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PURCHASING POWER PARITY IN THE 1920S: A REASSESSMENT USING EFFICIENT UNIT ROOT TESTS

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Özet: ***1990'larda ekonomistlerin taşıdığı inanış "satınalma gücü paritesi sadece uzun dönemde geçerli olan bir teoridir" şeklindeydi. Bu görüş uluslararası iktisat literatürün önemli bir teorisi olan satınalma gücü paritesine olan ilgiyi belirli ölçüde azalttı. Ancak son bir kaç yılda yapılan araştırmalar ve yayınlar satınalma gücü paritesinin kısa dönemde de geçerli olabileceğini (en azından gelişmiş ülkelerde) 1973'ten beri uygulamada olan dalgalı kur rejimi için göstermektedir. Bu sonucu değişik bir döneme uygulayarak genelleştirmek mümkün olabilir mi? Bu çalışma yeni geliştirilmiş tekdeğişimli verimli birim kök testleri kullanarak satınalma gücü paritesinin gerçek bir dalgalı kur rejimi olan 1920'lerde ve daha kısa bir dönem için doğruluğunu göstermektedir.***

I. INTRODUCTION

Testing the relevance of the purchasing power parity (PPP) doctrine has been a favorite pastime. In its simplest sense, the PPP theory is either an asset market equilibrium or a commodity arbitrage condition depending on the two different interpretations of the role of exchange rates. The asset market approach proposes that the equilibrium exchange rate is equal to relative commodity prices, while the arbitrage condition postulates that equilibrium of commodity prices in different countries is attained by commodity arbitrage. The existence of many factors like transaction costs and trade restrictions, anticipation of greater inflation in a country, and government intervention in foreign exchange markets cause deviations from this equilibrium condition. Hence, the common belief has been that PPP does not hold in the short-run. However, some studies provide favorable evidence for the "very" long-run, especially when the recently developed econometric techniques are used (For an excellent survey of the PPP literature, see Froot and Rogoff [1]). Therefore, the PPP literature relies on the development of econometric methodology which does not have low power against alternatives of slow parity reversion. In this category, we find 1) fractional cointegration methods (Fractional cointegration is introduced by Granger [2], and applied by Diebold [3], and Cheung and Lai [4]), 2) stationarity around deterministic trend models which allow for a single break in either the intercept and/or the slope of the trend function (For studies developing tests which treat the date of the break as unknown a *priori*, see Zivot and Andrews [5], Perron [6]. For studies applying these tests to the PPP literature see Perron and Vogelsang [7], Culver and Papell [8]), and 3) panel unit root testing methods (Among others see, Frankel and Rose [9], Jorion and Sweeney [10], MacDonald [11], Oh [12], Papell [13], O'Connell [14]). Among these, the stationary deterministic trend models are becoming popular even more than the panel unit root tests which possess problems as sample selection, cross-sectional dependence, the size of the panel and the grouping of countries.

In this study, we employ two recently developed efficient unit root tests which examine stationary around a deterministic trend in macroeconomic models. These tests are Dickey Fuller-Generalized Least Squares (DF-GLS) test of Elliott et. al. [15], and innovative outlier and additive outlier tests of Perron [16].

This article takes a different route for testing the empirical validity of PPP by using the float of 1920s rather than the post Bretton Woods period which has been studied extensively. Our main purpose is to investigate whether PPP survives the challenges using the efficient unit root tests for the 1920s flexible exchange rate period. This is interesting for two reasons: First, no study has employed the efficient unit root tests to assess whether PPP holds for the 1920s. Second, using a different data span will help us investigate how efficient these modified unit root tests are.

The organization of the paper is as follows: The second section restates the PPP theory. In the third section, we discuss the efficient unit roots and introduce our empirical results. The fourth section concludes.

II. PURCHASING POWER PARITY DOCTRINE and 1920S

The foundation of the PPP theory is based on the idea that the value of a currency-hence the demand for it-is determined fundamentally by the amount of goods and services that a unit of currency can buy in the country of issue. Considering two countries, the value of one country's currency relative to the other's is the short-run equilibrium exchange rate, and the ratio of the domestic price levels defines the absolute PPP. In this manner, we can define the PPP relationship as

$$s_t = \alpha_0 + \alpha_1(p_t - p_t^*) + v_t \quad (1)$$

where s_t is the logarithm of the spot exchange rate (domestic price of foreign currency), p_t and p_t^* are, respectively, the logarithms of the domestic and foreign price indexes, and v_t represents short-run deviations from PPP. It is a common practice in the literature to define the real exchange rate (and to test whether it is a random walk process) as;

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

During the 1920s, the surge in the prices due to wartime inflations meant adjusting the exchange rates to be consistent with PPP, so as to maintain the credibility of the gold standard. But this had not been the common practice due to the political fears of the costs of adjustment in nations which needed to deflate, or the possibility of hyperinflation in countries which had to reflate Eichengreen [17]. However, the period between February 1921 and May 1925 is the first example of floating exchange rates in several countries. In this manner, it has been the common practice for the studies of PPP before 1990s.

Like the studies of the modern float, there is conflicting evidence in the 1920s literature. Frenkel [18], and Clements and Frenkel [19] are among the first to demonstrate favorable evidence for PPP in the 1920s. Shortly after, applying dynamic specification methodology, Edison [20] challenges these articles and provides evidence against PPP doctrine. He is followed by MacDonald [21] who tests whether the deviations from PPP follow a random walk using error orthogonality property and Box-Jenkins methodology. Amid these controversies, Taylor and McMahon [22] present evidence in favor of PPP as a long-run equilibrium condition. They test whether exchange rates and price levels have unit roots, analyze the presence of cointegration and present error-correction forms. They find strong evidence of PPP for 5 out of 6 bilateral exchange rates they study, with the exception of the dollar-pound exchange rate. Ahking [23] takes a further step by an analysis of dollar-pound exchange rate. His main finding is similar to Taylor and McMahon [22]. However, he reports weak evidence of cointegration for a shorter sample period of February 1921 to May 1924.

Early empirical studies of the 1920s floating rate period employed simple analysis of ordinary least squares and autocorrelation functions. A common deficiency with these studies is the absence of stationarity analysis. The common hypothesis was to determine whether α_1 was statistically significant and different from unity.

On the other hand, once unit roots tests and cointegration analysis have been introduced, favorable results for PPP were attained [22,23]. These studies outlined the significance of analyzing the stochastic properties of dynamic adjustments toward PPP with emphasis on the error correction forms. With the attention switching to post-1973, the 1920s flexible exchange rate period has been neglected. This study tries to bridge the gap by employing available unit root tests; conventional and modified versions, to test whether PPP holds for the 1920s for 3 bilateral exchange rates of the dollar/pound, the franc/dollar and the franc/pound.

III. CONVENTIONAL vs. EFFICIENT UNIT ROOT TESTS

The fallacy of the literature to provide favorable evidence for PPP using the conventional ADF unit root tests has shifted attention to the panel unit root tests. Panel approach is believed to allow a different way of increasing power while using short time span of data by pooling across many different real exchange rates. However, recent studies show the pros and cons of the panel method which at best is at its infant stage (see [13,14]). On the other hand, various attempts have been made to modify ADF tests (Stock [24] present surveys of many of the modified versions of DF test). We consider two recent attempts, namely DF-GLS test of Elliott et. al. [15], and innovative outlier and additive outlier tests of Perron [16] (Cheung and Lai [25] also employ BLS sequential unit root tests. However, as they show BLS tests do not have enough rejection power for the post-1973 data. For this reason, we disregarded BLS tests.). For the purposes of comparison, real exchange rate series first are tested for the presence of a unit root using conventional ADF test. The validity of PPP depends on the rejection of a unit root in the real exchange rate series. The ADF test is defined as;

$$\Delta r_t = \alpha_1 t + \beta r r_{t-1} + \sum_{i=1}^{n} \theta_i \Delta r_{t-i} + \varepsilon_t \quad (3)$$

where Δ denotes the lag operator, and ε_t is the error term. The test statistic is the standard t-ratio for the estimate of β, and the rejection region consists of (absolutely) large, negative values. On the other hand, the two other unit root tests that we employ are relatively new to the literature, therefore we present a brief review below.

III.1. DF-GLS Test of ERS

ERS attain the asymptotic power envelope for a modified version of the Dickey-Fuller test, DF-GLS, employing the sequence of Neyman-Pearson Lemma.

The null hypothesis is H_0: $\lambda = 1$ versus the local alternative that H_1: $\lambda = 1 + c/T$ where c is the parameter defining the local alternative and T is the number of observations.

The DF-GLS τ test is carried out in two steps.

In the first step, the series r_t^* and z_t are defined as

$r_t^* = [r_1, (1-\lambda L)\, r_2, \ldots, (1-\lambda L)\, r_T]'$ and

$z_t = [z_1, (1-\lambda L)\, z_2, \ldots, (1-\lambda L)\, z_T]'$ where L is the lag operator, z_t is $(1,t)'$, $\lambda = 1 + c/T$, and r_t the original time series. Regressing r_t^* on z_t and saving the estimate β (the least squares regression coefficient), we can obtain the locally detrended data process, r_t^T which is the residual series, $r_t^T = r_t - z_t\,\beta$. In the second step, using the following regression

$$\Delta r_t^T = \beta r_{t-1}^T + \sum_{i=1}^{n} \theta_i \Delta r_{t-i}^T + \varepsilon_t \qquad (4)$$

the DF-GLS τ statistic is obtained by the t-ratio for testing H_0: $\beta=0$ against H_1 : $\beta < 0$. ERS suggest using c= -13.5 for the test with a linear trend and c= -7 for the test without a time trend.

Compared to its predecessors (The conventional augmented Dickey-Fuller (ADF) tests (Fuller [25]) and Dickey and Fuller [26]), Bhargava [27] extension for linear trend case and Phillips and Perron [28] tests), the DF-GLS test performs better with respect to sample-size and power. A recent study by Cheung and Lai [29] employing DF-GLS test shows that there is parity reversion in the post-1973 data for 8 out of 10 bilateral exchange rates considered.

III.2. Perron's Innovative and Additive Outlier Tests

Perron [16] improves the arguments of Perron [30] examining his three models, innovative outlier (IO) models, IO1 and IO2, and additive outlier (AO) model. The IO1 model is:

$$\begin{aligned} r_t &= \alpha_0 + \alpha_1 t + \alpha_2 DU_t + \alpha_3 D(T_b)_t \\ &\quad + \beta r_{t-1} + \sum_{i=1}^{n} \theta_i \Delta r_{t-i} + \varepsilon_t \end{aligned} \qquad (5)$$

where $DU_t = 1(t > T_b)$ and $D(T_b)_t = 1(t = T_b + 1)$ with $1(.)$ indicator function, r as the real exchange rate, and T_b is the time of the change in the trend function. The unit root test using the t-statistic for testing $\beta = 1$ produces the statistic for testing the presence of a change in the intercept under both the hypotheses. The IO2 model is:

$$\begin{aligned} r_t &= \alpha_0 + \alpha_1 t + \alpha_2 DU_t + \alpha_3 D(T_b)_t + \alpha_4 DT_t \\ &\quad + \beta r_{t-1} + \sum_{i=1}^{n} \theta_i \Delta r_{t-i} + \varepsilon_t \end{aligned} \qquad (6)$$

where $DT_t = 1(t > T_b)$ with $1(.)$ indicator function, r as the real exchange rate, and , T_b is the time of the change in the trend function. The unit root test using the t-statistic for testing $\beta = 1$ produces the statistic for testing the presence of a change in both the intercept and the slope at time T_b. Using the third model (AO), a change in the slope is allowed, however, both segments of the trend function are joined at the time of the break. The test is performed in two steps. First, the series is detrended employing the following regression:

$$r_t = \alpha_0 + \alpha_1 t + \alpha_2 DT_t^* + r_t^* \qquad (7a)$$

where $DT_t^* = 1(t > T_b)(t - T_b)$. Then it is possible to obtain the test statistic; using the following regression to test for $\beta = 1$,

$$r_t^* = \beta r_{t-1}^* + \sum_{i=1}^{n} \theta_i \Delta r_{t-i}^* + \varepsilon_t \qquad (7b)$$

Though BLS sequential tests look similar to Perron's analysis, they consider only the one-step innovative outlier model with no allowance made for a change in slope under the null hypothesis. Furthermore, Perron obtains the limiting distribution of the sequential tests without trimming. His main finding is that his tests perform better than all the above mentioned modified versions of DF test.

III.3. Empirical Results

We study the 3 bilateral real exchange rates of dollar/pound (USUK), franc/dollar (FRUS) and franc/pound (FRUK) for the floating exchange rate period of February 1921 till May 1925. The exchange rate data for dollar/pound and franc/pound are taken from Einzig [31] with the end of the month data used as that month's observation. The exchange rate data for franc/dollar is taken from Dulles [32], again as the end of the month's figures. The data on wholesale prices are from Tinbergen [33].

For the purposes of comparison, we first test all real exchange rate series for a unit root using the ADF test. As data dependent methods to select the value of n are superior than choosing a fixed n *a priori*, we use the method of Ng and Perron [34]. We start with an upper bound of n, n_{max}, and test the statistical significance of the last included lag. If significant, we choose $n = n_{max}$, if not we decrease n by one until the last lag included is significant. If no lags are significant, we are back to the original DF test. The value of n is set to, $n_{max} = 8$ and a 10 % significance level of the asymptotic normal distribution, 1.645, is used to determine whether we keep the last lag.

The results of the ADF test are in Table 1. Similar to Taylor and McMahon [22], and Ahking [23], we find evidence of non-stationarity in the dollar/pound exchange rate. However, for the purpose of comparison we keep our analysis of all the exchange rates when we employ the modified versions of ADF tests. First, in Table 2, we perform the DF-GLS test. All of our series still appear to be non-stationary. It is surprising to notice that ADF performs better than the DF-GLS test. Hence, we turn our attention to Perron's unit root tests. Using all his three models we test for the possibility of representing our real exchange rates as stationary fluctuations around a deterministic trend. First, we allow for a shift in the intercept (IO1). In the second model, allowance is made for a shift both in the intercept and in the slope (IO2). In the third model, allowance is made for a shift in slope with joining both segments of the trend function at the time of the break (AO). Our results are in Table 3. For franc/dollar, our values are close to 10 % level, however we are unable to reject non-stationarity. On the other hand, for the franc/pound exchange rate, the ideal representation could be any of the three models. However, our main concern is the dollar/pound exchange rate. We obtain stationarity with the IO2 and AO models. This is probably the first example of stationary dollar/pound exchange rate for the 1920s. Hence, we have enough evidence to reject the unit root in the dollar/pound bilateral exchange rate. This demonstrates the power of the Perron unit root tests.

IV. CONCLUSION

Since Taylor and McMahon [22] and Ahking [23], the 1920s floating rate period has been neglected in the shadow of the post Bretton Woods era. This study makes an attempt to demonstrate that there is parity reversion in bilateral exchange rates using U. S., U. K., and France. We show that PPP holds for at least two of our exchange rates when we use the unit root tests of Perron [16]. Using a short sample does not prevent us from rejecting the non-stationarity of the bilateral real exchange rate series.

APPENDIX

Table.1. Augmented Dickey Fuller Tests

$$\Delta r_t = \alpha_0 + \alpha_1 t + \beta r_{t-1} + \sum_{i=1}^{n} \theta_i \Delta r_{t-i} + \varepsilon_t$$

Real exchange Rate	Test type	n	ADF test statistic
USUK	No trend	6	-1.2141
FRUK	No trend	0	-3.8498**
FRUS	No trend	0	-3.6212**

When the time trend is used, it is significant at 10 % level or better. 'n' shows the number of lags used for the ADF test with n=8 as the maximum. We use Ng and Perron [34]'s methodology to determine the number of lags included. Hence, we start with an upper bound of 8 lags and check whether the last lag included is significant. Critical values are from Hamilton [35]. Statistical significance is indicated by a single asterisk (*) for the 10 % level and double asterisks (**) for the 5 % level.

Table.2. ERS DF-GLS Test

$$\Delta r_t^T = \beta r_{t-1}^T + \sum_{i=1}^{N} \theta_i \Delta r_{t-i}^T + \varepsilon_t$$

Real exchange Rate	Test type	n	ERS test statistic
USUK	No trend	0	-0.6955
FRUK	No trend	0	-0.3581
FRUS	No trend	0	-0.2573

When the time trend is used, it is significant at 10 % level or better. 'n' shows the number of lags used for the ERS test with n=8 as the maximum. We use Ng and Perron [34]'s methodology to determine the number of lags included. Hence, we start with an upper bound of 8 lags and check whether the last lag included is significant. Critical values are from Elliott et. al. [15]. Statistical significance is indicated by a single asterisk (*) for the 10 % level and double asterisks (**) for the 5 % level.

Table.3. Perron's Unit Root Tests

Real exc. Rate	n	IO1	n	IO2
USUK	4	-4.7610	4	-4.9127*
FRUK	1	-5.7832**	1	-6.001**
FRUS	0	-4.6952	0	-3.7835

Real Exchange rate	n	AO
USUK	4	-4.3869**
FRUK	1	-5.1984
FRUS	0	-4.0901

'n' shows the number of lags used for the Perron unit root tests with n=8 as the maximum. We use Ng and Perron [34]'s methodology to determine the number of lags included. Hence, we start with an upper bound of 8 lags and check whether the last lag included is significant. Critical values are from Elliott et. al. [15]. Statistical significance is indicated by a single asterisk (*) for the 10 % level and double asterisks (**) for the 5 % level.

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