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A Cointegrating Test of the PPP Hypothesis: Evidence from a Capital-rich Labor-short Economy

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Abstract: The paper considers a test of cointegration to see if the purchasing power parity (PPP) hypothesis is tenable in the context of a capital-rich but otherwise developing country. We used quarterly data for Kuwait and the United States from the period 1972I to 1993IV to test the hypothesis. We found strong evidence in favor of cointegration (that is, a long-run equilibrium relationship in the relevant equation) and thus in favor of the hypothesis. This is in contrast to many empirical findings in the case of other non-OPEC and non oil-exporting countries.

I. Introduction

Many theoretical and empirical models of exchange rate behavior have been built around the purchasing power parity (PPP - as an aggregate interpretation of the law of one price) hypothesis. The conventional test of hypothesis, which normally uses Two Stage Least Squares (2SLS) estimation method and then tests coefficient restriction, finds little evidence in favor of the empirical validity of the hypothesis [1-2]. However, these tests neglect the fact that the levels of spot exchange rates and domestic and foreign price levels are typically non-stationary. If, indeed, these variables are non-stationary, then the standard critical values are inappropriate for testing purposes and hence any inference based on these tests becomes untenable.

In this study, we make use of the theory of cointegrated process to test whether the PPP holds as a long-run equilibrium relationship, which is presumed in the hypothesis. The equilibrium relationship in the PPP hypothesis asserts that perfect commodity arbitrage acts as an error correction mechanism to force the dollar price (say) of a consumption bundle of US goods in line with the dollar price of a common bundle of foreign goods. If

the PPP holds, inter-country commodity arbitrage ensures that any deviation from a linear combination of spot exchange rates and domestic and foreign price levels should be stationary. Since a cointegrated system allows individual time series to be integrated of order one [that is, I(1) or units roots], but requires a linear combination of the series to be stationary [that is, I(0)], the PPP is testable using the theory of cointegrated process. Frenkel's [2] finding that the PPP worked better during the 1920s than during the 1970s created a lot of confusion. Davutyan and Pippenger [3] argued that the so-called collapse of the PPP was a result of an increase in the relative importance of real versus monetary shocks. They observed that the 1970s (as opposed to 1920s) was characterized by real supply shocks and the international coordination of monetary policies. The argument is that the PPP did not fail; as a matter of fact, there was an increase in the volatility of those factors that give rise to deviations from the PPP. Hakkio [4] re-estimated the PPP model over the 1920s and 1970s. By building a model of cross-country tests (that is, SURE estimates) to improve the efficiency of the estimates, he was able to support the view that the PPP worked better in the 1970s than in the 1920s. Besides, his estimated parameter for the autoregressive (AR) process was close to unity indicating that no cointegration occurs. This finding is diametrically opposed to that of Frenkel's [2] finding. However, Frankel, *et al.* [1, 5, 6-8] among others report findings contrary to the validity of the PPP hypothesis. Furthermore, Kennen and Rodrick [9] find that the volatility of real exchange rates has increased throughout the flexible exchange rate period. Enders [10] reports, partial support for the hypothesis. Hoque [11] observed that the PPP did not hold for the developing countries in the Indian sub-continent.

It should be noted that the above studies test the validity of the hypothesis for the developed countries except by the paper by Hoque [11]. In this paper, we would like to extend the analysis to the case of Kuwait with some unique features that it is a capital-rich, oil-exporting developing country with heavy dependence on imported goods and expatriate labor force. The study covers the period from 1972I to 1993IV. The tests were performed for entire period as well as sub-periods. Two sub-periods have been considered and the cut-off point has been chosen to be the fourth quarter of 1979. The ideal cut-off point could have been the fourth quarter of 1973 based on two major events in the international financial scene: (a) breakdown of the Bretton Woods monetary system, and (b) quadrupling of the oil price by the OPEC. However, the lack of data availability for Kuwait precluded the use of 1973 as the break point. Nevertheless, it could be argued that within the sample period 1972-1993, the year 1979 is a good candidate for being a break point. This is the year when OPEC engineered second oil price hike that changed the economic behavior of firms and households here in oil-exporting countries as well as in oil-importing countries. It should be mentioned that we have allowed some time lag for the event to work through its influence upon the world economy. Tests for the two sub-periods will help us understand whether price level and exchange rate behavior have significantly been different in the post-1979 period from those in the pre-1979 period. It should also be noted that we have considered the United States as a standard of comparison following the convention in the literature in this area.

Plan of the paper

We present the formal model in Section II. Section III describes the time series properties of the variables, particularly the tests for units roots and cointegration; we also present cointegrating regressions in this section. In Section IV, we discuss the estimates of short-run PPP equation and address the stability issue. Section V provides a conclusion.

II. The Model

We consider the following standard model.

$$\pi_t = \alpha + \beta p^*_t + \varepsilon_t \qquad (1)$$

where $\pi = p/e$ and
p = the index of domestic price level;
p^* = the index of US price level;
e = the domestic currency price of US dollar (exchange rate).

The modern version of the PPP says that the hypothesis is valid as a long-run relationship if $\beta = 1$ and ε is a zero-mean stationary stochastic process. The model also allows us to determine how price level and/or exchange rate adjusts to eliminate any deviation from the PPP. There might be a problem if β turns out to be purely stochastic. This problem cannot be perfectly diagnosed by a stability test and hence we would also like to test this by following the methods developed in [12] and [13]. The test of cointegration between domestic price level and the US price level (adjusted for exchange rate) is performed in Section III.

Data sources

We should note that the PPP will perform differently depending on the particular price index chosen. Commonly the choice is among CPIs, WPIs and GDP deflators. The WPIs are often ruled out on the ground that conceptually they are poorly defined being neither producer nor consumer price indices. The CPIs in different countries might have different baskets with different relative weights. The preference is most often given to the GDP deflators that have a clear methodological definition. But because of a lack of consistent GDP deflator series for Kuwait, we worked with CPIs for both countries. The data were obtained from *International Financial Statistics* of the relevant period.

III. Time Series Properties of the Variables

Most previous studies have not considered the problem of unit roots in exchange rate and its determinants. As a result, the econometric methodology used in these studies did not

account for non-stationarity in the data. The test of non-stationarity is essential because if the variables in question are non-stationary, then the estimated model will yield misleading values of R^2, t, and F and hence the inference will not be valid [14] . In other words, the conventional diagnostics to validate a model are not appropriate [15, pp. 370-380]. It has been found in many empirical studies that most macro variables are integrated of order one or units roots [denoted by I(1)]. Statistically speaking, a time series is said to be stationary if its mean, variance and covariance are all invariant with respect to time. Such a series is denoted by I(0), that is, integrated of order zero. A time series requiring first order differencing to achieve stationarity is said to be I(1). If all the variables in equation (1) are I(1), then it is generally true that any linear combination of these variables will also be I(1). However, it there exists a linear combination which is I(0), then the concerned variables are said to be cointegrated (a concept initially developed by Granger [16]). On the other hand, if the variables are I(1), but not cointegrated, the estimated results will give misleading conclusions. That is why, it becomes imperative in a study involving macro time series data to test for unit roots and cointegration before a structural relationship is estimated and reported for potential policy use. Failure to conduct test for non-stationarity may suffer from two general kinds of biases:

(a) residuals of the estimated relationship may not be stationary, that is, the relationship is not cointegrated and hence the test statistics (critical values) which are based upon the stationarity of the residuals are not the appropriate ones to be compared with the estimated statistics from the sample observations;

(b) the estimated dynamic specification does not guarantee that a stable relationship exists.

The testing procedure follows [11,14,17-21], among others. Our first step is to determine the order of integration of the variables, that is, we test whether they are stationary in their levels or whether they have to be differenced once or more before they become stationary. Testing for unit roots has been carried out by a number of methods. They give rise to similar conclusion and we report here the results obtained by using Augmented Dickey-Fuller (ADF) test. The results in Table 1 support the presence of non-stationarity in all the series.

Table 1. Testing for unit roots in the level (ADF statistics)

Period	p*	π
1972I - 1993IV	-0.62	-1.94
1972I - 1979IV	-0.44	-0.17
1980I - 1993IV	-0.54	-1.98

H_0: Series are non-stationary; H_A: Series are stationary

The calculated ADF statistics are compared with the critical values in [18]. One can easily check that H_0 is accepted for all the variables. Since the null hypothesis is accepted, a straightforward estimation of equation (1) in levels would give rise to misleading regression

results. The next step is to examine if the first difference of these variables is stationary or not. If they are, then we can be sure that the level variables are all I(1) and hence one can go for the tests of cointegration. The results are reported in Table 2.

Table 2. Testing for unit roots in the first difference (ADF statistics)

Period	Δp^*	$\Delta \pi$
1972I - 1993IV	-29.75	-14.99
1972I - 1979IV	-21.62	-13.43
1980I - 1993IV	-24.99	-12.27

H_0: First difference is non-stationary; H_A: First difference is stationary

In this case H_0 has been rejected for all the series and for all the periods considered (at 1% level of significance). In other words, the first differences are all stationary series. This implies that there is a possibility that the variables in levels might have a cointegrated (or latent/equilibrium) relationship. We now test for this. We used, DF, ADF and CRDW (Cointegrating Regression Durbin-Watson) tests but the conclusions are similar and we report here the results based on ADF test in Table 3. We first report the estimates of equation (1) for different sample periods:

Cointegrating regressions

Period: 1972I - 1993IV

$$\pi_t = 15.32 + 0.96p^*_t$$
$$(13.49) \quad (58.33)$$
$$R^2 = 0.97; \text{ DW} = 1.95 \qquad (2)$$

Period: 1972I - 1979IV

$$\pi_t = 2.44 + 1.14p^*_t$$
$$(1.11) \quad (23.21)$$
$$R^2 = 0.94; \text{ DW} = 1.79 \qquad (3)$$

Period: 1980I - 1993IV

$$\pi_t = 7.03 + 1.03p^*_t$$
$$(6.41) \quad (56.05)$$
$$R^2 = 0.98; \text{ DW} = 1.88 \qquad (4)$$

(figures in parentheses are t values; β coefficients are significant at 1% level of significance).

The relevant residuals for cointegration tests are obtained for different sub-periods from the following:

$$e_t = \pi_t - \alpha - \beta p^*_t \qquad (5)$$

Table 3. Test for cointegration (ADF satistics)

Period	ADF Statistics	Decision
1972I - 1993IV	-4.67	Cointegrated
1972I - 1979IV	-5.07	Cointegrated
1980I - 1993IV	-5.32	Cointegrated

H_0: Relevant residuals are non-stationary; H_A: Residuals are stationary
Dependent variable = π, Independent variable = p*

The results in Table 3 indicate that the PPP relationship shows cointegratedness for all the periods considered at 1% level of significance. In other words, the PPP holds good for Kuwait in contrast to the case of Indian sub-continent [11]. The hypothesis requires that the estimated value of β should not be significantly different from unity. The estimated equations show high degree of goodness of fit and at the same time the errors are not autocorrelated as supported by the DW values. Therefore, there is no problem of spurious regression in the estimated relationship. Let us now try to explain the results on the PPP from the movements of the Kuwaiti currency and domestic price level vis-a-vis the US dollar and price level. First consider the exchange rate.

The Central Bank of Kuwait maintained stability for the dinar (Kuwaiti currency) exchange rate against other major currencies, taking into consideration the particular characteristics of the Kuwaiti economy and the financial and trade relations between Kuwait and its trading partners. After the US dollar devaluation of about 10% in February 1973, the dinar-gold parity was maintained but the dinar-dollar rate appreciated by about 11%. However, that rate continued to move within the margin declared under the Smithsonian Agreement, that is, within 2.25% on either side. Accordingly, the dollar-dinar exchange rate in the period from June 1972 to March 1975 ranged from KD 0.289392 to KD 0.302714 per US dollar. The period after March 1975 became the floating exchange rate period for Kuwait. The dinar-dollar rate was freed from the official margins after the dollar value against dinar had remained close to the minimum limit (that is, 289.39 fils per dollar; 1 dinar = 1000 fils) for a long period. Consequently, the value of the dinar in the international market moved far from its parity rate with major currencies of those countries with which Kuwait maintained substantial trade and financial relations. Note that the β parameter for the first sub-period (1972I-1979IV) has moved further from unity to confirm such a movement of dinar away from parity with major currencies. Following the floating of the Kuwaiti dinar, the KD value against the dollar appreciated by around 1.6%. Since then, the dinar exchange rate has maintained a relative stability with the major currencies.

The movements of the price level in Kuwait, however, were subject to a number of interventions from the government. This intervention, as a matter of fact, worked in favor of the PPP as we explain below. It should be noted that Kuwait's needs for commodities and goods (consumer as well as capital goods) are mostly satisfied by imports, and owing to the narrow productive base of the domestic economy, domestic prices are affected by the prices

of exports of the industrial countries (for example, USA, Japan, Germany, France, United Kingdom among others) that are trading with Kuwait. Imports by Kuwait from major industrial countries represent about 70% of its total imports and thus annual increase in the prices of exports of these countries will have substantial impacts on domestic price level in Kuwait. The IMF estimates indicate that prices in Kuwait increased at an annual rate of about 9% throughout the 1970s and 1980s compared to an annual average of about 4% in the previous decade.

The increase in prices is attributable to the rise in import prices, the growing margins of profit exacted by importers, and the gains which importers realized from the exchange rate margin between the Kuwaiti dinar and foreign currencies used for importation purposes, such as the US dollar. Despite the successive appreciation in the KD exchange rate and the depreciation in the import value in dollars, consumer prices for goods and commodities were not reduced. Nevertheless, the prices of basic foodstuffs such as bread, rice, fish and meat remained fixed at their 1965/66 level. This is primarily because the government took some measures to reduce prices, such as subsidies to local producers, exemption of import duties for foodstuffs, and overall low import duty (4% *ad valorem*) for other goods. The government also highly generously subsidizes non-tradable goods and services such as water, electricity, health, education, construction materials (cement, reinforcing steel and bricks) to keep the overall price level low. Provision of housing is also highly subsidized in the form of low-cost plot of land, interest-free loan with easy instalment and very long repayment period (as long as 85 years on the average). The discussion above suggests that the exchange rate and the inflation rate in Kuwait are watched very closely and a parity with international level especially with its major trading partners are maintained. This explains why the PPP hypothesis as a long-run proposition proved tenable in case of Kuwait.

IV. Short-run Dynamics and Parameter Stability

The results thus far indicate that the error correction model (ECM), the second stage of Engle-Granger two-step procedure (to account for the short-run dynamics), does exist for Kuwait for all the sub-periods. When the hypothesis of no-cointegration is rejected, one can use the residuals of the equilibrium regression equation as explanatory variable in the ECM. This would show the adjustment in p^* and/or π in response to any deviation from the long run path of the PPP.

In the Engle-Granter approach, the residuals from equations (2), (3) and (4) are used as estimates of the disequilibrium errors. The estimated short-run equations for Kuwait for the three periods are presented below.

Short-run dynamics

Period: 1972I - 1993IV

$$\Delta\pi_t = 0.61\Delta p^*_t - 0.47e_{t-1} \quad (6)$$
$$(16.40) \quad (-2.08)$$
$$R^2 = 0.79; \quad DW = 1.92$$

Period: 1972I - 1979IV

$$\Delta\pi_t = 0.57\Delta p^*_t - 0.19e_{t-1} \quad (7)$$
$$(14.05) \quad (-2.49)$$
$$R^2 = 0.86; \quad DW = 1.77$$

Period: 1980I - 1993IV

$$\Delta\pi_t = 0.56\Delta p^*_t - 0.34e_{t-1} \quad (8)$$
$$(15.56) \quad (-2.18)$$
$$R^2 = 0.81; \quad DW = 1.85$$

We note that equations (6), (7) and (8) do not contain intercept terms. This is because the long-run relationships (cointegrating regressions) already contain such terms and an estimate of this is included in e_{t-1} (the disequilibrium error). The estimated equations show high degree of goodness of fit and absence of autocorrelatedness in the residuals as supported by the DW values. The coefficients are also highly significant. The short-run coefficients are represented by the rate of change variable. The coefficients of e_{t-1} indicate the speed of adjustment, for example, the value of 0.47 (for the entire period) implies that 47% of any disequilibrium in one quarter is made up during the next quarter. This is rather a relatively quick tendency to converge to the long-run PPP.

Parameter Stability

One of the criteria of a satisfactory model is the existence of parameter stability. We have argued at the end of Section I that there exists a possibility of a structural break around 1979 when a number of changes took place in the world economy. We use Chow test to check for the stability and calculated the sum of squares due to errors (SSE) for the whole period and the two sub-periods as indicated earlier. We used equations (6), (7), and (8) to calculate the required SSE for the entire sample, sub-sample 1 and sub-sample 2 respectively. These are:

$SSE = 1011.47$ (entire sample); $n = 88$, $k = 2$
$SSE_1 = 163.71$ (sub-sample 1); $n_1 = 32$, $k = 2$
$SSE_2 = 297.61$ (sub-sample 2); $n_2 = 56$, $k = 2$

H_0: Parameters are stable over the entire sample

Now, the Chow statistic is defined as

$$\lambda = [SSE - (SSE_1 + SSE_2)]/[(SSE_1 + SSE_2)(n_1 + n_2 - 2k)]/k = 50.09,$$

where $n = n_1 + n_2$ and λ is an F distribution with k and (n-2k) degrees of freedom.

The calculated F of 50.09 is much larger than the corresponding critical value of 19.5 at 5% level of significance. Therefore, we should not accept the null hypothesis of parameter stability over the entire sample. Certainly there was a break especially after Kuwaiti dinar switched to floating exchange rate. It should be noted that using equations (2), (3), and (4) for this purpose yields the same conclusion as using equations (6), (7), and (8). We also estimated the model following [12] and [13] to see if there was purely stochastic behavior for the β coefficient over the entire sample beside the break point around 1979. Our results indicate that there was no significant coefficient variation from quarter to quarter over the entire sample.

V. Conclusion

The results of cointegration tests of the PPP as a long-run relationship provide quite strong support for the hypothesis so far as Kuwait and the sample period are concerned. The error correction equations for the entire period show that the adjustment o changes is rather fast although not so for the first sub-sample (that is, 1972I - 1979IV). Some of the adjustments that took place to correct the deviation came through exchange rate appreciation and price subsidy for the imported and domestically produced goods. Government policy had a big role in bringing such a quick adjustment to disequilibrium in the PPP. It should be noted that foreign trade is highly liberalized in Kuwait. Tariff rate is very low (4% *ad valorem* for most imported items) and certain goods like foodstuffs, industrial raw materials, and intermediate capital goods are exempted from import duties. There is no quota system either. The foreign exchange market is almost free from government restriction; the Central Bank of Kuwait intervened at times in the foreign exchange market especially after the fixed exchange rate system collapsed in 1973. Frenkel [22] argued that much of the controversy over the usefulness of the PPP doctrine results from the fact that PPP specifies a final, equilibrium relationship rather than a precise theory of exchange rate determination. If we interpret cointegration as an evidence of a long-run equilibrium relationship, then the finding of this paper suggests that prices and exchange rates converged in the long run for a capital-rich, oil-exporting country like Kuwait, given the sample period and the monetary-fiscal policy mix of the country.

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اختبار التكامل المشترك لفرضية تعادل القوة الشرائية : تطبق على بلد نام وغني برأس المال

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(قدم للنشر في ٢٣/ ٥/ ١٤١٧هـ ؛ وقبل للنشر في ١٦/ ٦/ ١٤١٩هـ)

ملخص البحث. توظف الدراسة منهجية التكامل المشترك لاختبار مدى انطباق فرضية تعادل القوة الشرائية على بلد نام وغني برأس المال. ولهذا الغرض تم استخدام بيانات فصلية من دولة الكويت والولايات المتحدة الأمريكية تغطي الفترة الزمنية (١٩٧٢- ١٩٩٣). وتشير نتائج التكامل المشترك إلى وجود علاقة توازنية طويلة الأجل، مما يؤكد انطباق هذه الفرضية. وتخالف هذه النتائج ما توصلت إليه كثير من الدراسات التي تم تطبيقها على أقطار من خارج منظمة أوبك وأقطار غير مصدرة للنفط.