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PURCHASING POWER PARITY IN AN EMERGING MARKET ECONOMY: A LONG-SPAN STUDY FOR CHILE

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Resumen

Recientes investigaciones han encontrado evidencia a favor de la condición de paridad de poder de compra (PPC) en países desarrollados usando muy larga data, sin embargo en países en desarrollo la evidencia casi no existe. Este artículo intenta llenar ese vacío evaluando la validez de largo plazo de la PPC para Chile desde 1810, usando data de Díaz, Lüders y Wagner (2003). Aplicamos una batería de tests de raíz unitaria y cointegración encontrando evidencia a favor de PPC. Los resultados son robustos a diferentes índices de precios, tamaño de muestra y especificaciones de tests.

Abstract

Recent research has found evidence that supports the purchasing power parity (PPP) condition in developed countries using very long-span data, while evidence for developing countries is almost nonexistent. This paper tries to fulfill this void by testing the validity of PPP as a long run equilibrium condition for Chile, using data, since its birth as a nation, developed by Díaz, Lüders and Wagner (2003). A battery of unit-root and cointegration tests is applied. We found evidence in favor of PPP. Results are robust to changes in the domestic price index, to changes in the sample period, and to the econometric technique applied.

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1. Introduction

Most general equilibrium models of open economies impose the Purchasing Power Parity (PPP) as a long run equilibrium condition (Obstfeld and Rogoff, 1996).[1] However, the literature has casted doubt on its empirical validity (Froot and Rogoff, 1995; Rogoff, 1996; Sarno and Taylor, 2002). The availability of new databases of long span and the development of new econometric techniques have marked the rebirth of the empirical literature on PPP.

Having rejected the validity of the PPP condition in the short run, the development of time series techniques for non-stationary series motivated the use of unit root and cointegration procedures on the real exchange rate (RER) in order to test the validity of the PPP condition in the long run. Many studies found a unit root in the RER, especially for the post-Bretton Woods period. This implied the rejection of the PPP hypothesis as a valid equilibrium condition in the long run. However, this evidence is considered inconclusive due to the low power of unit root tests in small samples to distinguish between non-stationary and stationary but highly persistent processes (Canzoneri *et al.*, 1999).

Two different strategies have been followed by recent research in order to overcome the power problem of unit root tests. First, some researchers have applied unit root tests in recently available long-span data sets (Frankel, 1986; Edison, 1987; Lothian and Taylor, 1996; Taylor, 2002; among others). Although subject to some criticism in the literature, these studies have found evidence in favor of the PPP condition.[2] Second, some researchers have applied recently developed panel unit root and panel cointegration techniques (Frankel, 1996; Papell, 1997; O'Connell, 1998; Cheung and Lai, 2000).

In the spirit of recent research, our main goal is to assess the validity of the PPP condition in an emerging market economy like Chile using a recently available long span database developed by Díaz, Lüders and Wagner (2003). Most long span studies have been undertaken for developed countries instead of developing countries. This is due to the lack

[1] According to this assumption, prices of goods in countries will tend to equate so that people would be able to purchase the same quantity of goods in any country for a given sum of money.
[2] It has been argued that real shocks may generate structural breaks or shifts in the equilibrium real exchange rates in such long periods. In addition, the speed of mean reversion is difficult to measure in these studies given the different exchange rate regimes that may have taken place (Hegwood and Papell, 1998).

of long-span historical series for the latter group.[3] Our objective is to test the PPP hypothesis using annual data for Chile during the 1810-2002 period.

Using a battery of econometric tests, we found evidence that mostly supports the PPP hypothesis in the Chilean economy. In most cases, unit root and stationarity tests reject the possibility of a random walk process in RERs. These results are robust to the use of different domestic price indexes (special CPI, WPI or GDP deflator), periods of time (providing they are long enough to assure the power of the tests), and econometric issues such as, optimal lag length, lag truncation, and other test specifications. Similarly, cointegration tests support the existence of a long-run relationship among the nominal exchange rate and the domestic and foreign prices. Finally, we evaluate for the existence of structural breaks in the process of the RER using Hansen´s (1997) threshold autoregressive model. Results indicate that there is a break in the process of the RER around 1973, however we interpret these results carefully. This fact can be reconciled with the prior evidence presented by analyzing the differences between the theoretical and our practical measure of RER. Thus, we could suspect that the changes in the properties of the RER after 1973 might be attributed to the omission in the RER proxy of reduced barriers, tariffs or transaction costs due to trade and financial liberalization strategies undertaken in Chile in the seventies.

The paper is divided as follows. Section 2 provides a brief review of the empirical literature of the PPP hypothesis. In general, the literature would show that its results are mixed and inconclusive. However, recent research has found more support in favor of PPP in the long run and among major currencies. Section 3 discusses the data and particularly the short-run evolution of the RER in Chile from 1810 to the present. Section 4 presents the econometric tests and their main results. Finally, the paper ends with some concluding remarks.

[3] Recently, Taylor (2002) presents evidence for Argentina, Brazil and Mexico with more than 100 years of data. He finds that real exchange rates are stationary.

2. A Brief Literature Review

The empirical literature on the "Purchasing Power Parity" (PPP) hypothesis is as vast as its history (Froot and Rogoff, 1995).[4] In the present section, we review the main empirical findings of this literature. For expositional reasons, we can divide the empirical literature on PPP into five stages or generations. Table 1 sums up the main studies and their respective findings on this subject.

First Stage: Naive Techniques

Early studies specified the following fundamental equation for testing PPP:

$$E_t = b_0 + b_1 P_t + b_2 P_t^* + u_t \qquad (1)$$

where E is the nominal exchange rate (NER), P denotes domestic prices, P^* stands for foreign prices[5], and u is the error term. Traditional econometric techniques (OLS) were applied in this first stage, with mixed results. Frenkel (1978) found evidence in favor of PPP only for economies with high inflation, whereas Frenkel (1981) found no evidence for countries with low and moderate inflation.

<Insert Table 1 about here>

The inference obtained from the standard econometric techniques applied in this stage is not valid since it did not take into account the fact that exchange rates and prices were non-stationary processes. Specifically, we should examine the stochastic properties of the error term, u, in equation (1). If u is non-stationary, any relationship obtained from equation (1) is spurious.

Second Stage: Introducing Univariate Techniques

To address the issue of non-stationarity –fundamental criticism of the first stage– the next generation applied unit root and cointegration techniques to RER data. Specifically, they tested whether the RER was stationary or not. In this stage, the evidence found was mainly

[4] This brief review draws from some excellent new surveys on the PPP literature such as Froot and Rogoff (1995), and Sarno and Taylor (2002).

[5] All the variables are in log form.

against PPP (Taylor 1988; Edison and Pauls, 1993; among others).[6] Only a few studies rejected the null of unit root in the RER (Huizinga, 1987; Chowdhuri and Sdogati, 1993). For the Chilean economy, Céspedes and De Gregorio (1999), and Valdés and Délano (1999) found evidence against PPP for different periods (see table 1).

We must point out that a unit root tests on the RER implicitly assumes the validity of two conditions: symmetry ($\beta_1 = -\beta_2$ in equation 1) and proportionality ($\beta_1=1$ and $\beta_2= -1$).

Third Stage: Applying Multivariate Cointegration Techniques

Instead of imposing the conditions of symmetry and proportionality, researchers in this stage applied cointegration techniques to test the existence of long-run relationships between exchange rates and prices. Specifically, they applied not only uni-equational techniques (Engle and Granger, 1987) but also vector autoregressions with an error correction mechanism (Johansen, 1988, 1991). In this stage, we also obtained mixed results. Kim (1990) and Cheung and Lai (1993) found evidence in support of PPP, whereas Taylor (1988) and Mark (1990) rejected the validity of PPP in the long run.

The main findings from this stage of the empirical literature are the following: (i) it is more likely to find support for the PPP hypothesis if fixed exchange rate regimes prevail instead of flexible ones, (ii) it is more likely to reject the null of no-cointegration if we used WPIs instead of CPIs or GDP deflators, (iii) it is more likely to find evidence against PPP if we employ trivariate systems instead of bivariate ones (Sarno and Taylor, 2002).

The last two stages of the literature deal with the "power problem" of unit root testing procedures. When applied to the recent floating period, these tests may have very low power to distinguish between non-stationarity and stationarity but highly persistent processes (see, for instance, Froot and Rogoff, 1995; Lothian and Taylor, 1997). Monte Carlo experiments by Lothian and Taylor (1996) support this fact.

[6] It was argued that permanent real shocks (e.g. productivity shocks) were the source of non-stationarity in real exchange rates, in the spirit of the Harrod-Balassa-Samuelson hypothesis.

Fourth Stage: Long-Span Studies and Panel Data Analysis

The empirical literature followed two different routes to overcome the problem of low power of unit root tests in small samples: (i) long-span studies and (ii) panel data studies.

Long Span Studies. This research avenue analyzed the behavior of the RER in the very long run. They mostly used long-span data on RERs for industrial countries. Frankel (1986), Edison (1987), Lothian and Taylor (1996), and Cuddington and Liang (2000)[7] provide evidence that PPP holds. Recently, Taylor (2002) has provided evidence in favor of the PPP hypothesis in the very long run not only for industrial countries but also for developing countries (Argentina, Brazil, and México). On the other hand, Délano (1998) found that the RER is stationary for Chile during the 1830-1995 period, but that it presents a unit root for the period 1918-1995.

One of the main criticisms to the use of long-span data is the presence of real shocks that may shift the RER permanently. Hegwood and Papell (1998) found that although most RERs in industrial countries had at least 2 structural breaks during the last 100-200 years, they were stationary. Strictly speaking, they could not find evidence of long-run PPP (*i.e.* reversion to a constant mean). Instead, they found reversion to a changing mean or what they call "*quasi-purchasing power parity*."

Panel Data Studies. The recent development of panel unit root and cointegration techniques has generated an important amount of empirical literature of long run PPP using panel data sets of industrial and developing countries (Abuaf and Jorion, 1990; Wu, 1996; Papell, 1997). The panel data evidence shows the following results:

- Evidence in favor of PPP is stronger for larger than for smaller panels, and for monthly than for quarterly data (Papell, 1997).
- The choice of numeraire matters for PPP testing and the evidence is stronger for European than for non-European base currencies (Papell and Theodoridis, 2001).
- Evidence in favor of PPP for panel data holds even if we control for cross-sectional dependence (O'Connell, 1998).

[7] They find that PPP holds for the franc-sterling but not the dollar-sterling.

- The strength of the PPP evidence is highly cyclical. That is, it strengthens when the US dollar appreciates, and it weakens when the US dollar depreciates (Papell, 2001).

Finally, Sarno and Taylor (2002) provide a very important caveat on the analysis of the inference obtained from panel data unit root tests. The null hypothesis in most of these studies is the joint stationarity of the RER, with the rejection of the null hypothesis occurring even if only one of the series considered is stationary.[8] A test with low power would drive the rejection of the unit root null with few stationary series. However, Karlsson and Lothgren (2000) found that the power of panel unit root tests increased monotonically with a higher number N of individuals in the panel, a larger dimension T in each individual series, and a higher proportion of stationary series in the panel.

Fifth Stage: Application of Non-Linear Techniques

The last generation assumes that RERs can exhibit some sort of non-linearity based on the following facts: (a) the slope coefficient of changes in the nominal exchange rate and inflation differentials is always below unity and it increases with the length of the observation interval, (b) the PPP link is stronger under hyperinflation than under modest inflation (Sercu, Uppal, and Van Hulle, 1995).

The non-linear behavior that the RER could display might be rationalized in a model of international trade with transaction costs (Sercu and Uppal, 2000) or in a model where transactions take time (Benninga and Protopapadakis, 1988). According to these models, the deviations from the RER are corrected when the imbalance is larger relative to the transaction cost. Hence, the RER is a mean reverting process. However, if the deviation from the RER is small relative to the transaction cost, the process is non-stationary.

[8] Taylor and Sarno (1998) have proposed a multivariate tests in which the null hypothesis is that at least one of the series in the panel is a realization of a unit root process. This null hypothesis is violated if all of the series are in fact realizations of stationary processes (*i.e.* H_1: $\rho_i < 1$, for all *i*). The test procedure is a special application of Johansen's (1988) maximum likelihood procedure for testing for the number of cointegrating vectors in a system. Although this alternative hypothesis is more rigorous towards stationarity than the one presented by Im *et al.*(2003), we can not perform this test because we lack the sufficient time dimension *T*, given the number *N* of countries involved.

Using threshold autoregressive (TAR) and exponential smooth transition autoregressive (STAR) models, it has been found evidence against linearity and in favor of some kind of non-linear process (Michael, Nobay, and Peel, 1997; Taylor, Peel, and Sarno, 2001).

In sum, the PPP literature shows mixed results. As Sarno and Taylor has pointed out, if nowadays there is a consensus, it is probably reverting towards the view that long-run PPP does hold, at least for the major exchange rates, although some puzzles do not have conclusive answers yet.

3. The Evolution of the Real Exchange Rate in Chile, 1810-2002

Before we proceed to analyze the stochastic properties of the RER in Chile for the 1810-2002 period, we present the evolution of the exchange rate in Chile. This historical review of the RER and shocks that might have affected it will help us understand analytically some of the results that will be discussed later. For a more detailed description of the data used and the construction of the RER see Appendix A.

In figure 1, we observe that the RER in Chile follows different patterns in the short long run. We will try to link these patterns with events occurred in the Chilean Economy (for a more detailed description of the evolution of the Chilean economy and its policies, see Tables B.1 and B.2 in Appendix B):

<Insert Figure 1 about here>

We first observe a period of low volatility before the 1920s, and a period of higher volatility starting from the 1930s. These changes in behavior could be attributed to structural shocks faced by the Chilean economy such as the Great Depression of 1929, the World Wars, and several stabilization attempts.

During the boom of the nitrates in Chile, the RER declined significantly. Specifically, the Chilean peso appreciated 36.6 percent over the 1870-1913 period (an annual average appreciation of 1.1 percent). This trajectory may be attributed to the so-called "Dutch disease" phenomenon.

Next, the RER depreciated at an annual average rate of 31.7 percent during the Great Depression years (128 percent over the 1929-1932 period). During this period, the Chilean was severely hit, with output per capita falling 60%, exports fell 79%, and nitrate and copper prices declining 60 and 70 percent, respectively (Meller, 1996).

After the Depression, the Chilean peso started a real appreciation at an annual average rate of 3.9 percent (i.e. 60 percent accumulated appreciation of the Chilean peso) over the 1932-1955 period. This trajectory may be explained by internal imbalances due to an inward-oriented development strategy (i.e. forced import substitutions, increasing role of the government in the economy).

In the beginning of the 1970s, the RER appreciated due to exchange rate controls and an increasing government spending. The Chilean peso declined (in real terms) at an average annual rate of 57.9 percent during the period 1971-73 (that is an accumulated appreciation of 35 percent). This period is characterized by weak macroeconomic management in Chile and Latin America. In addition, domestic shocks such as the military takeover in 1973, and external shocks such as the oil shock crises and the collapse of the fixed exchange rate system, increased the volatility exhibited by the RER.

Unsustainable fiscal deficits in the first years of the military government, deteriorated terms of trade, repercussion on the net foreign asset position of the Latin American debt crisis affected negatively the Chilean peso. The RER depreciated at an annual average rate of 10.6 percent during the period 1973-88 (that is, 351 percent throughout the entire period). Observe the significant fluctuations in the RER especially in the middle of seventies (see figure 1). Finally, market-oriented policies, liberalization strategy and strict fiscal discipline were among the main sources of the high growth experienced by Chile in the "Golden Years," 1986-1997, with an annual growth rate of 7 percent (Gallego and Loayza, 2002). During this period, the RER appreciated 34.6 percent over the entire period (an annual average of 3.8 percent). Faster productivity growth in tradables might explain the real appreciation of the Chilean peso in the

1990s. However, since 1998 the Chilean peso has depreciated in real terms probably due to decreasing productivity growth, adverse terms of trade shocks, and lower (or negative) capital inflows.

4. Empirical Strategy and Main Results

In this section we test the hypothesis of PPP using unit-root and cointegration tests. After that, we also test for structural breaks in the process of the RER in order to complete the analysis. We use annual, end-of-period, nominal exchange rates, both multilateral (between the Chilean peso and a weighted average of US$ dollar and UK£ pound sterling) and bilateral (only with the US$ dollar); special price index for the Chilean economy[9]; and US and UK Wholesale Price Indexes. The series span the last 192 years, from 1810 to 2002. The detail of the series, its sources and the construction of the RERs can be found in Appendix A.

4.1. Testing the Null Hypothesis of Unit Root in the RER

First, we evaluate the presence of a unit root process in the log of the RER. If the null of unit-root cannot be rejected then we can affirm that there is not enough evidence to support the PPP hypothesis. As table 2 shows, we apply a battery of traditional and non-traditional tests:

- Augmented Dickey-Fuller (DF),
- Phillips-Perron (PP),
- the Generalized-Least-Squares (GLS) version of the DF test due to Elliot *et al*. (1996, DF-GLS henceforth),
- the modified version of the PP test due to Ng and Perron (2001b, NP henceforth), and
- Kwiatkowski *et al.* (1992) test for stationarity (KPSS henceforth). For a detailed description of each test, see Appendix C.

<Insert Table 2 about here>

[9] Following the suggestion by Wagner (1992) and Díaz *et al*. (2003). According to that, using CPI could be misleading for the 1830-1925 period, since the index includes the fluctuations of the UK Wholesales Price Index. Sensitivity analysis is performed using also WPI and GDP deflator series and very similar results were obtained.

In order to analyze the sensitivity of the tests we also report different (optimal) lag length and lag truncation. We use basically Schwarz and Hannan-Quinn criteria of choice[10], different types of bandwidth (see table 2, rows below each test).

For instance, Table 2 provides evidence that the traditional ADF and PP tests reject the null of unit root in both the multilateral RER (e^M) and the bilateral RER (e^B) even at 1% of confidence. These results are invariant to the number of lags. Similarly, the DF-GLS and NP tests verify that the presence of a unit root can be rejected in both RER series.[11] Finally, the application of the KPSS to test stationarity in the RER series suggests that the null of stationarity cannot be rejected at conventional confidence levels. That is, in most of the cases, it is possible to affirm with a high likelihood that both the multilateral and the bilateral RERs are stationary.

It must be mentioned that following Culver and Papell (1999), we have opted by omitting time trend in the tests since their inclusion would be inconsistent with the PPP hypothesis in the long run.

As a sensitivity analysis, we also apply the same tests using different periods of time and different domestic price indexes. In both cases the results are almost invariant. In the first exercise we use 150 years of time span after the first and before the last period and 100-year rolling windows (see table 3 and figure 2). Aside from that, we take the 1918-1995 period only to contrast to Délano's (1998) results. Remind that for the Chilean case, Délano (1998) found that the RER is stationary for the 1830-1995 period, but that it is non-stationary for the 1918-1995 period.[12] We have also performed the same tests for both time intervals finding again evidence in favor of the PPP hypothesis (see table 3, last two columns).

<Insert Table 3 about here>
<Insert Figure 2 about here>

[10] Akaike criterion is not used here because it is known that it is inconsistent and tends to overfit the regressions of the tests (see Greene, 1998).
[11] The exception is the multilateral RER in the 1810-1960 period in the GLS-DF and NP test using Hannan-Quinn criterion.
[12] There are some differences between that work and ours: the time span, the unit-root tests used to verify PPP, and the domestic price indexes used to construct the RER.

Finally, in the last exercise we use other domestic price indexes (WPI and GDP deflator) in the construction of the RERs (see table 4). As we mentioned before the results are virtually invariant to the domestic price index used as denominator of the RER.[13]

<Insert Table 4 about here>

4.2. Testing for Cointegration in the Components of the RER

As we have explained in the literature review, assessing stationarity through unit-root tests implies the assumptions of symmetry and proportionality in the RER. In order to overcome this fact, we also perform tests of cointegration among the series of nominal exchange rates and domestic and foreign prices. In this case the strategy is as follows. Using the same tests applied before, first we verify that all series are integrated of order one. If they can be represented by unit root process there might be at least one cointegration vector among them. Finally, we test for cointegration using typical Engle-Granger test of the residuals and Trace and Maximum-Eigenvalue tests developed by Johansen (1991, 1992). If the null of non-cointegration can be rejected then we can say that there is evidence in favor of the PPP hypothesis in the long run.

Table 5 illustrates the first step outlined. Unquestionably the null of non-stationarity cannot be rejected for all the series in levels through the ADF, PP and NP tests, suggesting that the nominal exchange rate, the domestic price level, and the foreign price level can be represented each by a non-stationary process. Also the results of the DF-GLS and the KPSS mainly imply that the series in levels are not stationary. Except in the case of nominal exchange rate for the DF-GLS test and the series with the choice of the Andrews bandwidth in the KPSS test.

<Insert Table 5 about here>

The results appear even clearer when the same tests are applied to the series in differences. In this case, almost all the tests agree with the rejection of unit root in the series.

[13] According to Sarno and Taylor (2002) it is more likely to find evidence in favor of PPP using WPIs instead of CPIs or GDP deflators, a fact that is not obtained in our results.

Again some exceptions come out in certain cases only through the KPSS test.[14] In other words, the evidence most likely supports the presence of unit root in the series in levels.

Under the highly possible presence of unit roots in the series, we continue with the application of cointegration tests. Hence an Engle-Granger test is performed for the residuals of the regression among the components of the RER. Table 6 shows that the residuals are stationary. In this case, the tests coincide to reject the null of unit root.

<Insert Table 6 about here>

This fact is verified when Johansen’s cointegration tests are applied. As it can be seen in table 7, the trace and the maximum-eigenvalue test find at least one cointegration vector in the regression among the domestic prices, the nominal exchange rate and the foreign prices, in both the multilateral and bilateral case.

<Insert Table 7 about here>

The results are statiscally significant at conventional confidence levels. This would strongly suggest the possibility of a long-run relationship among the series and the support of the PPP hypothesis.

4.3. Testing for Structural Breaks

As we stated in section 2, one of the main criticisms of testing PPP over the very long run is the presence of real shocks that may cause a structural break in the RER (Taylor, 2002). For this reason, the literature suggests testing for structural changes in the RER process. We also should note that most unit root tests are biased towards the non-rejection of the null when we do not acknowledge the presence of a structural break (Perron, 1989). In this long period of analysis, it seems valid to wonder whether there has been a structural change in the RER process or not. Accordingly, we perform a structural break test using Hansen´s (1996, 1997) threshold autoregressive (TAR) model.

[14] It must be noted that Rothman (1997) shows that KPSS critical values present important size problems when the series have high persistence.

As Hansen (1992) contends, there is a wide variety of structural tests but unfortunately, not all are equal and many, developed from ad hoc criteria, are somewhat poor. Perhaps, the most popular test is the one by Chow (1960). However, the major disadvantage of this procedure is the need to select the timing of the structural change that occurs under the alternative hypothesis.[15] Therefore, we opted to perform a test that allows for the estimation of the breakpoint in a non-arbitrary way.

<Insert Table 8 about here>

Table 8 summarizes the main results. We find a statistically significant breakpoint in 1973, with a 95%-confidence interval between 1972 and 1984. However, we should be careful how we interpret these results. First, we obtain strong evidence in support of PPP over the 1810-2002 period in sections 4.1 and 4.2. In the presence of structural breaks, the Dickey-Fuller and Phillips-Perron test statistics should have been biased towards not rejecting the null of unit root. Second, we can reconcile the evidence presented in this section with our main finding by analyzing the differences between the theoretical and our practical measure of RER. According to Lucas (1982), the real exchange rate is equal to the marginal rate of substitution of consumption of domestic and foreign goods:

$$e_t = \frac{E_t P_t^*}{P_t} = \frac{u_2(c_t, c_t^*)}{u_1(c_t, c_t^*)}$$

According to this model, changes in the value of the real exchange rate, e_t, may be introduced by transaction costs or tariffs. In this sense, if we were able to perfectly measure transportation costs and/or trade barriers, we could incorporate them into the data used to test the PPP condition. Third, in the spirit of possible measurement errors in the RER proxy used, we could suspect that our change in the mean of this process may be attributed to trade and financial liberalization strategies undertaken in Chile and the declining transport costs driven by improvements in the communication technology.[16]

[15] See Davies (1987), Hansen (1992), Davidson and MacKinnon (1993) for the features of typical structural tests as Chow's.

[16] There are two additional issues upon the results of this test. First, the process of the RER remains stationary before and after 1973. That is, PPP might be seen as a valid hypothesis within those spans, a fact that has been called "*quasi* PPP" by Hegwood and Papell (1998). And second, the half-life of the process falls from 2.1 to 1.6 years along both periods, which are even lower than the 2.8 years found for the full sample. In any case, these estimates are fairly lower than the traditional consensus, from 3 to 5 years, stated by Rogoff (1996).

5. Concluding Remarks

Many models of exchange rate determination are built under the assumption that PPP holds. The PPP condition is not only key to understand the nature of nominal and real shocks in these models, but also is widely used in policy circles to compute RER misalignments. Theoretical and empirical evidence have shown that the PPP can be violated in the short run. PPP may not hold if: (i) there are transaction costs and trade frictions, (ii) differential baskets of goods are used to construct aggregate price indices, and (iii) government intervenes in foreign exchange rate markets. However, recent evidence using long-span data and panel-data sets is leaning towards the validity of PPP in the long run (Papell, 1997; Papell and Theodoridis, 1998; O'Connell, 1998; Taylor and Sarno, 1998).

The main goal of this paper was to assess the validity of the PPP condition in an emerging market economy like Chile using the recently available long span database constructed by Díaz, Lüders and Wagner (2003). Thus, we applied a battery of econometric tests to determine whether the PPP condition holds in the 1810-2002 period. Aside from its conclusions, perhaps the main differences among this study and others - for Latin American countries including Chile- are the use of very long span data and a wide and suitable variety of econometric tests.

We find robust evidence that supports the PPP hypothesis in Chile. In most cases, unit root and stationarity tests reject the possibility of a non-stationarity in RERs. These results are virtually invariant to the use of different domestic price indexes (special price index, WPI or GDP deflator), sample periods (provided that they are long enough to assure the power of the tests), and econometric issues such as optimal lag length, lag truncation, and other test specifications. Similarly, there is a cointegrating relationship between the nominal exchange rate and the domestic and foreign prices. Finally, we test for the presence of structural breaks in the RER process using Hansen´s (1997) TAR model. We find a breakpoint in 1973, although we should interpret this result carefully. We reconcile this finding with our main result (i.e. validity of PPP over the full sample) by analyzing the possible shifts of the theoretical measure of the RER over time. If we define the RER as the marginal rate of substitution of consumption between domestic and foreign goods, this relative price may change in the presence of transaction costs and tariff barriers. Our finding of a structural break in the RER may be reflecting measurement errors in our proxy. We cannot adjust our RER measure for the presence of tariffs and transportation costs due to the lack of good proxies. In this sense, the changes in the properties of the RER after 1973 may be attributed to trade and financial liberalization strategies undertaken in Chile as well as declining international transportation costs (see Hummels, 1999).

Among our future avenues of research we will test the presence of non-linearities and its consequences in terms of the stationarity properties of the RER. We will use not only STAR modeling for the RER series but also we will perform a close inspection to the coefficient β in equation (1) using threshold cointegration techniques (Balke and Fomby, 1997; Lo and Zivot, 2001).

APPENDIX A
Data, Sources and Definitions

Variable	Type	Source
Nominal Exchange Rates	Bilateral NER (E^B): Ch$/US$	1810-2000: Díaz *et al*. (2003) based on: - 1810-1928: D'Ottone and Cortés (1965) - 1929-1935: Several sources (D'Ottone and Cortés, 1965; Lüders, 1968; among others) - 1936-1939: Central Bank of Chile - 1940-1951: CORFO (1957) - 1952-1959: Ffrench-Davis (1973) - 1960-2000: Central Bank of Chile (2001) 2001-2002: Central Bank of Chile (2003)
	Multilateral NER (E^M): basket of US$ dollar and UK£ sterling	1810-2000: Díaz *et al*. (2003) based on: - 1810-1959: D'Ottone and Cortés (1965) - 1960-2000: Central Bank of Chile (2001) 2001-2002: Central Bank of Chile (2003)
Domestic Prices	Special Price Index (P)	1810-2000: Díaz *et al*. (2003) based on: - 1810-1860: Riveros (1987) - 1861-1928: Wagner (1992) - 1929-1969: Central Bank of Chile (monthly bulletins) - 1970-1977: Schmidt-Hebbel and Marshall (1981) - 1978-2000: Central Bank of Chile (2001) 2001-2002: Central Bank of Chile (2003)
Foreign Prices	US Wholesales Price Index (P^B or P^{US})	1810-2000: Díaz *et al*. (2003) based on: - 1810-1889: USBC (1960) - 1890-1912: National Bureau of Economic Research (www.nber.org) - 1913-2000: US Department of Labor, Bureau of Labor Statistics (www.bls.gov) 2001-2002: US Department of Labor, Bureau of Labor Statistics
	UK Wholesales Price Index (P^{UK})	1810-2000: Díaz *et al*. (2003) based on: - 1810-1965: Mitchell (1983) - 1966-1973: IMF (1996) - 1974-2000: UK National Statistics (www.statistics.gov.uk) 2001-2002: UK National Statistics

Definitions[/a/b]		
Multilateral Foreign Price Index (P^M)		$P_t^M = 100.\prod_i \left(\frac{P_t^i}{P_{1996}^i} \right)^{a_i}, i = US, UK$
Multilateral Effective Nominal Exchange Rate (E^M)		$E_t^M = 100.\prod_i \left(\frac{E_t^i}{E_{1996}^i} \right)^{a_i}, i = US, UK$
Real Exchange Rates	Bilateral RER (e^B): with US$	$e_t^B = \frac{E_t^B P_t^{US}}{P_t}$
	Multilateral RER (e^M): basket of US$ and UK£ sterling.	$e_t^M = \frac{E_t^M P_t^M}{P_t}$

a. Base year 1996=100. All the series are end-of-period annual variables.
b. For the values of the weights a_i, see Díaz et al. (2003).

APPENDIX B
B1. Evolution of Policies in the Chilean Economy, 1810-2002

Year	Fact
1810	Independence from Spain. Bimetalic monetary standard.
1850-75	Boom in the production of silver.
1879-1883	Pacific War: Economic condition in Chile normalized very rapidly after 1879. Positive wealth shock: Chile takes over nitrate mines from Peru and Bolivia.
1880s	Beginning of the Nitrate's Era. Large scale production by British firms. Ended in 1930. Outward oriented development strategy based on the exports of natural resources.
1914-1919	World War I. High volatility of Chilean nitrate exports and prices. Largest drop in fiscal revenues.
1920	Beginning of the Copper's Era. Large investments from the United States (1904: El Teniente; 1911: Chuquicamata).
1925	Creation of the Central Bank of Chile. Fiduciary System.
1929	Great Depression. GDP in Chile declined 47% and output per capita fell 60%, exports fell 79% and imports fell 83% over the 1929-32 period. Nitrate and copper prices declined 60 and 70%, respectively, over the same period.
1930s	Deflationary process due to depression. External debt payments are suspended. Inward-oriented development strategy: Industrialization as the engine of growth. Force import substitution. Increasing role of the State in the economic activity.
1939	Creation of CORFO: State institution in charge of formulating? development programs and allocating resources to activities included in those programs.
1939-1945	World War II.
1953-1955	Wage adjustment to public administration officials financed with public resources and bank lending. Inflation of 40% in 1953, 64% in 1954, and 86% in 1955.
1956	Klain-Saks Consulting: Financial stabilization program and foreign exchange reform. Wage adjustment=50% of last year's inflation. Controled prices raise no more than 40%.
1958-1964	Large program of public works. Failed un-orthodox anti-inflationary programs. Inflation increased from 17% in 1957 to 33% in 1958.
1959	New stabilization program: Adjustment of wages=Inflation in 1959. Reduction of money via reserve requirements. Collapse of exchange rate system in 1961.
1964-1970	State acquired 51% of the property of copper mines. Poor fiscal discipline.
1965	Plan of gradual reduction of inflation. Diagnostic of inflation: Increasing costs. Inflation slight lower than 30% in 1968-69.
1971	Nationalization of the Copper Mines, Financial System, Public Utilities, Oil and petro-chemicals. Price controls, multiple exchange rates, high tariffs, controls on K movements, interest rate and credit. Inflation= 20%. BoP goes from surplus of US$ 110 millions in 1970 to deficit of US$ 300 millions in 1971. Inflation= 163% in 1972.
1973	Unsustainable fiscal deficits, black markets and rationing. Profound economic crisis. Military takeover in September. New Economic Program: Emphasis on role of private sector. Still 3-digit inflation in 1973-76.
1975-79	Liberalization of the Chilean Economy. Trade Reform: Flat tariff of 10%, elimination of non-tariff barriers. Capital Markets: Reprivatization of the Banking System, free interest rate, liberalization of capital movements.
1982-1983	Latin American Debt Crisis. Chilean GDP declined 14.4% in 1982. Banking crisis. Unemployment rate greater than 30% in 1983. International reserves declined almost 50% in the 1981-1983 period.
1986-98	Golden Years of the Chilean Economy: GDP average growth rate of 7% annual.
1990	Return to Democracy. Market-oriented policies were deepened. Autonomy of the Central Bank of Chile (Law No. 18840).
1994	The Chilean economy is insulated from the Mexican Crisis.
1998-at present	Recession in the Chilean Economy due to Asian Crises. Central Bank applies contractionary monetary policy.

Sources: Larraín and Vergara (2000), Lüders (1998), Marshall (1991), Meller (1996), Morandé and Tapia (2002).

B2. Monetary and Exchange Rate Policies in the Chilean Economy, 1925-2002

Year	Monetary Policy	Exchange Rate Policy
1925	Creation of the Central Bank.	Gold Standard.
1931-32	Massive credits to the Government to estimulate the economic activity.	Foreign exchange controls are imposed. Suspension of the Gold Standard. Pound sterling is the reference (until 1937).
1942	Economic Law (No. 7200): Government can obtained credits from Central Bank for 1/12 of the budget approved by Congress.	Managed floating / Multiple Rates (1937-46).
1956	Selective credit oriented to economic activities and margins of credit expansion.	Dual Markets: (i) foreign trade activities, (ii) capital account transactions.
1958	Limits to the amount of credit expansion by the Central Bank. Margins to credit expansion for Banco del Estado.	Managed Floating / Dual Markets.
1959-60	Wage indexation by 10%. Reserve requirements for the banking system are increased.	Escudo replaces the "old" peso.
1963-64	Controls on domestic credit by the Central Bank.	Continued nominal devaluations to improve the external equilibrium.
1965-70	High legal reserve requirements. Credit allocation to desired activities. Interest rates determined by banks every semester.	Mini-devaluations / Dual Markets.
1971-72	Fiscal deficit financed with banking credit. Price controls.	Multiple Exchange Rates.
Sep. 1973	Restrictive monetary policy to gradually reduce inflation.	Hyperfloat
1975	Shock program to reduce inflation. Interest rates determined by market conditions. Reduction of high reserve requirements.	(New) peso replaces the escudo. Crawling peg to US dollar (1976)
1978	Exchange-rate-based stabilization program. Capital inflows allowed high growth rates for the monetary base and M1.	Tablita Plan: Pre-announced crawling peg to US dollar. Exchange rate as the nominal anchor.
1981-83	Banking Crisis. Central Bank bought non-performing loans from the banks. Massive intervention of banking institutions.	Second phase of the Tablita plan (1979-82)
1985	Gradual elimination of inflation. Interest rate targets. High interest rates attracted capital inflows to Chile.	Managed floating / Dual Market: Official rate kept within a +/- 2% crawling band to US$. Parallel market premia remain in 20-40% range and scores as managed floating.
1991	Adoption of Inflation Targeting. Monetary policy subordinated to inflation targets.	Controls on capital flows to prevent further appreciation of the peso in real terms.
1995	Change of policy rate: from UF-indexed 90-day bonds issued by the Central Bank of Chile to UF-indexed policy interest.	Crawling band remains.
1998	Commitment to inflation targeting despite external shocks. Overnight interest rate reinstated as main instrument of monetary policy and increased from 8.5 to 14%.	Central Bank narrows the exchange rate band from 25 to 5.5%. Width of the band increased to 7% in September.
1999	Inflation targeting scheme modified to keep low and stable inflation, after reaching 3% annual inflation.	Gradual shift to flexibility: regulations on currency mismatches, liberalization of securities markets and capital inflows (reserve requirement decreased to 0 and then eliminated). Free floating in September.
2001	Nominalization of interest rates in August.	Free float.

Sources: Edwards (2000), Marshall (1991), Morandé and Tapia (2002), Reinhart and Rogoff (2002).

APPENDIX C
Test of Unit Roots

Augmented Dickey-Fuller (ADF) Test

The ADF test constructs a parametric correction of the typical Dickey-Fuller test for higher-order correlation by assuming that the series (e_t) follows an AR(p) process and adding p lagged difference terms of the dependent variable e_t to the right-hand side of the original test regression:

$$\Delta e_t = a_1 e_{t-1} + \sum_{i=1}^{p} a_{i+1} \Delta e_{t-i} + x_t' d + v_t \tag{1}$$

where x_t is a vector of exogenous variables (usually a constant and a linear time trend) and v_t the error term. The null and alternative hypothesis may be written as H_0: $\alpha_1=0$; H_1: $\alpha_1<0$; and evaluated using the conventional t-ratio for α_1:

$$t_{\hat{\alpha}_1} = \frac{\hat{\alpha}_1}{se(\hat{\alpha}_1)}, \tag{2}$$

where $\hat{\alpha}_1$ is the estimate of α_1, and $se(\hat{\alpha}_1)$ is the coefficient standard error. As it is known, under the null this statistic does follow conventional Student´s t-distribution, so it must be compared with MacKinnon (1991, 1996) critical values.

Phillips-Perron Test (PP)

The Phillips and Perron (1988)´s test estimates the non-augmented DF test equation (equation 1 with p=0), and modifies the t-ratio of the α_1 coefficient so that serial correlation does not affect the asymptotic distribution of the test statistic[17]. The PP test is based on the statistic:

$$\hat{t}_{\hat{\alpha}_1} = \left(\frac{\hat{\alpha}_1}{se(\hat{\alpha}_1)}\right)\left(\frac{g_0}{f_0}\right)^{1/2} - \frac{T(f_0 - g_0)se(\hat{\alpha}_1)}{2 f_0^{1/2} s}, \; where \; g_0 = \frac{(T-K)}{T} s^2 \tag{3}$$

where g_0 is a consistent estimate of the error variance of equation 1 with p=0 (s^2), f_0 is an estimator of the residual spectrum at frequency zero, and K is the number of regressors. This statistic involves the same null as in the ADF test and also has to be compared with MacKinnon (1991, 1996) critical values.

[17] The PP test is an alternative (nonparametric) method of controlling for serial correlation when testing for unit root.

Dickey-Fuller Test with GLS Detrending (DF-GLS)

Elliot, Rothenberg, and Stock (1996) propose a modification of the ADF test in which the data are detrended so that the explanatory variables are subtracted in the data prior to running the test regression. The DF-GLS is based on the test regression:

$$\Delta e_t^d = a_1 e_{t-1}^d + \sum_{i=1}^{p} a_{i+1} \Delta e_{t-i}^d + v_t \tag{4}$$

where e^d_t is the GLS-detrended series. That is, it is the original e_t without either a constant or a constant and trend. As with the ADF test, one considers the same t-ratio for α_1 and null hypothesis. However the critical values for the constant-and-trend case change (see Elliot *et al*,.1996).

Ng-Perron Test (NP)

Ng and Perron (2001b) construct test statistics that are also based on the GLS detrended data e^d_t. They are modified versions of some other tests such as the PP tests. The one used in this paper is:

$$MZ_{a_1}^d = \frac{\left(\frac{e_t^d}{T}\right)^2 - f_0}{2k}, \ where\ k = \frac{\sum_{t=2}^{T} \left(e_{t-1}^d\right)^2}{T^2} \tag{5}$$

Kwiatkowski et al. (KPSS)

Kwiatkowski, Phillips, Schmidt, and Shin (1992) propose a Lagrange Multiplier (LM) test in which the null hypothesis is that the series e_t is level-stationary or trend-stationary and the alternative that it is difference-stationary. It is based on the residuals from the OLS regression of e_t on the exogenous variables x_t:

$$e_t = x_t' d + v_t \tag{6}$$

The LM statistic is defined as:

$$LM = \frac{\sum_t S_i(t)^2}{T^2 f_0}, \quad where \quad S_i(t) = \sum_{r=1}^{t} \hat{v}_r$$

where the *S(t)* is a cumulative residual function and $\hat{v}_r$ is the estimated residual from (6). The critical values for the LM test statistic are based on asymptotic results presented in Kwiatkowski *et al.* (1992, table 1). All the tests explained above require specification for the explanatory variables x_t (e.g. constant and/or deterministic trend) and most of them need the choice of the method for estimating the residual spectrum at frequency zero f_0 (e.g. kernel based sum-of-covariances and autoregressive spectral density estimators).

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Table 1. Main Empirical Studies on the PPP Hypothesis

Author(s)	Sample	Empirical Method	Main Findings
Frankel (1986)	USA, annual data, 1869-1984 (dollar-pound sterling)	OLS AR(1) estimates.	PPP holds. Autoregressive coefficient: 0.86.
Edison (1987)	USA, annual data, 1890-1978 (dollar-pound sterling)	Cointegration method (ECM)	PPP holds.
Abuaf and Jorion (1990)	10 developed countries, monthly data, (1973.1-1987.12), and annual data (1901-72)	SUR AR(1) estimates and DF test.	PPP holds (marginal rejection of joint nonstationarity).
Kim (1990)	10 developed countries, CPI and WPI annual data, 1900-87	PP, Perron (1988), and cointegration tests (Johansen, 1992) , and ECM.	PPP holds (in general with both CPI and WPI).
Lothian and Taylor (1996)	3 developed countries, WPI annual data, 1791-1990	DF and PP tests. AR(1) recursive estimates.	PPP holds.
Papell (1997)	20 developed countries, CPI monthly and quarterly data, US$ dollar and German mark, 1973.1-1994.09	ADF and panel unit root tests.	PPP holds. Stronger conclusions when panel is larger, with the mark rather than US dollar, with monthly rather than quarterly data.
Michael, Nobay, and Peel (1997)	5 developed countries, WPI monthly (1921.1-1925.5) and annual (1791-1992) data	ESTAR model	Reject linearity in favor of EAR process.
Délano (1998)	Chile, CPI annual data, 1830-1995.	ADF test.	RER~I(0) whole sample, I(1) for 1918-1995.
Hegwood and Papell (1998)	5 developed countries, 2 annual-datasets: 1900-72 and 1791-1990	ADF and Bai-Perron test for structural breaks.	Quasi PPP holds. RER~I(0) but with reversion to an occasionally changing mean.
Céspedes and De Gregorio (1999)	Chile, Effective and Bilateral RER, quarterly data, 1977.1-1998.1	ADF test and cointegration estimates.	RER~I(1). Evidence of cointegration among RER, productivity, Net Foreign assets, Government expenditure, and Terms of trade.

Table 1. Main Empirical Studies on the PPP Hypothesis (continued)

Author(s)	Sample	Empirical Method	Main Findings
Culver and Papell (1999)	21 developed countries, quarterly data, 1973.1-1996.4	ADF, KPSS and Shin (1994) tests; Cointegration tests (Engle-Granger, Shin-KPSS).	PPP holds. RER~I(0) and cointegration among RER, domestic prices, and foreign prices.
Valdés and Délano (1999)	Chile, CPI quarterly data, 1977.1-1997.4. A panel of 92 countries, 1960-1990.	ADF and cointegration test. Panel data estimates.	RER~I(1). Evidence of cointegration among RER, Tradable-non tradable productivity, Net Foreign assets, Government expenditure, and Terms of trade. PPP does not hold.
Cuddington and Liang (2000)	USA, annual data, 1791-1990 (US dollar- sterling, franc-sterling)	ADF and PP tests. General-to-specific methodology.	Dollar-sterling RER is trend stationary or I(1) with MA(5) error, but franc-sterling I(0).
Ng and Perron (2001a)	18 developed countries, quarterly data, 1973.1-1997.2	ADF and PP tests.	RER~I(1), except for Canada.
Taylor, Peel, and Sarno (2001)	USA, CPI monthly data, 1973.1-1996.12 (dollar-sterling, marc, franc, yen)	ESTAR and Logistic ESTAR	Evidence of nonlinear mean reversion.
Taylor (2002)	20 developed and developing countries (including Argentina, Brazil, Mexico; except Chile), annual data, 1870-1990	Cointegration method and ADF-GLS tests.	PPP holds in long run.
Morales and Peruga (2002)	7 developed countries, disaggregated price indexes, monthly data, 1975.1-1995.12	Bai and Perron (1998) structural-break model and ECM.	Relative PPP holds in general. Exchange rates adjust in all sectors. Evidence of instability is larger in cointegration coefficients than in the adjustment coefficients.

Notes: (A)DF denotes (Augmented) Dickey-Fuller, GLS denotes Generalized Least Squares, OLS denotes Ordinary Least Squares, CPI denotes Consumer Price Index, WPI denotes Whole Price Index, EAR is Exponencial Autoregressive, ESTAR is Exponencial Smooth Transition Autoregressive, PP test denotes Phillips and Perron (1988) test, ECM denotes Error Correction Mechanism, RER denotes Real Exchange Rate, UR-test denotes Unit Root test, VECM denotes Vector Error Correction Model, SUR denotes Seemingly Uncorrelated Residuals. Studies for the Chilean economy are shadowed.

Figure 1a. Multilateral Real Exchange Rate in Chile (1810-2002)

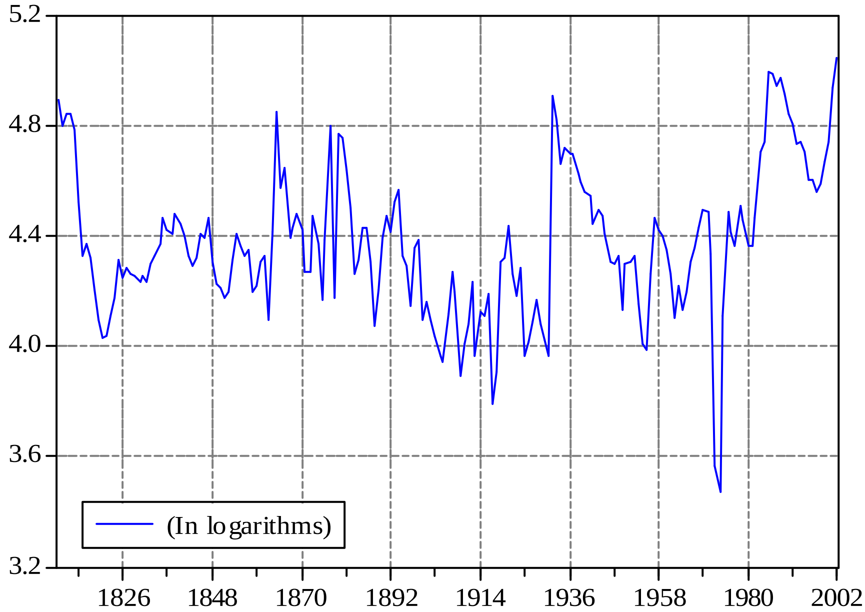

Figure 1b. Bilateral Real Exchange Rate in Chile (1810-2002)

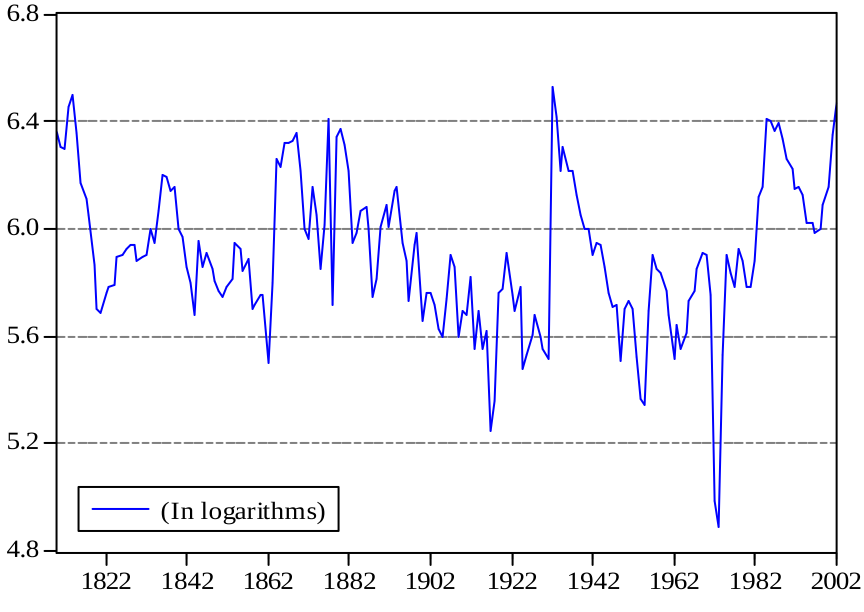

Table 2. Unit-Root Tests for Real Exchange Rate (Chile: 1810-2002)[a]

Unit Root Tests	Multilateral	Bilateral
Augmented Dickey-Fuller		
Schwarz optimal lag	-4.74***	-4.69***
Hannan-Quinn optimal lag	-4.74***	-4.69***
Lag=1	-4.65***	-4.64***
Lag=2	-3.90***	-4.00***
Phillips-Perron		
Newey-West Bandwidth	-4.82***	-4.77***
Andrews Bandwidth	-4.83***	-4.78***
DF-GLS (Elliot *et al.*)		
Schwarz optimal lag	-2.45**	-2.76***
Hannan-Quinn optimal lag	-1.86*	-2.76***
Ng-Perron		
Schwarz optimal lag	-11.47**	-14.24***
Hannan-Quinn optimal lag	-7.01*	-14.24***
KPSS		
Newey-West Bandwidth	0.26∅∅∅	0.21∅∅∅
Andrews Bandwidth	0.19∅∅∅	0.17∅∅∅

a. e^M is the log of the multilateral RER, e^B is the log of the bilateral (with US$) RER; DF-GLS stands for Generalized Least Squares Dickey-Fuller test; KPSS denotes Kwiatkowski et al test; *, **, *** denote rejection of the null at the 10%, 5%, and 1% level, respectively; ∅∅ and ∅∅∅ denote no rejection of the null at the 5% and 1% level, respectively.

Table 3. Sensitivity Analysis: Unit-Root Tests for Real Exchange Rates with Different Samples[/a]

Unit Root Tests	Sample Period					
	1810-1960		1860-2002		1918-1995[/b]	
	e^M	e^B	e^M	e^B	e^M	e^B
Augmented Dickey-Fuller						
Schwarz optimal lag	-5.45***	-4.68***	-4.08***	-4.09***	-3.26**	-3.26**
Hannan-Quinn optimal lag	-5.45***	-4.68***	-4.08***	-4.09***	-3.78***	-3.78***
Lag=1	-4.87***	-4.16***	-3.97***	-4.02***	-3.78***	-3.78***
Lag=2	-4.35***	-3.71***	-3.11**	-3.32**	-2.96**	-3.00**
Phillips-Perron						
Newey-West Bandwidth	-5.27***	-4.60***	-4.08***	-4.16***	-3.29**	-3.31**
Andrews Bandwidth	-5.39***	-4.54***	-4.08***	-4.16***	-3.37**	-3.38**
DF-GLS (Elliot *et al.*)						
Schwarz optimal lag	-2.22**	-2.56**	-3.78***	-3.72***	-1.81*	-1.90*
Hannan-Quinn optimal lag	-1.44	-1.77**	-3.78***	-3.72***	-2.31**	-3.35***
Ng-Perron						
Schwarz optimal lag	-9.54**	-12.53**	-28.33***	-26.15***	-8.10*	-8.53**
Hannan-Quinn optimal lag	-4.46	-6.93*	-28.33***	-26.15***	-6.66*	-11.44**
KPSS						
Newey-West Bandwidth	0.14∅∅	0.42∅∅	0.37∅∅	0.20∅∅∅	0.31∅∅∅	0.21∅∅∅
Andrews Bandwidth	0.13∅∅∅	0.36∅∅	0.27∅∅∅	0.15∅∅∅	0.24∅∅∅	0.16∅∅∅

a. e^M is the log of the multilateral RER, e^B is the log of the bilateral (with US$) RER; DF-GLS stands for Generalized Least Squares Dickey-Fuller test; H-Q is the Hannan-Quinn information criterion, KPSS denotes Kwiatkowski et al test; *, **, *** denote rejection of the null of unit root at the 10%, 5%, and 1% level, respectively; ∅∅ and ∅∅∅ denote no rejection of the null of stationarity at the 5% and 1% level, respectively.

b. Corresponds to Delano´s (1998) sample period with which the author finds that RER is I(1).

Figure 2. Sensitivity Analysis: Unit-Root Tests for Real Exchange Rates (Sample: 100-year rolling window, in absolute values)

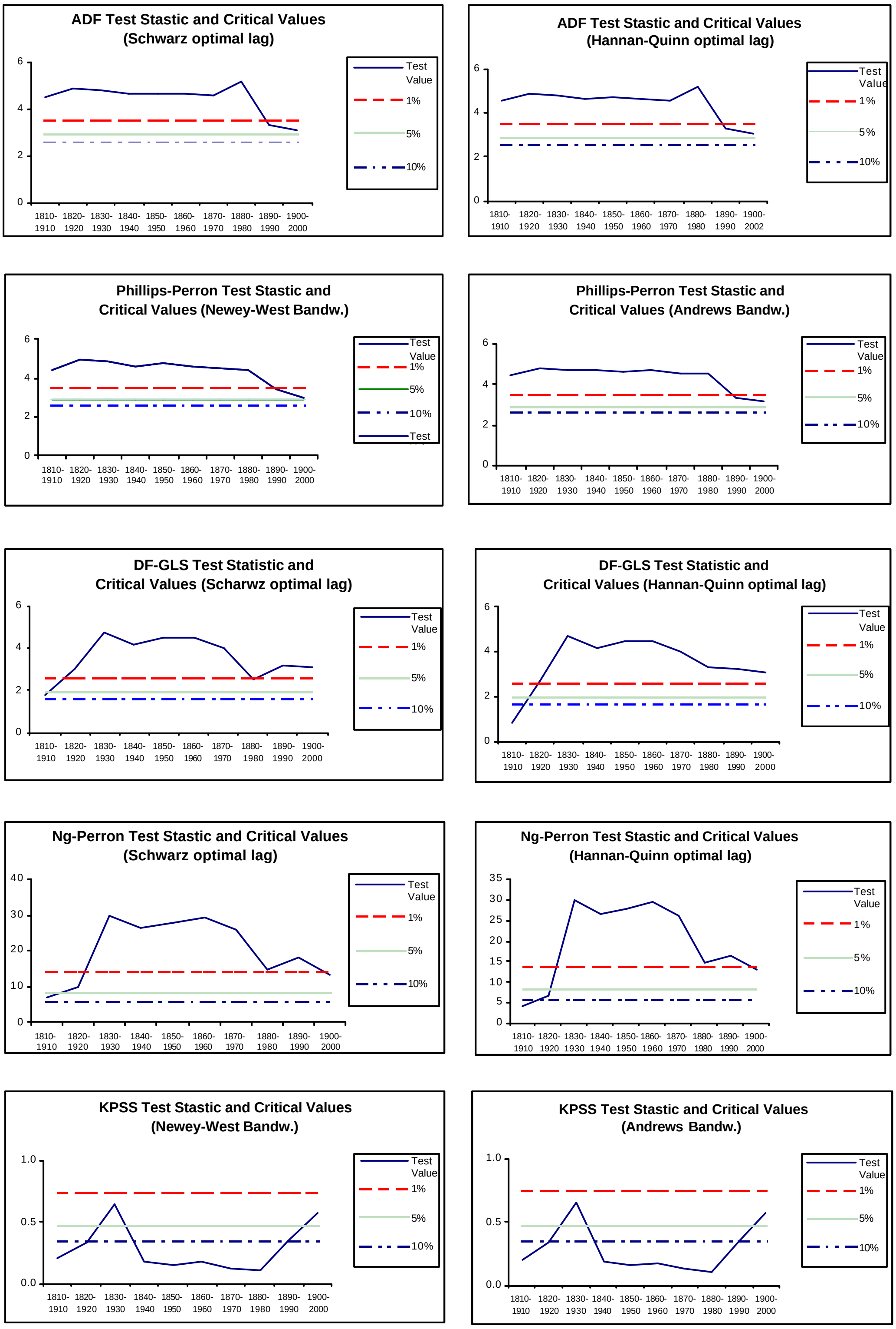

Table 4. Sensitivity Analysis: Unit-Root Tests for Real Exchange Rates using WPI and GDP Deflator Index (Chile: 1928-2002)[/a]

Unit Root Tests	Using WPI		Using GDP Deflator	
	e^M	e^B	e^M	e^B
Augmented Dickey-Fuller				
Schwarz optimal lag	-2.80*	-2.62*	-2.59*	-3.72***
Hannan-Quinn optimal lag	-3.13**	-2.88*	-2.59*	-3.72***
Lag=1	-3.13**	-2.88*	-2.58*	-3.76***
Lag=2	-2.96**	-2.77*	-2.44	-3.69***
Phillips-Perron				
Newey-West Bandwidth	-2.80*	-2.62*	-2.59*	-3.81***
Andrews Bandwidth	-3.00**	-2.80*	-2.66*	-3.82***
DF-GLS (Elliot *et al.*)				
Schwarz optimal lag	-2.82***	-2.57**	-1.75*	-2.46**
Hannan-Quinn optimal lag	-3.15***	-2.57**	-1.75*	-2.46**
Ng-Perron				
Schwarz optimal lag	-13.27**	11.31**	-6.04*	-11.46**
Hannan-Quinn optimal lag	-19.20***	11.31**	-6.04*	-11.46**
KPSS				
Newey-West Bandwidth	0.34∅∅∅	0.41∅∅	1.20	0.75
Andrews Bandwidth	0.25∅∅∅	0.30∅∅∅	0.47∅∅∅	0.47∅∅∅

a. DF-GLS stands for Generalized Least Squares Dickey-Fuller test; KPSS denotes Kwiatkowski et al test; *, **, *** denote rejection of the null at the 10%, 5%, and 1% level, respectively; ∅∅ and ∅∅∅ denote no rejection of the null at the 5% and 1% level, respectively. All the series are expressed in logs.

Table 5. Unit Root Tests for Components of the Multilateral and Bilateral Real Exchange Rates (Chile: 1810-2002)[/a]

Tests and Specifications	Series in Levels					Series in Differences				
	Multilateral			Bilateral		Multilateral			Bilateral	
	P	E^M	P^M	E^B	P^B	P	E^M	P^M	E^B	P^B
Augmented D-F										
Schwarz lag (constant)	0.8	1.2	0.7	1.4	0.2	-4.2***	-5.7***	-9.2***	-6.1***	-9.6***
Schwarz lag (trend)	-1.1	-0.8	-1.8	-0.7	-1.5	-4.7***	-6.2***	-9.4***	-6.6***	-9.8***
H-Q lag (constant)	0.8	1.2	0.7	1.4	0.2	-4.2***	-5.7***	-9.2***	-6.1***	-9.6***
H-Q lag (trend)	-1.1	-0.8	-1.8	-0.7	-1.5	-4.7***	-6.2***	-9.4***	-6.6***	-9.8***
Lag=1 (constant)	1.6	1.2	0.7	1.4	0.2	-4.2***	-5.5***	-7.3***	-5.6***	-8.2***
Lag=1 (trend)	-0.7	-0.8	-1.8	-0.7	-1.5	-4.7***	-6.1***	-7.6***	-6.2***	-8.5***
Lag=2 (constant)	0.8	1.4	0.7	1.5	0.4	-3.9***	-5.2***	-5.8***	-5.4***	-7.2***
Lag=2 (trend)	-1.1	-0.6	-2.1	-0.7	-1.5	-4.4***	-5.9***	-6.2***	-6.0***	-7.6***
Phillips-Perron										
Newey-West (constant)	2.2	2.2	0.9	2.3	0.8	-5.9***	-5.6***	-9.2***	-6.0***	-9.3***
Newey-West (trend)	-0.4	-0.3	-1.8	-0.3	-1.3	-6.6***	-5.9***	-9.4***	-6.4***	-9.4***
Andrews (constant)	2.1	1.9	0.9	2.1	0.7	-5.9***	-5.8***	-9.2***	-6.1***	-9.6***
Andrews (trend)	-0.4	-0.4	-1.8	-0.4	-1.3	-6.4***	-6.3***	-9.4***	-6.6***	-9.8***
DF-GLS (Elliot *et al.*)										
Schwarz lag (constant)	1.2	1.7**	1.0	2.0*	0.4	-4.0***	-5.4***	-3.8***	-5.8***	-8.4***
Schwarz lag (trend)	-0.8	-0.5	-0.7	-0.4	-1.0	-4.6***	-6.1***	-9.0***	-6.5***	-9.7***
H-Q lag (constant)	1.2	1.7**	1.0	1.9*	0.4	-4.0***	-5.4***	-3.8***	-5.8***	-8.4***
H-Q lag (trend)	-0.8	-0.5	-0.7	-0.4	-1.0	-4.6***	-6.1***	-9.0***	-6.5***	-9.7***
Ng-Perron										
Schwarz lag (constant)	2.4	2.7	1.6	2.8	1.0	-28.4***	-44.9***	-26***	-49***	-72***
Schwarz lag (trend)	-0.8	-0.6	-0.7	-0.5	-1.0	-4.2***	-5.1***	-6.5***	-5.4***	-6.6***
H-Q lag (constant)	2.4	2.7	1.6	2.8	1.0	-28.4***	-44.9***	-26***	-49***	-72***
H-Q lag (trend)	-0.8	-0.6	-0.7	-0.5	-1.0	-4.2***	-5.1***	-6.5***	-5.4***	-6.6***
KPSS										
Newey-West (constant)	1.2	1.2	1.4	1.2	1.2	0.8	0.8	0.5∅∅∅	0.8	0.5∅∅∅
Andrews (constant)	0.4∅∅	0.4∅	0.4∅∅	0.4∅∅	0.4∅∅	0.7∅	0.6∅∅∅	0.5∅∅∅	0.7∅∅∅	0.4∅∅

a. P denotes Special (Domestic) Price Index, E^M is the Multilateral (with US$ and UK£) Nominal Exchange Rate, P^M is Multilateral (US and UK) Wholesales Price Index, E^B denotes the Bilateral (with US) Nominal Exchange Rate, P^B is Bilateral (with US) Wholesales Price Index. All the series are expressed in logs. DF-GLS stands for Generalized Least Squares Dickey-Fuller test; H-Q is the Hannan-Quinn information criterion, KPSS denotes Kwiatkowski *et al* test; *, **, *** denote rejection of the null at the 10%, 5%, and 1% level, respectively; ∅, ∅∅ and ∅∅∅ denote no rejection of the null at the 10%, 5% and 1% level, respectively.

Table 6. Engle-Granger Test for Cointegration of the Components of the Real Exchange Rate (Chile: 1810-2002)[/a]

$$P_t = b_0 + b_1 E_t^i + b_2 P_t^i + u_t^i, \quad i = M, B$$

Unit Root Tests	u^M	u^B
Augmented Dickey-Fuller		
Schwarz optimal lag	-5.69***	-4.80***
Hannan-Quinn optimal lag	-5.69***	-4.80***
Lag=1	-5.66***	-4.74***
Lag=2	-4.95***	-4.12***
Phillips-Perron		
Newey-West Bandwidth	-5.78***	-4.88***
Andrews Bandwidth	-5.80***	-4.88***

a. u^M is the residual of the cointegration equation of the multilateral RER, u^B is the residual of the cointegration equation of the bilateral (with US) RER; H-Q is the Hannan-Quinn information criterion; *, **, *** denote rejection of the null of non-cointegration at the 10%, 5%, and 1% level, respectively. In this case, the Phillips and Ouliaris (1990) critical values are: -3, -3.3, and -3.8. The series are expressed in logs.

Table 7. Trace and Maximum Eigenvalue Statistics for Cointegration of the Components of the Real Exchange Rate (Chile: 1810-2002)[/a]

$$P_t = b_0 + b_1 E_t^i + b_2 P_t^i + u_t^i, \quad i = M, B$$

Cointegration Test	Multilateral Case		Bilateral Case	
	Statistic Value	Number of Cointegrating Relations	Statistic Value	Number of Cointegrating Relations
Trace[b]				
Schwarz optimal lag	47.8***	1	48.2***, 15.9**	1, 2
Lag=2	33.8**	1	34.2**	1
Lag=3	32.9**	1	35.6**	1
Maximum Eigenvalue[b]				
Schwarz optimal lag	38.8***	1	32.3***, 14.7**	1, 2
Lag=2	25.2**	1	19.7	1
Lag=3	23.9**	1	23.4**	1

a. *, **, *** denote statistical significance at the 10%, 5%, and 1% level, respectively. All the series are expressed in logs.

b. Linear deterministic trend included. Schwarz optimal lag is one in each case.

Table 8. Test for Structural Break in the Real Exchange Rate using a Threshold Autoregressive Model (Chile: 1810-2002)/[a]

Regressor	Dependent Variable: Real Exchange Rate Threshold Variable: Trend; Threshold Estimate=1973 95% Confidence Interval: [1972-1984]			
	Sample: 1810-1973		**Sample: 1974-2002**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
Constant	1.2125144	0.28847259	1.6801108	0.42337518
RER (-1)	0.71766730	0.065894626	0.64778263	0.090197101
Statistics				
R^2	0.49179716		0.74587407	
Sum of Squared Errors	4.4211925		0.39333259	
Residual Variance	0.027460823		0.014567874	
Observations	163		29	
Half-Lives				
Estimate (in years)	2.1		1.6	

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