convergence to PPP is not rejected. On the contrary, if the series appear to contain a unit root null then PPP does not hold. The works that have used this method have found mixed results. For example, Darby (1983) and Huizinga (1987) found UR in the (post Bretton-Woods) RER of several countries, while Frankel (1986) supports long-run PPP for UK-USA using long-span data to increase the power of UR tests.

A second group of works tests the PPP using cointegration methods, which model long-run equilibrium relations between same-order integrated variables. When a combination of these variables is integrated of lesser order, they are said to be cointegrated. Since the NER and prices are usually first-order integrated variables and under PPP a long-run equilibrium relation should exist between them, this method is very well suited to test the theory. Hence, if the NER and the relative prices are cointegrated there are short-run deviations from the equilibrium relation but in the long run these deviations are dissipated and PPP holds. On the contrary, when they are not cointegrated PPP does not hold. An additional advantage of this testing strategy is that weaker versions of the PPP theory can be tested since cointegration tests check if:

$$s_t + \mu p_t + \mu^* p_t^* \tag{4}$$

is stationary for *any* constants μ and μ^* which can be equal among them (denoted the "restricted case") or different (in the "unrestricted case"), while unit root tests implicitly impose the so-called "homogeneity condition" that requires $\mu = \mu^* = 1$.

Again, results from works that use cointegration techniques to test the PPP theory are mixed. For instance, Taylor (1988) and Mark (1990) reject the PPP, while works that use longer data sets as Kim (1990) or Cheung and Lai (1993) tend to confirm the long-run PPP. In any case, this approach has been criticized because cointegration coefficients have not a clear meaning, especially when the homogeneity condition does not hold (Breuer, 1994).

Finally, works in the third group employ non-linear methods to test the PPP, using two different models. The first is the smooth transition threshold autoregressive model (STAR; Granger and Teräsvirta, 1993; Teräsvirta, 1994)

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6 See Alves *et al*. (2001), Alba and Park (2003), Holmes and Wang (2004) and the works cited for the case of Argentina in Table 7, for studies that test PPP in Latin American countries.

7 The existence of a unit root is a sufficient condition for nonstationarity but not a necessary one. If the process is trend-stationary (stationary around a deterministic trend) then it does not contain a unit root but it is also non-stationary since its mean is time-varying.

that checks if the RER is increasingly mean reverting with the size of deviation from equilibrium (Sarno and Taylor, 2002, pp. 84-88). For example, Michael *et al*. (1997) reject the linear framework for several RER, supporting for them a non-linear mean reversion. The second non-linear testing strategy, used in two recent works, is to allow for a Markov Regime Switching behavior (Hamilton, 1989) in an Augmented Dickey-Fuller (Said and Dickey, 1984) test regression. Using this testing strategy, Kanas (2006) found that most of the 16 countries he analyzes show regime-dependent stationarity since there are periods over which the RER is stationary and PPP holds and others over which it is non-stationary and PPP does not hold. In a related work, Kanas and Genius (2005) find that the US/UK RER is stationary in a *low volatility* regime and non-stationary in a *high volatility* state.

3. Purchasing Power Parity: Econometric Study for Argentina

In this Section we test the PPP theory using yearly data from Argentina and USA between 1900 and 2006 (107 annual observations), replicating the linear testing strategies of works in groups 1 and 2. While we consider that the use of non-linear methods to test PPP is an important further step, considering them here would considerably extend the length of this work, so we use here the linear techniques which are a necessary first step when testing PPP in any country, and let for future research the extension to non-linear ones.

Thus, in Sub-section 3.1 we test if the Argentinean RER[8] is stationary using several unit root tests and in Sub-section 3.2 we study the robustness of these results to the existence of structural breaks in the series[9]. After that, in Sub-section 3.3 we test for cointegration between the NER and the prices of Argentina and USA, with and without breaks. In Sub-section 3.4 we analyze what we have found for Argentina and compare it with the results from other works that have tested the PPP theory for this country. In Sub-section 3.5 we mention some *caveats* that weaken our results.

We use annual data because the available monthly price series of Argentina start in 1943 for the consumer price index (CPI) and in 1957 for the wholesale price index (WPI), which are (until 2006) only 64 and 50 years, respectively. This is insufficient because unit root tests have low power so with small samples and slow mean reversion tend to accept a false UR null, so several decades of data are needed to reliably reject the existence of a random walk component. Cointegration tests suffer the same low problem in short samples. In his review, Rogoff (1996) finds that half mean reversion time of PPP deviations were between three to five years, very low rates that implies that the power problem is

[8] From now on we will use the terms "Argentinean RER" or "RER" as shorthand for "Argentinean RER with the USA"; "NER" for "NER between Argentinean currency and US dollar"; and "relative prices" for "relative prices of Argentina and USA".

[9] In order to save space we do not describe the 16 tests used in section 3. An appendix with the details of these tests is available from the author upon request. Interested readers should also refer to the cited papers or to specialized texts like Stock (1994) or Maddala and Kim (1998).

relevant[10]. Importantly, the power problem is not eluded by increasing the number of observations with higher-frequency data (Shiller and Perron, 1985; Hakkio and Rush, 1991) so although with monthly data we have more data points (728 with CPI, 600 with WPI) than with annual data (107) it does not improve the power of the tests employed.

3.1. Is the Argentinean Real Exchange Rate Stationary?

The Argentinean RER is built as stated in (3) using the annual average of the free NER between the Argentinean currency and the US dollar and the corresponding national prices. Since we use price *indices* instead of *levels* Crownover *et al*. (1996, pp. 784-5) convincingly argue that we test for *relative* instead of *absolute* PPP. The issue is what price index should be used to test PPP as some authors argue that it refers only to tradable goods and hence suggest to use indices composed only of these good prices like WPI, while the line traced by Cassel (1928, p. 33) and Keynes (1924, pp. 100-1) states that PPP only makes sense if it comprehends a wider range of goods including non-tradable goods and suggests to use the consumer price index. To obtain robust results we use both CPI and WPI showing the resulting RER series in Graph 1.[11]

To test for the existence of a unit root in the RER series we use the following tests: the Generalized-least-squares version of the Augmented Dickey-Fuller (ADF, Dickey and Fuller, 1979; Said and Dickey, 1984) test due to Elliott, Rothenberg, and Stock (ERS, 1996), denoted ADF GLS; the Kwiatkowski, Phillips, Schmidt, and Shin test (KPSS, 1992); the ERS Point Optimal (ERSPO) test; and the modified forms of the Phillips-Perron (PP, 1988), the Bhargava (1986) and the ERSPO tests due to Ng and Perron (NP, 2001). With the exception of the KPSS test, which has a null of stationarity, all of them have as their null hypothesis the existence of a unit root in the series. The traditional ADF, Bhargava, and PP tests are not considered since their modified versions that use GLS detrended data combined with the modified Akaike information criteria (MAIC) to select the optimal lag truncation have better power and size properties than the original ones (Ng and Perron, 2001), so the original tests do not add any relevant information over their modified more powerful versions.

As stated by Culver and Papell (1999), proper testing of the PPP theory implies testing for unit roots without a deterministic trend in the testing equation

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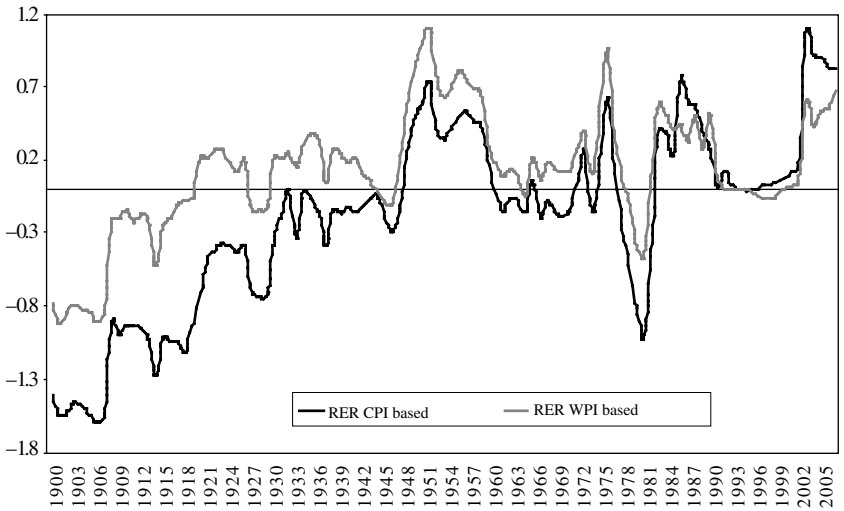
[10] Initially, we have also employed the monthly dataset, but recognizing the power problem and following a suggestion of A. Gay we work here only with the longer annual dataset. The use of long-span annual data is a common way to solve the power problem. See for example, Frankel (1986) and Lothian and Taylor (1996).

[11] The NER is the annual average of the monthly series of free NER taken from Fundación de Investigaciones Económicas Latinoamericanas (FIEL), except the last three years of the series that is from Banco Central of Republica Argentina (BCRA). Argentinean CPI is constructed using data from the Argentinean Institute of Statistics and Census (INDEC) from 1943 to 2006, and from Gerchunoff and Llach (1998) from 1900 to 1943. Argentinean WPI is constructed using data from Della Paolera (1994) from 1900 to 1913, Gerchunoff and Llach (1998) from 1913 to 1958 and INDEC from 1959 to 2006. US CPI and Producer Price Index (PPI) are from the US Bureau of Labor Statistics. Until 1978 US PPI was named WPI so it is a proper counterpart of Argentinean WPI.

GRAPH 1
ARGENTINEAN RER - CPI AND WPI BASED – IN LOGARITHMS - (1993=0)



since the existence of a time trend in the RER is inconsistent with the theory. However, we test for a unit root in the RER with and without a trend to see if the Argentinean RER is: (i) stationary around a constant, which occurs when the UR null is rejected not including a trend in the testing equation; (ii) difference-stationary (DS), when the UR null is not rejected not including a trend; (iii) trend-stationary (TS), when the existence of a UR is rejected including a trend; or (iv) contains both a UR and a trend, when the existence of a unit root is not rejected including a trend. While PPP holds strictly only when the RER does not contain either a unit root or a time trend, the economic implications of these two sources of non-stationarity are different in terms of the effect of shocks so we aim to distinguish between them.

If the series is DS it is said to contain a *stochastic* trend because each random shock imparts an enduring change on its conditional mean causing a permanent shift on the intercept. Thus, the series have no particular tendency to increase or decrease over time, or to revert to a given mean value. In contrast, if the series is TS, i.e. is non-stationary but due to the presence of a deterministic trend its mean is a linear function of time and shocks are transitory since deviations from the trend are temporary. In our case, if the RER is TS then the PPP is not the only source of long-run RER changes but the other long-run factors change in a predictable way so their influence can be approximated as a deterministic function of time. In particular, a trend in the RER of a medium-income country like Argentina relative to a high-income country like USA can be explained by the Balassa-Samuelson effect. This effect is the result of the productivity bias generated by asymmetrical productivity growth in the tradable and the nontradable sectors within a country, which leads to a higher nontradable/tradable price ratio in developed countries where this asymmetry is greater. It operates as follows: if the LOP holds for tradable goods and there is intra-country equalization of

wages, productivity rises in the tradable sector lead to economy-wide wage rises (without affecting tradable prices) that can only be afforded in the nontradable sector by increasing prices. It causes rises in the general price index that will be higher in countries with higher productivity growth. This leads to the prediction that currencies of high productivity countries tend to be overvalued. Associating low productivity growth with slow GDP growth, poorer countries tend to have depreciated RER, as their real GDP per capita falls relative to developed economies. We go further into this theme in the next section.

We present the results of the mentioned UR tests in Table 1.

TABLE 1
UNIT ROOT TESTS RESULTS

Unit Root tests	CPI RER		WPI RER	
	Without trend t-statistic	With trend t-statistic	Without trend t-statistic	With trend t-statistic
GLSDF	−0.62[a]	−1.52[b]	−0.99[a]	−2.15[a]
KPSS				
Newey-West Bandwidth	0.96•••	0.22•••	0.54••	0.21•••
Andrews Bandwidth	0.44•	0.15••	0.37•	0.16••
ERSPO	15.39[a]	19.12[b]	11.96[a]	9.32[a]
NP				
Modified PP statistic (MZa)	−1.43[a]	−4.76[b]	−2.60[a]	−11.00[a]
Modified PP statistic (MZt)	−0.57[a]	−1.54[b]	−0.93[a]	−2.34[a]
Modified Bhargava statistic	0.40[a]	0.32[b]	0.36[a]	0.21[a]
Modified ERSPO statistic	11.62[a]	19.12[b]	8.61[a]	8.28[a]

•, •• and ••• denote rejection of the null at 10%, 5%, and 1% respectively, using the corresponding critical values for each test (not reported).
a: 0 lags according to the Modified Akaike Information Criteria (MAIC). b: 9 lags according to the MAIC.

As can be seen in the Table, results of these tests are conclusive against the PPP for both the CPI RER and the WPI RER since in any case we reject the UR null (even at 10% level) or with KPSS we reject the null of stationarity at least at 10% level of significance. These results are robust to the inclusion of a deterministic trend in the testing equation. Hence, both real exchange rates appear to be non-stationary, and hence PPP does not hold.

3.2. Testing for a Unit Root in the Argentinean RER under Structural Breaks

When there are structural breaks in a stationary series unit root tests are biased towards non-rejecting the UR null. Thus, structural changes in the long-span

Argentinean RER could have biased the results making them appear as non-stationary when perhaps they were stationary if controlled for breaks. Hence, we check here if results are robust to the existence of breaks[12].

As a first step we apply Perron (1989, 1990) UR test under an exogenous structural break, which considers a break both under the null and the alternative hypothesis. Perron specified four structures for the test: (1) a change in level in a non-trending series; and for trending series (2) a change in level, (3) a change in slope; and (4) a change in both level and slope[13]. The proper version for testing PPP is (1) since the existence of a trend in the RER is contrary to the PPP theory, but as we did in Section 3.1 and in order to verify if the RER series are DS or TS under a structural break we also perform options (2)-(4) of Perron test. A drawback of this test is that it assumes that the break date is known, so we must identify in advance which the break date candidates are. In this sense, and since it has been argued that PPP theory is more easily verified in high-inflation economies where price level movements are dominated by monetary factors, a major change that would probably affected the validity of PPP occurred in the Argentinean economy in the early 1950s from a low to a high inflation regime first and to a hyperinflationary regime later (around 1975) that lasted until 1991 when the "convertibility" currency board succeeded in returning to a low-inflation regime[14]. Hence, we perform Perron test considering possible breaks in all the years between 1945 and 1960[15] and present the results less favorable to the unit root null in Table 2[16].

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12 Hegwood and Papell (1998, p. 281) assert that the presence of structural breaks is evidence against long-run PPP arguing that it only holds when the RER reverts to a constant mean and denote "Qualified PPP" when the RER returns to a changing mean. In this view, results of Section 3.1 are enough evidence against PPP in Argentina. Papell and Prodan (2006) also distinguish between "trend PPP" when the RER is TS and "Qualified Trend PPP" when it is TS under breaks. To simplify the discussion and give PPP more chances of being verified we do not distinguish among PPP and the weaker Qualified PPP.

13 Perron allows for two transition effects: the additive outlier (AO) when the change to the new level/trend occurs instantly; and the innovation outlier (IO) when the change is gradual. To limit the technicalities, we do not detail in each case which transition effect was chosen but in most cases the preferred is the AO being results robust to both specifications. It confirms Papell and Prodan (2006, p. 1337) claim that "… [IO transition] is more appropriate for macroeconomic aggregates than for real exchange rates".

14 From 1900 to 1945 the average annual inflation was 2% (maximum of 25.9% in 1918), from 1946 to 1974 it was 27.3% (114% in 1959); and from 1975 to 1991 it rises to 578% (4.923% in 1989). I owe to J. Llach for pointing out to me this possible source of structural break in the RER series.

15 We confirmed the existence of a break in the RER series using Chow (1960) test for simple ARMA models for the RER series, founding breaks in CPI RER in 1948, 1952, 1957 and 1959 and in PPI RER in 1952 and 1959.

16 Certainly, there are many other sources of possible breaks in the Argentinean economy, as changes in the pattern of economic growth (Taylor, 1992; Sanz-Villaroya, 2006); in the trade policy (Richaud, *et al*. 2003), or in the integration in world capital markets (Taylor, 1998). We consider the change in the inflation regime following Zhou (1997), and as a first step. The study of the sources of RER breaks is a relevant avenue for further research.

TABLE 2
RESULTS OF PERRON UNIT ROOT TEST WITH AN EXOGENOUS STRUCTURAL BREAK

Model	CPI RER				WPI RER			
	Break Date	t–stat	Trend before break	Trend after break	Break Date	t–stat	Trend before break	Trend after break
Change in level in a non-trending series	1951	2.89	–	–	1952	−3.02	–	–
Change in level in a trending series	1960	−3.37	0.016 (8.94)	–	1959	−4.25••	0.017 (8.75)	–
Change in slope in a trending series	1952	−4.02••	0.021 (9.50)	−0.007 (−7.90)	1957	−5.04•••	0.018 (9.21)	−0.009 (−6.82)
Change in level and slope in a trending series	1957	−5.13•••	0.036 (14.7)	0.011 (6.36)	1957	−4.61••	0.025 (11.4)	0.001 (7.33)

t-stat. in parenthesis. •, •• and ••• denote rejection of the UR null at 10%, 5%, and 1% respectively using Perron critical values.

When we allow for a change in level in a non-trending series the UR null is not rejected for any RER even at the 10% level of significance, therefore data supports that the RER series are DS with a break in 1951 for the CPI RER and in 1952 for the WPI RER. Since this is the only specification plainly compatible with the PPP results do not support the theory.

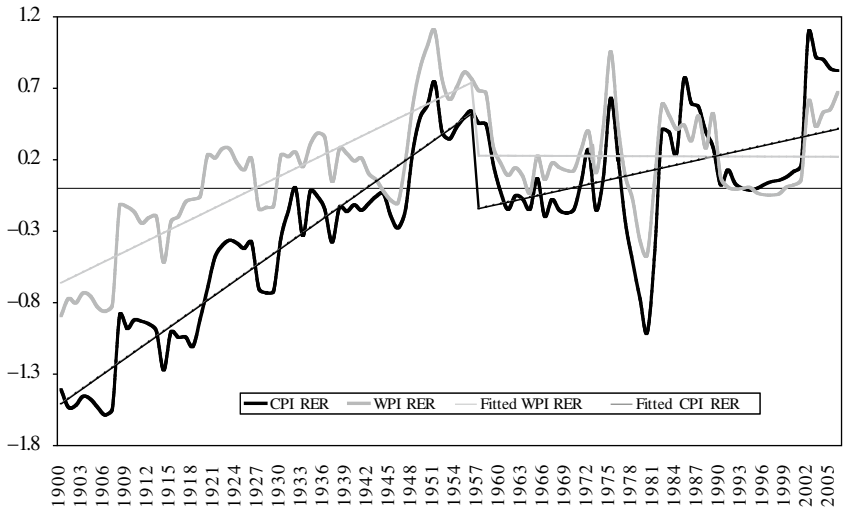
When a trend is allowed the UR null is rejected in all cases but one in favor of the TS with one break alternative, being the stronger results for a change in level and slope for the CPI RER and for a change in slope for the WPI RER in 1957. Interestingly, their trends are positive until the break and still positive but with a significant lower slope, almost zero (or no trend) for the WPI RER, after it. This suggests that the Argentinean RER was TS in the first half of 20th century and stationary around a constant since then[17]. Since as we explained above from early 1950s Argentinean economy suffered very high inflation this confirms the guess that it is more likely to verify the PPP theory under high inflation as then real factors fall behind monetary events (Frenkel, 1980)[18]. Moreover, it explains why works that test the PPP in Argentina using data for the second half of 20th century tend to verify the theory (see Table 7 below). As

[17] UR tests for sub-samples support this argument since the UR null is not rejected for the 1900-1956 period but it is rejected for the 1957-2006 sample. However, the power problem is more relevant in shorter samples so these results are merely illustrative.

[18] *Inter allia*, McNown and Wallace (1989), Mahdvi and Zhou (1994), and Zhou (1997) found support to PPP in high inflation economies. In particular, Zhou (1997) cannot reject a UR in the RER for five high inflation countries, but concludes in favor of stationarity after allowing for structural breaks associated with changes in the inflation regime.

an illustration, in Graph 2 we present both RER series and their fitted equations of the model with a change in both level and slope with a break in 1957.

GRAPH 2
ARGENTINEAN RERS (1993 = 0, IN LOGS) AND PERRON TEST FITTED EQUATIONS



Two related things of Graph 2 are worth mentioning. First, the positive trend implies a continuous real depreciation of the Argentinean currency[19]. This can be evidence on the BS effect since as we explained above the productivity bias in favor of tradable goods is higher in faster-growing countries so a slow-growing economy should experience real currency depreciation over time. Second, the CPI RER has a more pronounced trend than the WPI RER. As the CPI contains a higher fraction of non-tradable goods than the WPI it is also consistent with the BS effect since, if present, it would be more noticeable in the CPI RER than in the WPI RER.

In any case, results of Perron test indicate a possible structural break in the RER series. We go further into this finding in two ways. First, whereas Perron (1989, 1990) assumes that the break date is known *a priori* subsequent literature allowed the break to be determined from data, so we apply alternative unit root tests under *endogenous* structural break. Second, the Perron test allows for just one break, but it is far from obvious that this is a proper feature of long-term RER, so we carry out several UR tests under two structural breaks[20].

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[19] Remember that since we are working with the log of the RER, the trend in this series is the rate of growth of the series in level.

[20] To evaluate the existence of more breaks we apply Bai and Perron (1998, 2003) multiple-break test and found: (i) the existence of at least one break is accepted at 1% level in the CPI RER and at 10% in the WPI RER; (ii) for the CPI RER results supports that it has

Thus, we apply the following six tests: for non-trending series, (i) the Perron and Vogelsang (PV, 1992) one-break test, which is a variant of the Perron test in which the break is determined where the UR test statistic is minimized, and (ii) the Clemente, Montañés and Reyes (CMR, 1998) test which extends the PV test to the two breaks case. For trending-series, (iii) the Zivot and Andrews (ZA, 1992) test, which also estimates the break where the UR test statistic is minimized, and (iv) the Lumsdaine and Papell (LP, 1997) test, which extends the ZA test to include two breaks. A drawback of the ZA and LP tests is that their null is "UR without structural break" so there is the option left that besides "TS with breaks", "UR with structural break" could be the alternative. In fact, Lee and Strazicich (2001) show that ZA test show size distortions with a break under the null so it is rejected too often causing *spurious rejections*, and that the break is usually incorrectly estimated. In order to avoid these limitations, we use two additional tests which do not exhibit such size distortions so rejection of the null unambiguously implies trend stationary: (v) the one-break minimum Lagrange multiplier (MLM) test of Lee and Strazicich (LS1, 2004) and (vi) the two-break MLM test of Lee and Strazicich (LS2, 2003). We present the results of these six tests in Table 3.

Four facts emerge from the application of the unit root tests under endogenous breaks to the RER series: (i) Using the PV and CMR tests we do not reject the UR null for any RER, which is the same result obtained with previous tests for non-trending series. (ii) With a trend and considering a change in level, we reject the UR null for the WPI RER only with the ZA test, so this model suggests that the WPI RER is DS with breaks. For the CPI RER and evaluating a change in level in a trending series, tests drop mixed results: with one break they do not reject the UR null, but with two breaks the UR null is rejected at 5% in favor of TS with breaks. (iii) Considering only a change in slope, the UR null is clearly rejected for both RERs with a break in 1958. (iv) When we consider a change in both level and slope, all tests but LP reject the UR null for both RERs in favor of TS with break(s).

As a summary of this subsection, using several tests for UR with breaks we have found that the RER series appear to be non-stationary; and evidence appears to support that they are TS with breaks instead of DS.

3.3. Cointegration Tests for Argentinean RER Components

We test now the PPP theory by checking if the NER and the prices of Argentina and USA are cointegrated. Thus, in the restricted case we build for each price index a relative price series (CPI Arg/CPI USA; WPI Arg/PPI USA) and check if it is cointegrated with the NER. Alternatively in the unrestricted case we work with the price series separated and check if they are cointegrated with the NER. In Graph 3 we present all these series of NER and prices.

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either two breaks, in 1919 and in 1947 using the LWZ criteria, or four breaks, in 1919, 1947, 1963 and 1981 using the BIC criteria; (iii) in the WPI RER, results supports that it has either one break, in 1916 using the LWZ criteria, or three, in 1916, 1946 and 1962 using the BIC criteria. See Bai and Perron (1998) for test details. We thank Pierre Perron for the Gauss code used for this test.

TABLE 3
RESULTS OF UNIT ROOT TESTS UNDER ONE OR TWO ENDOGENOUS STRUCTURAL BREAKS

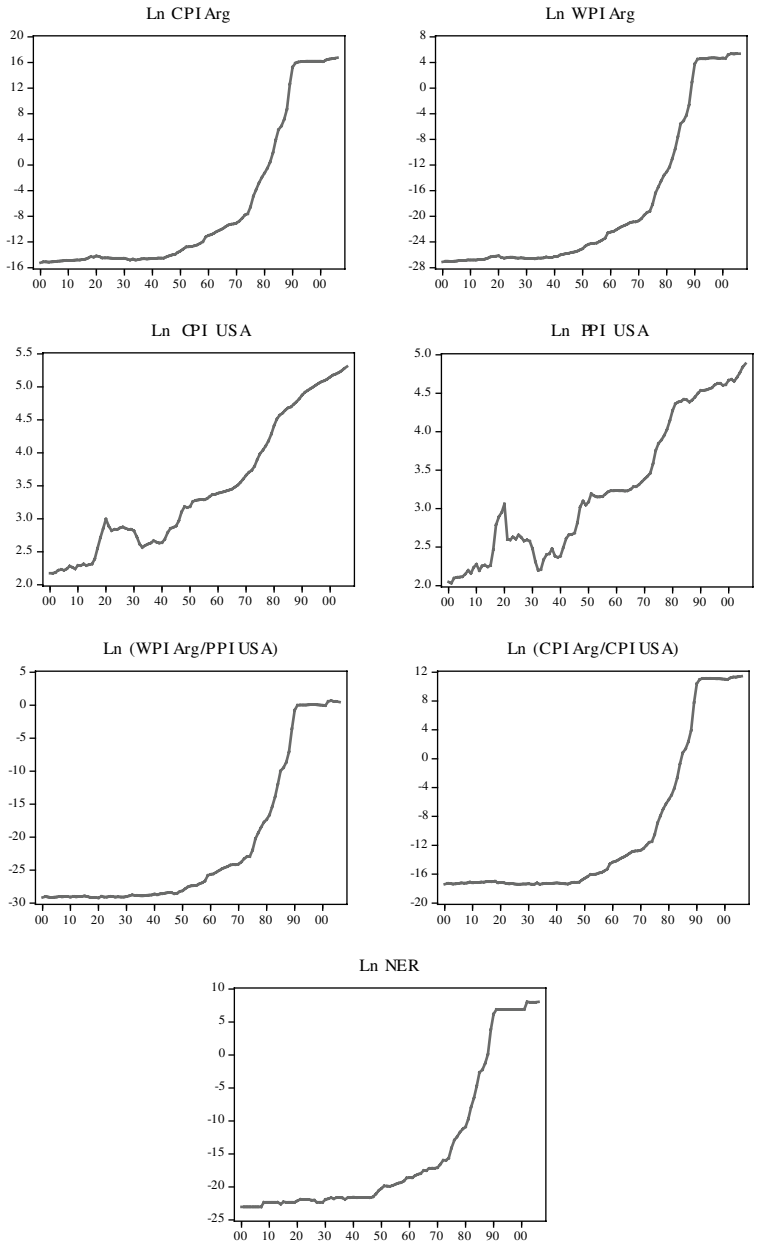
Model	Test	CPI RER					WPI RER				
		Break dates	t-stat	Original trend	Trend after 1st break	Trend after 2nd break	Break dates	t-stat	Original trend	Trend after 1st break	Trend after 2nd break
Change in level in a non-trending series	PV	1953	−2.21	–	–	–	1953	−2.92	–	–	
	CMR	1927 1978	−4.55	–	–	–	1949 1956	−3.76	–	–	–
Change in level in a trending series	ZA	1965	−4.37	0.008 (3.44)	–	–	1975	−4.88••	0.004 (3.04)	–	–
	LS1	1976	−3.16	0.023 (13.1)	–	–	1958	−2.88	0.016 (7.95)	–	–
	LP	1958 1975	−6.47••	0.019 (6.03)	–		1958 1976	−5.86	0.009 (4.40)	–	
	LS2	1958 1975	−3.99••	0.033 (15.39)	–	–	1914 1972	3.31	0.007 (3.13)	–	–
Change in slope in a trending series	ZA	1958	−5.69•••	0.021 (4.99)	0.007 (3.35)	–	1958	−5.10••	0.013 (3.82)	−0.001 (−2.96)	–
Change in level and slope in a trending series	ZA	1957	−5.62•••	0.022 (4.97)	0.007 (3.35)	–	1957	−5.04•	0.025 (4.47)	−0.001 (−2.95)	
	LS1	1957	−5.98•••	0.036 (14.8)	0.011 (6.46)	–	1957	−5.17•••	0.025 (11.4)	−0.000 (7.33)	
	LP	1958 1994	−6.26	0.024 (5.60)	0.005 (3.86)	0.051 (2.43)	1941 1958	−5.55	0.017 (3.29)	−0.005 (−2.11)	−0.03 (−3.29)
	LS2	1957 1983	−6.34••	0.036 (15.88)	−0.018 (−7.14)	0.014 (3.00)	1959 1974	−6.12•••	0.025 (12.17)	0.005 (1.24)	0.001 (0.23)

t-statistic in parenthesis. •, •• and ••• denote rejection of the null of UR at 10%, 5%, and 1% respectively using the corresponding critical values obtained from the cited papers.

GRAPH 3

NER, CPI, WPI AND RELATIVE PRICES FOR ARGENTINA AND USA –1900-2006

(In logs)



All these series were found to be integrated of order one[21]. To study whether a combination of these variables is integrated of order zero we first apply the Engle and Granger (EG, 1987) two-stage method that studies the stationarity of the residuals from equilibrium equations. It requires estimating in the constrained and unconstrained cases, respectively:

(5a) $$s_t + \mu\left(p_t - p_t^*\right) + \varepsilon_t$$

(5b) $$s_t + \mu p_t + \mu^* p_t^* + \varepsilon_t$$

Where ε_t is the error term, which should be stationary if the NER and the relative prices are cointegrated, and non-stationary otherwise. We present the results of the UR tests for the residuals of (5a, b) in Table 4.

TABLE 4
UR TESTS FOR RESIDUALS OF COINTEGRATION EQUATION

UR test	CPI RER		WPI RER		Test critical values					
	Restricted	Unrestricted	Restricted	Unrestricted	Restricted			Unrestricted		
					1%	5%	10%	1%	5%	10%
ADF					−4.08	−3.39	−3.08	−4.41	−3.82	−3.51
Lag = 0	−2.59	−3.03	−2.99	−3.29						
Lag = 1	−2.91	−3.42	−3.38•	−3.63•						
lag = 2	−2.78	−3.25	−3.28•	−3.56•						
PP					−4.08	−3.39	−3.08	−4.41	−3.82	−3.51
Newey West Band	−2.67	−3.03	−3.04	−3.44						
Andrews Band	−2.70	−3.22	−3.08	−3.44						

Tests were applied without trend and intercept. •, •• and ••• denote rejection of the unit root null at 10%, 5%, and 1% respectively, using Enders (2004) critical values because residuals are generated from a regression equation.

These results suggest that the residuals of the cointegration equations are non-stationary since only in four of twenty cases the UR null is rejected and only at the 10% level. Thus, using the EG test we reject the cointegration between the NER and the prices of Argentina and USA and hence the PPP does not hold.

A drawback of the EG test is that it requires choosing one of the variables as dependent and results are often sensible to which one is chosen. To avoid this limitation we apply the one-stage method of Johansen (1991, 1995) that does

[21] We have confirmed but do not present the results the presence of a single UR in all variables, since while tests in levels do not reject the UR null for any series at usual levels; tests in first differences reject the UR null at 1%.

not assume *a priori* a causality relation treating all the variables as endogenous and using a maximum likelihood estimator to find coefficients of equations (5a, b) and simultaneously test for the existence of cointegration relationships. We show the results of the Johansen test in the next table.

TABLE 5
JOHANSEN COINTEGRATION TEST FOR ARGENTINEAN RER COMPONENTS

Model	CPI RER				WPI RER			
	Restricted		Unrestricted		Restricted		Unrestricted	
	Trace statistic	ME statistic	Trace statistic	ME statistic	Trace statistic	ME statistic	Trace statistic	ME statistic
No intercept in CE, no trend in level data	6.97 (0.32)	6.94 (0.25)	17.76 (0.26)	10.38 (0.44)	3.00 (0.84)	2.60 (0.84)	23.60• (0.06)	18.52•• (0.03)
Intercept in CE, no trend in level data	13.91 (0.29)	8.32 (0.50)	31.56 (0.11)	19.06 (0.13)	13.90 (0.29)	12.49 (0.16)	33.68• (0.07)	19.95 (0.10)
Intercept in CE, linear trend in level data	8.49 (0.41)	7.47 (0.43)	22.26 (0.28)	15.48 (0.25)	10.93 (0.21)	10.85 (0.16)	27.31• (0.09)	17.97 (0.13)
Linear trend in CE and in level data	18.52 (0.31)	13.15 (0.31)	31.73 (0.40)	15.48 (0.59)	22.00 (0.14)	15.03 (0.19)	34.39 (0.27)	18.77 (0.32)

CE: cointegration equation. ME: Maximum eigenvalue. MacKinnon *et al.* (1999) p-values in parenthesis. •, •• and ••• denote rejection of the null of none cointegration relationship at 10%, 5%, and 1% respectively. The lag structure was selected prior the application of the test using the AIC criteria for the VAR in levels and implied the use of two lags in all cases but one, unrestricted WPI case in which it implied for lags. However, results are robust to the inclusion of more lags, up to a number of six.

The results of the Johansen test are conclusive against the existence of a cointegration relation between the NER and the prices of Argentina and USA. In almost all cases, the null of none cointegration relation between them is not rejected and only for the WPI case there is weak evidence of cointegration in the unrestricted case. Thus, using the Johansen procedure as well as the EG test data supports the notion that no long-run equilibrium relation exists between these variables, and therefore the PPP does not hold in Argentina.

In our last regression exercise, and in accordance with what we have done in Section 3.2 for the unit root tests, we test for cointegration allowing for the existence of a structural break in the cointegrating vector. This is important because in residual-based tests for cointegration, if the model is cointegrated with a one-time regime shift in the cointegrating vector, the ADF test may not reject the null and the researcher will falsely conclude that cointegration does not hold. For that purpose we use Gregory and Hansen (1996) residual-based tests for cointegration in models with regime shifts, where the cointegrating vector is allowed to change at a single unknown time during the sample period. They extend the Perron (1989), Banerjee, *et al*. (1992) and Zivot and Andrews (1992) univariate tests to a multivariate setting. In the Gregory and Hansen test,

the null hypothesis is no-cointegration, and the alternative is cointegration in the presence of a possible regime shift. They consider three different alternative hypotheses. The first is the "level shift" model, in which there is no trend in the cointegration relation and only the intercept (and not the cointegrating slope coefficients) changes after the break. The second is the "level shift with trend", in which a trend is included and again only the intercept changes after the break. The third is the "regime shift" model, in which there is no trend and both the intercept and the cointegrating slope coefficients are subject to a regime shift. We present the results of applying the Gregory and Hansen test to our series in the following table.

TABLE 6
GREGORY AND HANSEN COINTEGRATION TEST WITH STRUCTURAL BREAK

Model	CPI RER				WPI RER			
	Restricted		Unrestricted		Restricted		Unrestricted	
	Test statistic	Break date	Test statistic	Break date	Test statistic	Break date	Test statistic	Break date
Level shift								
t-statistic from ADF type test	−4.00	1974	−4.63	1984	−4.42•	1986	−4.34	1987
Zt statistic from a Phillips type test	−3.81	1974	−4.27	1985	−4.14	1985	−4.08	1917
Za statistic from a Phillips type test	−26.38	1974	−32.79	1984	−31.05	1984	−31.02	1917
Level shift with trend								
t-statistic from ADF type test	−5.28••	1984	−6.10•••	1960	−4.82•	1984	−5.10•	1960
Zt statistic from a Phillips type test	−4.95•	1983	−5.12•	1983	−4.56	1985	−4.85	1959
Za statistic from a Phillips type test	−41.84	1983	−44.31	1983	−37.43	1984	−40.97	1960
Regime shift								
t-statistic from ADF type test	−4.20	1960	−5.07	1984	−4.48	1983	−4.90	1983
Zt statistic from a Phillips type test	−3.97	1957	−4.98	1983	−4.26	1983	−4.69	1982
Za statistic from a Phillips type test	−28.85	1960	−41.95	1983	−31.89	1983	−37.16	1983

•, •• and ••• denote rejection of the null of no-cointegration at 10%, 5%, and 1% respectively using Gregory and Hansen (1996) critical values. Lags selected using the AIC criteria. It implied one lag in all cases but one (level shift model, unrestricted CPI) in which it implied four lags.

As before, the results of Gregory and Hansen cointegrating test do not support the PPP theory. When a trend is not included in the cointegrating relationship (first and third model), the null of no cointegration is not rejected at any of the usual significance levels except in one case (level model, WPI, restricted case) and only at 10% level of significance. Of course, failure to reject the null does not imply its acceptance, but we think we are safe to say that evidence does not support the existence of a cointegrating relationship among NER and relative prices, even allowing for the existence of a break at an unknown time. As in the case of UR test under breaks, when a trend is included (level shift with trend model), the null is rejected more often in favor of the alternative of cointegration with a break, notably when consumer prices are considered. Again, the existence of a trend in the cointegrating vector implies that other factors besides the PPP ones affect the relation between the nominal exchange rate and the prices.

3.4. What Have We Found About the Validity of Purchasing Power Parity in Argentina?

In this work we try to favor the verification of PPP in several ways. First, we have tested the weaker relative PPP instead of the stronger absolute PPP. Second, we do not require that the RER converge to a constant mean, but we allow it to change once or twice in the sample period and also allow the cointegration relation between the exchange rate and the prices to suffer one endogenous structural break. Third, we allow the homogeneity condition not to hold in the cointegration tests. In spite of that, the results obtained for Argentina against USA do not support the PPP theory. In this sense, when we check for the existence of a unit root in the RER series they appear as non-stationary variables. Moreover, the non-stationarity of the Argentinean RER is robust to the existence of breaks, since unit root tests under structural breaks do not reject the UR null when a trend is not included in the testing equation; or reject the null in favor of TS with breaks when a trend is allowed; being the breaks mainly around middle fifties. Hence, we have found evidence that the Argentinean RER is TS with breaks instead of DS. While both cases are contrary to the PPP theory, their economic implications are different.

Next, when we test for cointegration among the NER and the prices of Argentina and USA we cannot support the existence of a long-run equilibrium relation between those variables that would be consistent with the PPP, even after controlling for the existence of one break occurred at an unknown date. By and large, results show that deviations from the PPP do not vanish in the long run so the NER and the respective prices tend to diverge from one another and hence the PPP does not hold in Argentina over 20th century.

These results confirm the "survivorship-bias hypothesis" of Froot and Rogoff (1995, pp. 1660-62). They compellingly argued that long-span time series are usually available for those countries that have been continuously among the world's richest nations, but countries like Argentina that have experienced relative income changes are those for which long-run PPP is most likely to fail due to trends in the relative price of non-traded goods. In fact, to illustrate the likelihood of the survivorship bias Froot and Rogoff (1995) carry out the traditional ADF tests for Argentinean CPI RER against USA and UK over 1913-1988 and did not reject the hypothesis that Argentinean RER follows a random walk. As we stated above, their sample is too small (76 years) and the test that they have employed has very low power in small samples, so their results should be taken as merely illustrative[22]. However, our results using a longer dataset that mitigates the power problem, both CPI and WPI RER and a much wider set of econometric techniques (with more power and better size properties) corroborate their earlier results. Fernandes Guimaraes-Filho (1999) presents analogous results for Brazil finding a UR in its RER over 1855-1990 years, another country that have experienced sharp relative income changes with

[22] Richaud *et al*. (2003), without pretending to test PPP theory, have also test for the existence of a unit root in the Argentinean RER for the period 1913-1996 using the traditional (and low power) ADF and PP tests, and conclude also that the RER contains a unit root. Again, these results are in line with, but we take them as merely illustrative.

respect to the rest of the world. Clearly, the non-stationarity of the RER of these (and other) Latin American countries deserves further research.

What relation does exist between our results and those of the other 15 studies that test the PPP in Argentina? These works obtain results both in favor and against PPP in this country, diverse results which may come from differences in the data or in the estimation technique employed. We summarize the main characteristics of these works in Table 7.

In terms of the results, five works found support for the PPP theory in Argentina, and three obtained mixed results. Importantly, seven of these eight works use short-span data for the second half of 20th century with a maximum of 38 years (Anorou *et al*., 2002). Since as we mentioned before in this period Argentina had very high inflation this may explain the results supporting PPP. The other is Taylor (2002), which uses long-span annual data from 1884 until 1996 (113 years). To the best of our knowledge, it is the only study that employs Argentinean long-span data and accepts PPP theory so it is more challenging for us. The main differences between Taylor (2002) and our work are: (i) The samples are different, while Taylor data starts sixteen years earlier than ours, it finishes ten years earlier; (ii) Taylor uses official NER while we use free NER; (iii) besides studying the Argentinean RER against USA, Taylor uses a multilateral Argentinean RER against 19 countries, while we only consider the Argentinean RER against USA; (iv) we have employed both CPI and WPI while Taylor only uses consumer price deflator; (v) we have used a much wider set of econometric techniques, including cointegration tests and UR under structural breaks that were not considered by Taylor. Our guess is that the dissimilar results are mainly due to (i), because the different samples in the beginning and the end of the series may uncover differences in the mean-reverting behavior of RER[23]; and due to (ii) and (iv), because since the official and the free NER, on the one hand, and the CPI, WPI and the consumer deflator, on the other, do not usually behave in the same way. A detailed analysis of the behavior of the series used in those two works in terms of the inflation and nominal exchange rate depreciation they imply should reveal the sources of the different results.

3.5. Caveats

There are potential problems with the data and the estimation methods we have employed that weaken our conclusions. First, we have used aggregated price indices so we are implicitly assuming that relative prices within economies remain stable. If it is not the case we may have incurred in a specification bias (Frenkel, 1981). This is relevant in the Argentinean case because in the long-span period under scrutiny there have been big changes in the relative prices

[23] For example, Taylor sample does not include the end of the "convertibility" currency board that occurred in 2002 that cause after several years of appreciated RER a huge real depreciation of the Argentinean currency. In the same vein, we do not consider the last sixteen years of XIX, a period in which the RER suffer big changes that may modified, if considered with an homogenous consumer or wholesale price index, our results.

TABLE 7
EMPIRICAL STUDIES TESTING PPP USING ARGENTINEAN DATA

Authors	Data Frequency	Period	Type of data And sources	Ref. country	UR tests for RER	Cointegr. Tests	Evidence on PPP
McNown & Wallace (1989)	M	1976:1-1986:6	Official NER, CPI and WPI from IFS	USA	ADF	EG	In favor with WPI, against with CPI
Liu (1992), Liu & Burkett (1995)	Q	1956:1-1989:4	NER, CPI and WPI from IFS	USA	–	EG and Johansen	In favor*
Bahmani-Oskooee (1993)	Q	1973:1-1988:4	NEER built with NER and CPI from IFS	19 DCs	–	EG	Against
Mahdavi & Zhou (1994)	Q	1980:2-1991:2	NER and WPI from IFS	USA	–	Johansen	In favor
Froot and Rogoff (1995)	A	1913-1988	CPI and NER from Cavallo (1986) and IFS	USA UK	ADF		Against
Bahmani-Oskooee (1995)	Q	1971:1-1990:4	REER built with NER and CPI from IFS	19 DCs	ADF and Perron	–	Against
McLellan & Chakraborty (1997)	M	1973:7-1990:12	NER and WPI from IFS	USA	ADF and Sims (1988)	No	Against with ADF, in favor with Sims test
Bleaney *et al.* (1999)	M	1972:1-1993:5	NER and WPI from IFS	USA	ADF and stochastic		Against
Carrera *et al.* (1999)	Q	1980:1-1998:4	NER and CPI from Indec	USA	ADF, PP, VR and Perron		Against
Taylor (2002)	A	1884-1996	Off. NER, consumer deflator	USA, 19 ctrs	ADF and ERS	–	In favor
Anoruo *et al.* (2002)	Q	1961:1-1999:4	NER and CPI from IFS	USA	ADF	DECM	Against with ADF, in favor with DECM
Holmes (2001, 2002a,b)	Q	1973:2-2001:1	Off. NER and CPI from IFS	USA	ADF		In favor
Achy (2003)	M	1973:4-1998:12	Off. NER and CPI from IFS	USA	ADF, PP, Perron, VR, FI	-	Against with ADF and PP; in favor with FI and VR
Alba & Park (2003)	M	1976:1-1999:12	Off. NER and CPI from IFS	USA	ADF	-	Against
Diamandis (2003)	M	1973:11-1993:12	NER, CPI from IFS, black market NER from PCY and WCY	USA	-	Johansen	In favor
Our work	A	1900-2006	Free NER from FIEL; CPI and WPI	USA	ADF GLS, ERSPO, KPSS, modified PP- Bhargava-ERSPO, Perron, PV, ZA, LS1, LS2, LP, CMR	EG, Johansen, Gregory& Hansen	Against

New acronyms used in the Table: M: monthly; Q: Quarterly; A: Annual; IFS: International Financial Statistics, IMF; PCY: Pick's Currency Yearbook; WCY: World Currency Yearbook; DECM: Dynamic Error Correction Model; REER: Real Effective Exchange Rate; NEER: Nominal Effective Exchange Rate; DCs: Developed Countries; VR: Variance Ratio; FI: Fractional Integration.

* However, Liu and Burkett (1995) analyze the stability of adjustment to PPP finding that besides ECM coefficients are consistent with PPP as a rough average they have very high variances and contradict PPP during several quarters.

(Dabús, 2000). Furthermore, long-span price series have well-known problems as the introduction of new goods or measurement errors that can affect the results (Bresnaham and Gordon, 1997). Of course, these problems are common to all works that use aggregated price indices. Also, the use of annual data has the problem of "time aggregation" which as Taylor (2001) states biases the analysis towards finding a random walk behavior of the RER.

Besides, we have mixed data from different exchange rate regimes, since in the period under study Argentina and USA had alternated periods of fixed and floating NER (see Gerchunoff and Llach, 1998, for Argentina; and Grilli and Kaminsky, 1991, for USA). Two important differences between these regimes are that RERs tend to be less volatile under fixed than under floating exchange rate (Rogoff, 1996, p. 656), and under fixed NER deviations from the PPP are mainly dissipated by movements in the relative prices, while under floating rate the main adjustment mechanism is the NER that is much more flexible than prices. Blending data from regimes with diverse volatilities and adjustment mechanisms could have biased the results. Clearly, changes in the exchange rate regime can be a source of structural breaks. While we have controlled for one or two breaks these countries have had multiple changes in the exchange rate regime[24], so further research should evaluate the multiple breaks case, possibly following Kanas (2006)[25].

Besides, we have used bilateral RER which introduces a bias when the trade structure is diversified, since relying on prices that are not exactly related to trade flows fail to capture important aspects related to terms of trade effects. Therefore, the use of a real effective exchange rate is important. Data limitations do not allowed us to do it, but further research should consider this extension.

The last *caveat* is the possible existence of non-linearities in the Argentinean RER due to the heterogeneity of participants in the foreign exchange market in the way they form expectations or in their objectives, limited arbitrage in the event of small shocks because of the existence of transaction costs, the effect of trade reforms, etc. (Sarantis, 1999). If this were the case, our results would not be valid because we have worked with linear tests in which the adjustment process is continuous and at a constant speed. Holmes (2002b) have tested for nonlinearities in Argentinean RER using quarterly data for the period 1973:2-2001:1 and did not find a nonlinear RER adjustment. However, it is necessary to study this theme in the much longer period of our work. In particular, to apply STAR models for Argentina and other developing countries to study PPP is a clear and necessary path for future research.

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[24] Psaradakis (2001) shows that for a UR process with multiple Markov level shifts ADF tests can lead to spurious rejection of the UR null; and for stationary process with multiple and persistent Markov shifts UR tests have low power.

[25] However, Bai and Perron test suggests that CPI RER has at most four breaks and WPI RER at most three. See note 20.

4. Conclusions

Based on our empirical study we conclude that there is evidence against the PPP theory of exchange rates when it is tested for Argentina. This contrasts with the "consensus" on the literature about the long-run validity of the PPP in developed countries. Two questions emerge: why is the PPP not verified in Argentina? And what are its consequences?

In relation to the first question, besides the *caveats* of Section 3.5 there are some answers we can hypothesize. First, the "consensus" can be explained by the "survivorship bias" of Froot and Rogoff (1995). Since most studies use data from developed countries because longer series are available for them, there is a selection bias to successful countries and productivity differentials or other structural factors that can cause a trend in the RER are less likely between richer countries. As we have studied Argentina in relation with USA, those PPP adverse results are not so surprising since structural factors as the BS effect are expected to cause a steady depreciation of the RER of the poorest countries. These factors can be responsible for the non-stationarity of the Argentinean RER series since they appear to be TS with a more pronounced trend in the CPI RER than in the WPI RER[26]. Clearly, more research is needed on this subject [27].

A second factor that can explain our results is the high volatility of the Argentinean NER, which generates huge instability of nominal income and with imperfect capital markets permanent real effects on savings, investment and labor market (Andersen, 1997) which are translated, ultimately, to the RER. In addition, Argentina has had high barriers to international trade during several periods that made the arbitrage of goods and services very difficult, affecting the adjustment to PPP that is postulated to open economies[28].

Furthermore, it is important to note that a number of studies rejected the validity of the PPP theory even for developed countries. The consensus about its long-run validity is to some extent recent and professional judgment concerning the validity of the PPP has shifted several times in the last thirty years (Sarno and Taylor, 2002, p. 95). Econometric advances or the use of new data can change the actual consensus in the future. Besides, given the mixed evidence on the PPP can be considered in some sense an opinion of the reviewer[29].

Regarding the second question, there are crucial policy implications of the rejection of the PPP. First, it implies that economic policy advices derived from models in which PPP is a basic building-block are inappropriate for Argentina

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[26] Besides the higher fraction of tradable goods in WPI relative to CPI, an extra reason for expecting that PPP holds more using WPI is that wholesale goods have deeper markets. I owe to J. Llach for this remark that is not usually cited in the PPP literature.

[27] See Cavallo and Domenech (1988) and Carrera *et al*. (1998) for an analysis of Argentinean RER determinants.

[28] Of course, USA has also had periods of high barriers to international trade, being their protectionist policy in agricultural sector particularly persistent along 20th century (see Trebilcock and Howse, 1995, Ch. 2 and 11).

[29] For example, Breuer (1994, p. 262) qualifies the consensus stating that: "A judicious review [of PPP literature] would likely conclude that no consensus has yet emerged".

or at least should be taken carefully[30]. More generally, if PPP were verified deviations from it would be eventually dissipated due to changes in the NER and/or in the relative prices because when the PPP holds price level variations in two countries are the determining factor of the movements in the NER. In this case, despite short-term deviations from its PPP value the NER will eventually revert to it in the long-term so the PPP is an "anchor" for the exchange rate. As a result, the long-run RER would be a constant outside of the control of policymakers. Conversely, if the PPP is not valid deviations from it would not dissipate and there will be longer lasting effects on the country's external competitiveness and external balance, output and employment (Dornbusch, 1987). It is central for the debate regarding how long a country can obtain benefits from deliberately maintaining a depreciated RER, seeking competitive gains, better external balance and foster employment, or an appreciated RER if the aim is to fight inflation. These policies will be more effective and last longer the smaller is the connection between the NER, prices and salaries.

Finally, the validity of the PPP is relevant in practical matters, like the issue of knowing whether the RER is appreciated (depreciated) or not. If the PPP is valid, then the PPP exchange rate is a benchmark for the exchange rate or, as it is usual in practice, the RER long-run mean for the actual RER. Conversely, if the RER follows a definite tendency, it is no longer valid to compare the RER with its historical mean to test whether is appreciated or not.

Along the text we have indicated several avenues for further research. Three of them are worth mentioning again: (i) the study of nonlinear mean reversion of the Argentinean RER. (ii) If it is still non-stationary using nonlinear econometric methods, the study of the determinants of the non-stationarity of the RER to see which real factors cause structural deviations from the PPP in Argentina. (iii) To investigate the sources of the breaks founded in the RER series. Certainly, extending the whole analysis for other Latin American countries would be very relevant also.

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[30] As we saw, in spite of that PPP is not verified in Argentina in the whole sample it is possible that it could be in sub-periods, e.g. under high inflations, during which models that assume PPP would be applicable. For example, McNown and Wallace (1994) found that the monetary model of exchange determination which has PPP as a building block was valid for Argentina during the high-inflation period of 1977:3-1986:12. See Note 21, and Sections 3.2 and 3.5 for more on these themes.

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