THE KOREAN ECONOMIC REVIEW
Volume 15, Number 2, Winter 1999

# PURCHASING POWER PARITY AND REAL EXCHANGE RATES IN SRI LANKA, 1977:11-1996:12

HAN GWANG CHOO*

*This paper examines the long-run validity of PPP for Sri Lanka by means of Johansen's multivariate cointegration methodology and the unit root test. It provides further evidence on PPP by (a) using both consumer price index and wholesale price index, (b) using nominal and real exchange rates vis-a-vis four industrial countries (Germany, Japan, the UK, and the US), and (c) studying nominal and real effective exchange rates with respect to seven major trading partners (Germany, India, Japan, Korea, Singapore, the UK, and the US).*

*We use monthly data for the rather short-term period of 1977:11-1996:12 and find results supportive of PPP in almost all cases examined. Thus the paper renders quite a rare PPP-supporting example of a small open LDC, which suffered from chronic high unemployment rates and current account deficits, experienced rather rapid economic growth and mild inflation in comparison to other LDCs, and passed through structural changes as well.*

JEL Classification: F3
Keywords: Purchasing Power Parity, Real Exchange Rates, Sri Lanka

## I. INTRODUCTION

The purchasing power parity (PPP) theory postulates that the exchange rate between two countries' currencies equals the ratio of their price levels. One implication of PPP is that the prices of a common basket of goods and services in the two countries measured in the same currency will be the same, that is, the real exchange rate must equal the unity. Failure of PPP indicates that the real exchange rate is non-stationary and it changes over time, which has many economic implications. For example, a real depreciation (real appreciation) will

*Received for publication:* April 13, 1999. *Revision accepted:* June 22, 1999.

* Department of Economics and International Trade, Sejong University. The research was done by a research fund of Sejong University. I would like to appreciate the encouragement by Dr. Myung-Gun Choo, Chairman of Board of Trustees, Sejong University. I would like to thank two anonymous referees for their helpful comments in revising this paper. Remaining errors are mine.

bring about a gain (loss) in international competitiveness. PPP is one of the most thoroughly examined topics in international finance and in economics at large. Yet it remains a highly controversial topic, both from the theoretical and empirical perspective.

Previous studies like Frenkel (1978, 1981), Hsieh (1982), and Davutyan and Pippenger (1985) relied upon standard econometric procedures such as two stage least squares, and provided mixed conclusions. However, recent studies such as Corbae and Ouliaris (1988), Taylor (1988), Taylor and McMahon (1988), Abuaf and Jorion (1990), Kim (1990), Edison and Fisher (1991), Grilli and Kaminsky (1991), Glen (1992), and Cheung and Lai (1993a) have indicated that the previous studies neglect the fact that exchange rates and price levels are non-stationary, which makes the use of standard critical values inappropriate. Using new technique of cointegration, most of the recent studies rejected PPP, while Kim (1990) and Cheung and Lai (1993a) provided some support for PPP. And a relatively new concept of fractional cointegration is applied to support the validity of PPP in Cheung and Lai (1993b), and Masih and Masih (1995). More recently, researches like Frankel and Rose (1996), Oh (1996), Edison, et al. (1997), Meier (1997), and Cheung and Lai (1998) have used panel-based procedures and reported results in favor of PPP.

While above-mentioned studies use data on industrial countries, there are several studies on less developed countries (LDCs) which generally experienced high inflation. McNown and Wallace (1989) tested PPP for four high-inflation countries of Argentina, Brazil, Chile, and Israel during the 1970s and 1980s, and found some evidence supportive of the hypothesis. In particular, results with wholesale price index were more supportive of PPP than with consumer price index. Karfakis and Moschos (1989) examined Greece for the period 1975.I-1987.I and rejected PPP. Liu (1992) tested PPP for nine Latin American countries over the period 1948.I-1989.IV and showed that in each country there is at least one cointegrating relationship among exchange rate and domestic and foreign price, which supports PPP partly. Bahmani-Oskooee and Lee (1992) tested PPP for Korea during the period 1980.1-1989.12 and rejected the hypothesis.

Conejo and Shields (1993) tested for PPP for five Latin American countries over the period 1949-1990, and concluded with some supporting evidence. Mahdavi and Zhou (1994) tested for the absolute and relative PPP according to the degree of integration of exchange rates and price levels for thirteen high-inflation countries during the period from 1970s to early 1990s. They showed that relative PPP performed well in five countries out of eight countries and that absolute PPP performed well in only three countries out of eight countries. Bahmani-Oskooee (1995) tested real effective exchange rates of twenty-two LDCs during 1970s and 1980s and found that in most cases the hypothesis was rejected. Kahn and Parikh (1998) examined PPP for South Africa during the period 1975-1994 and found some evidence for the hypothesis.

Telatar and Kazdagli (1998) tested for PPP for Turkey during the period 1980-1993 and rejected the hypothesis.

Generally, results from the LDCs with the experience of high inflation rates, where the monetary shocks dominated real disturbances, and from long-term data support the hypothesis.

This paper provides further evidence on the performance of PPP in Sri Lanka over the period 1977:11-1996:12 by (a) using both consumer price index (CPI) and wholesale price index (WPI), (b) using nominal and real exchange rates vis-a-vis four industrial countries (Germany, Japan, the UK, and the US), and (c) studying nominal and real effective exchange rates with respect to seven major trading partners.

Sri Lanka is a small open LDC. It suffered from chronic high unemployment rates, and trade balance and current account deficits. The unemployment rate ranged from 14 percent to 20 percent, and the ratio of trade-balance deficit to GDP averaged 7 percent. The economy experienced rather rapid economic growth and mild inflation in comparison to other LDCs; the growth rate and inflation rate averaged 5 percent and 10 percent, respectively. It passed through structural changes as well. Thus, from results of other previous researches we might expect results which do *not* support PPP for such an economy as Sri Lanka.

The remainder of the paper is organized as follows. In Section II we explain the PPP formulation, and describe the unit root test and cointegration technique briefly. Section III outlines the Sri Lankan economy since 1977. Section IV first tests whether a long-run relationship exists between nominal exchange rate and relative price of domestic and foreign price. It also tests whether a long-run relationship exists between domestic price and exchange rate-adjusted foreign price. Then the non-stationarity of the real exchange rates is tested. Section V contains a summary and concluding remarks.

## II. THE PPP FORMULATION AND METHODOLOGY

If PPP holds, the data should not reject the restrictions $\beta=1$ and $\delta=1$ in the following regressions:

$$s_t = \alpha + \beta(p_t - p_t^*) + \nu_t \tag{1}$$

$$p_t = \gamma + \delta(s_t + p_t^*) + \eta_t \tag{2}$$

where $\alpha$ and $\gamma$ are constant terms, $s_t$ is the natural logarithm of the nominal spot exchange rate (defined as number of units of domestic currency per unit of foreign currency), $p_t$ and $p_t^*$ are the natural logarithms of the domestic and foreign price levels, respectively, and $\nu_t$ and $\eta_t$ are random error terms. Equation

(2) is added to take account of the fact that the Sri Lankan exchange rate regime has been the managed float.

Another simplest approach to testing for PPP is to impose the symmetry and proportionality restrictions by defining the real bilateral exchange rate, $q_t$, as follows:

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

and to examine whether $q_t$ is non-stationary or stationary. The rise (fall) in $q_t$ means a real depreciation (real appreciation). If long-run PPP holds, then the data should reject that $q_t$ has a unit root.

$s_t$, $p_t^*$ and $q_t$ in (1), (2), and (3) should be changed appropriately when we consider nominal effective exchange rate ($NEER_t$) and real effective exchange rate ($REER_t$) rather than nominal bilateral exchange rate ($s_t$) and real bilateral exchange rate ($q_t$). Seven major trading partners were selected, and the share of each country was calculated from Sri Lanka's imports.

Basically two kinds of econometric methods are used; unit root test and cointegration analysis. These methods have been extensively documented so we will only briefly describe them. The Augmented Dickey Fuller (ADF) and Phillips Perron (P-P) tests are employed to test for the unit root, that is, to test for the non-stationarity for the relevant variables. The series of a variable is said to be integrated of order one, denoted I(1), if the variable produces a non-stationary process but taking a first difference produces a stationary process. The unit root test is also applied to determine if the null hypothesis of a unit root in the real exchange rate defined as in (3) can be rejected.

To test (1) and (2), we use the multivariate cointegration methodology proposed by Johansen (1988), and Johansen and Juselius (1990). In contrast to the Engle-Granger (1987) procedure, the Johansen methodology provides a unified framework for estimating and testing cointegrating relationship within the vector error correction model (VECM), explicitly tests for the number of cointegrating vectors, and is independent of the choice of the endogenous variable.

We consider the $p$-dimensional vector autoregression (VAR) model;

$$X_t = \mu + \sum_{j=1}^{k} A_j X_{t-j} + \varepsilon_t, \qquad t = 1, 2, \cdots, T \tag{4}$$

where $X_t$ is a vector consisting of $p$ variables all of which are I(1), $\varepsilon_t$ is a vector of independently and identically distributed error terms, and $T$ is the sample size. By differencing (4) we write the model in the VECM;

$$\Delta X_t = \mu + \sum_{j=1}^{k} \Gamma_j \Delta X_{t-j} + \Pi X_{t-k} + \varepsilon_t \tag{5}$$

where

$$\Gamma_j = -(I - A_1 - \cdots - A_j), \qquad j = 1, 2, \cdots, k-1$$

and

$$\Pi = -(I - A_1 - \cdots - A_k).$$

Equation (5) is expressed as a traditional first differenced VAR model except for the term $\Pi X_{t-k}$. We investigate whether the coefficient matrix $\Pi$ contains information about long-run relationship among variables in $X_t$. There are three possibilities according to the rank of $\Pi$, which we denote as $r$. If $r$ equals $p$ then all the variables in $X_t$ are stationary. If $r$ equals zero then no cointegrating relationship in levels exists among the variables and we should rely on a traditional differenced VAR model. If $r$ is less than $p$ but greater than zero then $\Pi$ can be decomposed into $\Pi = ab'$, where $b$ contains the coefficients of the cointegrating vectors and $b'X_t$ is the cointegrating relationship.

Because the rank of $\Pi$ is usually unknown, the Johansen methodology proceeds to develop test procedures to test the rank of $\Pi$. The tests are based on the eigenvalue solution to the reduced rank regression. The test statistics are;

$$\text{Trace statistic} = -\sum_{i=r+1}^{p} T \ln (1-\lambda_i) \tag{6}$$

$$\text{Maximum eigenvalue statistic} = -T \ln (1-\lambda_{r+1}) \tag{7}$$

where $\lambda_i$ is the estimated eigenvalue. The trace statistic is related to the null hypothesis $H_0$ that at most $r$ cointegrating vectors exist against the alternative hypothesis $H_1$ that at least one more cointegrating vector than the null exist. The maximum eigenvalue statistic is related to the null of $r$ cointegrating vectors against the alternative of $r+1$ cointegrating vectors.

In identifying the cointegrating vectors, the maximum lag $k$ in (5) should be large enough to remove serial correlation in the residuals of (5). Having identified the significant cointegrating vectors, the Johansen methodology further allows us to test linear restrictions on the coefficients of the vectors; likelihood ratio tests and Wald tests are provided.

## III. THE ECONOMY OF SRI LANKA

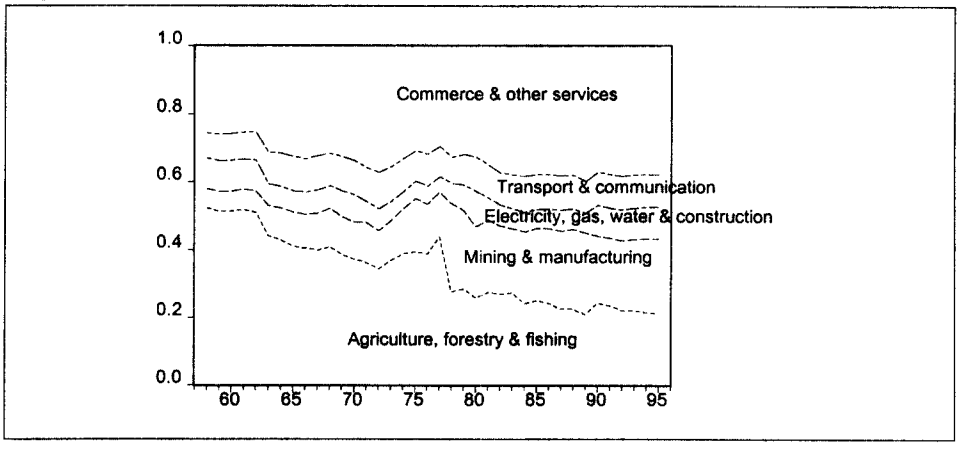
The Sri Lankan economy shares many structural features with most low-income commodity-exporting LDCs. Table 1 shows major economic indicators

**[Table 1]** Major Economic Indicators of Sri Lanka

| Year | dM2/M2 (%) | (T-G)/Y (%) | I/Y (%) | dp/p (%) | dY/Y (%) | (X+M)/Y (%) | (X-M)/Y (%) | TOT (1990=1) | FX (mil US$) |
|---|---|---|---|---|---|---|---|---|---|
| 1961-1965 | 8.6 | -6.0 | 14.2 | 1.6 | 3.5 | 54.4 | -1.2 | 2.63 | 75 |
| 1966-1970 | 6.3 | -6.6 | 16.1 | 4.2 | 5.4 | 46.7 | -3.7 | 2.02 | 47 |
| 1971-1975 | 8.9 | -6.1 | 13.9 | 7.5 | 2.6 | 54.0 | -3.9 | 1.38 | 66 |
| 1976-1977 | 36.1 | -6.5 | 14.5 | 1.3 | 3.6 | 62.2 | 0.7 | 1.50 | 193 |
| 1978-1980 | 34.3 | -14.2 | 25.5 | 16.3 | 6.8 | 80.3 | -13.1 | 1.31 | 387 |
| 1981-1985 | 19.0 | -10.7 | 27.2 | 12.2 | 5.2 | 69.2 | -13.6 | 1.11 | 388 |
| 1986-1990 | 12.8 | -9.6 | 22.6 | 12.6 | 3.4 | 63.0 | -10.1 | 1.07 | 304 |
| 1991-1996 | 18.5 | -7.7 | 24.6 | 11.2 | 5.1 | 76.2 | -10.0 | 1.17 | 1557 |

dM2/M2=growth rate of M2; $(T-G)/Y$=the ratio of budget surplus to GDP; I/Y=the ratio of fixed capital formation to GDP; dp/p=CPI-based inflation rate; dY/Y=growth rate of GDP; $(X+M)/Y$=trade dependence ratio; $(X-M)/Y$=the ratio of trade balance surplus to GDP; TOT=terms of trade; and FX=foreign exchange reserves.

**[Figure 1]** Industrial Structure of Sri Lanka

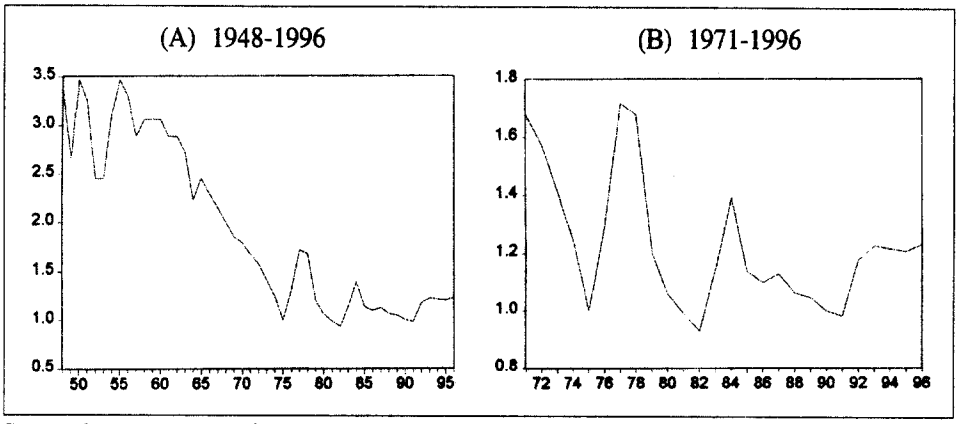



Source: UN, *Yearbook*

of Sri Lanka. The GDP share of the primary sector declined gradually while that of the manufacturing sector increased (see Figure 1). The economy has experienced a long-run secular decline in the real prices of traditional export crops (tea, rubber, and coconut) and periodically faced sharp swings in its terms of trade (see Figure 2). The trade dependence ratio (total imports and exports of goods and nonfactor services as a share of GDP) has fluctuated around 70 percent. The export share of the primary sector declined gradually while that of the manufacturing sector increased (see Figure 3)[1]. The export share of SITC 0 (tea, coconut, and spices) and SITC 2 (natural rubber) decreased while that of

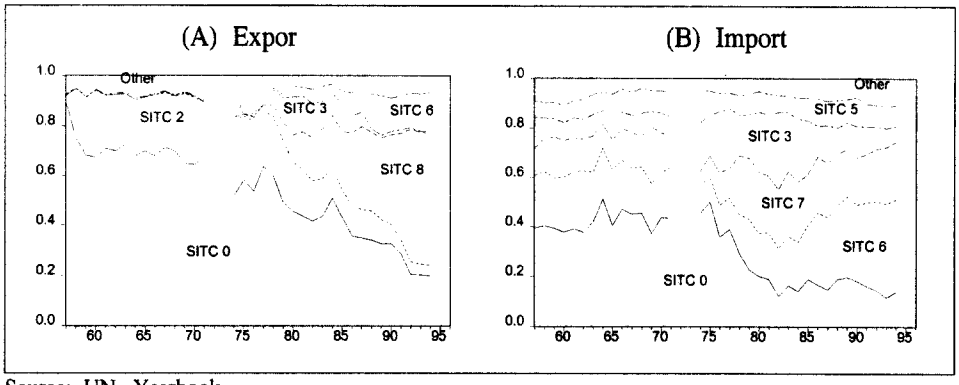
[1] The data for 1972 and 1973 are missing.

**[Figure 2]** Terms of Trade of Sri Lanka (1990=1.00)




Source: IMF, *International Financial Statistics*

**[Figure 3]** Trade Structure of Sri Lanka



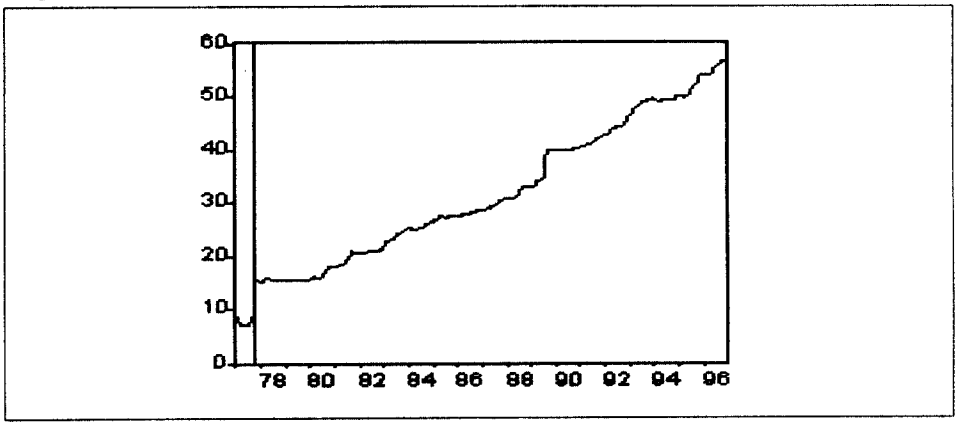

Source: UN, Yearbook

SITC 8 (garments) increased sharply. The import share of SITC 0 (wheatmeal and flour, rice, refined sugar, milk, and fish) and SITC 3 (fuel and fertilizers) declined gradually while that of SITC 6 (rubber tires and tubes, paper and paperboard, and cotton fabric) increased.

Since 1977 Sri Lanka has experienced (1) an extensive reform, (2) a dramatic investment boom, and (3) huge capital inflows from abroad. Below we will elaborate them a little.

First, the new government began an extensive reform after taking office in 1977. Quantitative restrictions on import were largely replaced by tariffs. A number of measures to encourage direct foreign investment, including general tax incentives and the establishment of an export processing zone, were implemented. Most of price controls were removed. The lifting of many restrictions on capital transactions was an important step toward greater integration of the domestic capital market with the international market.

[Figure 4] US Dollar Exchange Rate of Sri Lankan Rupee




Source: IMF, *International Financial Statistics*

The exchange rate system was also reformed. Until the late 1960s, a fixed rate with almost no change in par value was maintained and even the introduction of multiple rate in 1968 did not affect the commitment to a fixed rate. In November 1977 the exchange rate was unified, the rupee was devalued by 45.5 percent against the US dollar, and a managed float was adopted with a view to making the exchange rate an active policy instrument. Since 1977 the nominal exchange rate has steadily depreciated under the managed floating regime (see Figure 4).

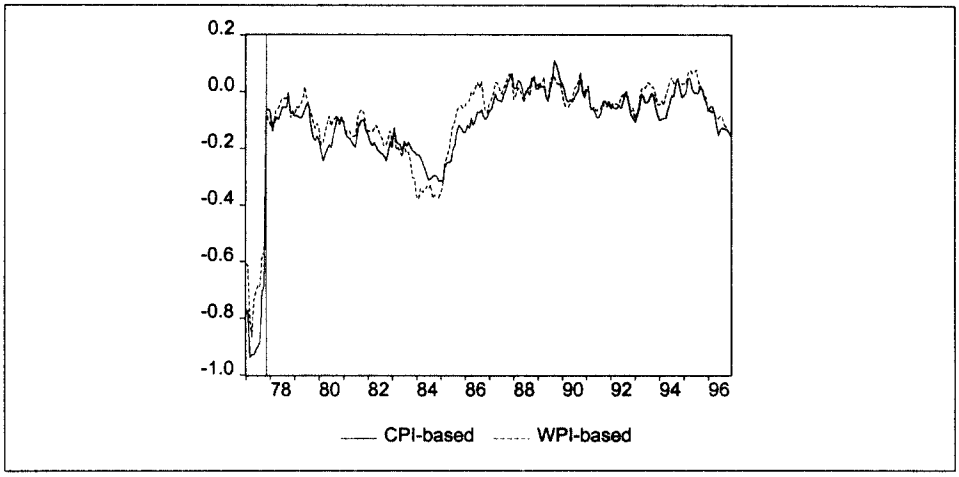
The main elements of the reform, such as trade liberalization, relaxation of controls on foreign exchange transactions, a more realistic value for the rupee, and the elimination of various controls on private sector activities, were intended to generate an economic climate conducive to export expansion. Thus the PPP is more likely to hold in the economy since 1977.

Secondly, the liberalization reform was accompanied by a massive public sector investment program. During the 1970s, total investment had been on average 15 percent of GDP. The investment level averaged 27 percent of GDP from 1978 to 1985 and then declined marginally to 24 percent during the 1986-96 period. Despite market-oriented policy reforms in 1977, the public sector share in total annual gross capital formation increased to above 50 percent because of aid-funded public sector infrastructure and housing construction activities. The economy was stimulated by the massive increase in investment, originating mainly in the public sector. The growth rate of GDP averaged 5.8 percent in 1978-1985 and then fell to 4.3 percent in 1986-1996. The non-traded sector increased gradually.[2]

As Balassa (1964) implied, the supply shock brought about by the massive

[2] According to Figure 1 the non-traded sector (electricity, gas, water and construction; transport and communication; and most of commerce and other services) increased gradually.

**[Figure 5]** Real Effective Exchange Rates




investment may cause the real exchange rate to change. We may also consider some evidence that positive demand shocks lead to short and medium-run real appreciation. Actually higher expenditures by the government as well as private agents on domestic goods and services tended to appreciate the real exchange rate in early 1980s (see Figure 5). The real exchange rate effects of the investment program tended to offset some of the incentives given to the tradable sectors by the trade and exchange rate reforms, whose goal had been to raise the profitability of tradable goods production. It had adverse implications for the promotion of nontraditional exports in general and manufactured goods in particular.

The nominal depreciation of rupee did not bring about any real depreciation and any improvement of the international competitiveness of Sri Lanka (refer to Athukorala and Jayasuriya (1994), Lal (1985), and White and Wignaraja (1992)).

Thirdly, the massive increase in domestic investment during the post-1977 period required large amounts of foreign capital inflows (aid, loans, and migrant-worker remittances) because of slow growth of domestic savings. As the terms-of-trade decline started to affect the current account, official aid proved insufficient to finance necessary imports. Loans from commercial sources had to be obtained to meet payment obligations. Sri Lanka's balance of payments position has been characterized by widening deficits in the merchandise and current accounts. This has been the outcome of adverse movements in the terms of trade and stagnation in export volume.

Foreign reserves accumulated during the Korean War commodity boom and the tea boom in the 1950s. Current account deficits were almost totally financed by foreign reserves. After these reserves were depleted, import restrictions became the basic tool for managing the balance of payments up to 1977. After 1977 Sri Lanka's reliance on foreign savings increased to an unprecedented extent. The heavy reliance on foreign finance, however, did not lift the debt

service burden to unmanageable levels, since nearly 75 percent of the foreign financial assistance received during this period consisted of grants and long-term loans. Nevertheless, the rising debt burden was becoming a matter of concern since early 1990s. With respect to the implication of the balance of payment for the PPP, the capital account surplus which offsets the current account deficit allows the economy to be more supportive of PPP.

In order to understand the international trade of Sri Lanka we estimate the export and import equations since 1970s as follows:[3]

$$\ln(Exp) = \underset{(2.657)}{4.050}\ln(Y^*) - \underset{(0.501)}{0.770}\ln(P_{EXP}/P^*) - 4.160 \tag{8}$$

$$\ln(Imp) = \underset{(0.323)}{0.768}\ln(Y) - \underset{(0.218)}{0.356}\ln(P_{IMP}/P) + 2.190 \tag{9}$$

where $Exp$ is the export volume, $Imp$ is the import volume, $Y$ is the domestic income, $Y^*$ is the weighted average of seven trading partners' income, $P_{EXP}$ is the export price, $P^*$ is the weighted average of seven trading partners' price, $P_{IMP}$ is the import price, and $P$ is the domestic price. It is noted that the international trade has been stable over the sample period.

## IV. EMPIRICAL RESULTS

We use monthly data for the period of 1977:11-1996:12. The starting point of our sample is determined from the following fact; as we mentioned above, in 1977 the Sri Lankan government introduced new economic policies and in November 1977 it devalued its currency by 45.5 percent against the US dollar. Even when we change the starting point from 1977:11 to 1977:1, the results do not change much. The data are obtained from *Direction of Trade Statistics* and *International Financial Statistics* published by the International Monetary Fund.

The exchange rates are monthly-end market exchange rates; they are calculated with each currency's exchange rate against the US dollar and Sri Lankan rupee's exchange rate against the US dollar. We calculate the real bilateral exchange rates using the nominal bilateral exchange rates and price indices. We use both consumer price index (CPI) and wholesale price index (WPI).

The nominal effective exchange rate ($NEER_t$) and real effective exchange rate ($REER_t$) are calculated from the shares of seven foreign countries in Sri Lanka's average imports in 1980, 1985, 1990, and 1995. The shares of Germany, India, Japan, Korea, Singapore, the UK, and the US are 9%, 14%, 30%, 10%, 11%,

[3] The estimation is done by Johansen methodology. The number in the parenthesis denotes the standard error.

12%, and 14%, respectively. There are two kinds of *REER*; one is based on CPI and the other is based on WPI.

As indicated above, we first need to determine the degree of integration of each variable. To this end we rely upon Augmented Dickey Fuller (ADF) and Phillips Perron (P-P) tests. Tables 2 and 3 report the unit root tests for the four nominal bilateral exchange rates, nominal effective exchange rate, relative prices, domestic price, and exchange rate-adjusted foreign prices. In order to avoid any arbitrariness in selecting number of lags, we use the Akaike information criterion (AIC) according to which the final prediction error (FPE) statistic must be minimized. From the tables we note that all the variables appear to be I(1).

Then the results of applying the Johansen methodology to our data on the variables in the equations (1) and (2) are reported in Tables 4 and 5, respectively.

**[Table 2]** Unit Root Test I

**Panel A**

| | Nominal exchange rates (Rupee/foreign currency) | | CPI-based relative prices (Sri Lankan CPI/Foreign CPI) | | WPI-based relative prices (Sri Lankan WPI/Foreign WPI) | |
|---|---|---|---|---|---|---|
| | ADF | P-P | ADF | P-P | ADF | P-P |
| Germany | -0.15(11) | -2.05(4) | -0.83(10) | -0.78(4) | -0.61(1) | -0.65(4) |
| Japan | -0.41(11) | -2.03(4) | 0.07(10) | -0.13(4) | -0.25(8) | -0.42(4) |
| UK | -0.43(11) | -2.67(4)+ | 1.63(10) | 2.09(4) | -0.47(1) | -0.53(4) |
| US | -0.96(11) | -2.95(4)* | 0.96(10) | 1.19(4) | -0.32(1) | -0.34(4) |
| 7 Economies | -2.47(2) | -2.71(4)+ | 0.06(3) | 0.14(4) | -0.62(7) | 0.84(4) |

**Panel B**

| | First difference of nominal exchange rates (Rupee/foreign currency) | | First difference of CPI-based relative prices (Sri Lankan CPI/Foreign CPI) | | First difference of WPI-based relative prices (Sri Lankan WPI/Foreign WPI) | |
|---|---|---|---|---|---|---|
| | ADF | P-P | ADF | P-P | ADF | P-P |
| Germany | -5.90(11)** | -14.55(4)** | -6.10(9)** | -12.69(4)** | -4.87(7)** | -11.83(4)** |
| Japan | -5.46(11)** | -14.12(4)** | -4.89(11)** | -14.96(4)** | -5.11(7)** | -11.57(4)** |
| UK | -6.41(11)** | -13.96(4)** | -6.45(9)** | -16.46(4)** | -7.12(5)** | -12.05(4)** |
| US | -8.47(10)** | -15.83(4)** | -6.41(9)** | -15.77(4)** | -9.16(1)** | -11.89(4)** |
| 7 Economies | -7.95(10)** | -14.65(4)** | -5.73(5)** | -14.92(4)** | -4.97(9)** | -11.66(4)** |

The number of lags is shown in parentheses. **=1% significance, *=5% significance, +=10% significance.

**[Table 3]** Unit Root Test II

**Panel A**

| | CPI | | WPI | |
|---|---|---|---|---|
| | Domestic price ($p$) or $sp^*$ | | Domestic price ($p$) or $sp^*$ | |
| | ADF | P-P | ADF | P-P |
| Sri Lanka | -1.18(3) | -1.40(4) | -1.16(1) | -1.16(4) |
| Germany | -1.92(2) | -2.06(4) | -2.23(2) | -2.38(4) |
| Japan | -2.07(2) | -2.22(4) | -2.51(2) | -2.68(4)$^{+}$ |
| UK | -2.45(2) | -2.80(4)$^{+}$ | -2.48(2) | -2.84(4)$^{+}$ |
| US | -2.38(11) | -3.42(4)$^{*}$ | -2.19(11) | -3.65(4)$^{**}$ |
| 7 Economies | -1.24(12) | -2.84(4)$^{+}$ | -1.74(12) | -3.30(4)$^{*}$ |

**Panel B**

| | CPI | | WPI | |
|---|---|---|---|---|
| | First difference of domestic price ($p$) or sp* | | First difference of domestic price ($p$) or sp* | |
| | ADF | P-P | ADF | P-P |
| Sri Lanka | -6.38(4)$^{**}$ | -12.16(4)$^{**}$ | -9.00(1)$^{**}$ | -11.90(4)$^{**}$ |
| Germany | -9.10(1)$^{**}$ | -14.67(4)$^{**}$ | -9.19(1)$^{**}$ | -14.74(4)$^{**}$ |
| Japan | -8.99(1)$^{**}$ | -14.06(4)$^{**}$ | -9.27(1)$^{**}$ | -14.62(4)$^{**}$ |
| UK | -8.95(1)$^{**}$ | -13.90(4)$^{**}$ | -8.90(1)$^{**}$ | -14.09(4)$^{**}$ |
| US | -9.07(1)$^{**}$ | -15.78(4)$^{**}$ | -7.88(10)$^{**}$ | -15.58(4)$^{**}$ |
| 7 Economies | -7.02(11)$^{**}$ | -14.68(4)$^{**}$ | -6.98(11)$^{**}$ | -14.81(4)$^{**}$ |

Domestic price=Sri Lankan price; $sp^*$=(exchange rate)$\times$(foreign price) for other countries. The number of lags is shown in parentheses. **=1% significance, *=5% significance, +=10% significance.

Panel A shows the trace and maximum eigenvalue tests, according to which there is one cointegration vector in most cases. The significance level is related to the null hypothesis of $r=0$ and $r\leq 1$. Lags denote the augmented lag terms included; as mentioned above, the maximum lag $k$ should be large enough to remove serial correlation in the residuals.

Panel B presents the cointegration vector for each case. In reporting the cointegrating vectors it is a common practice to normalize them on the dependent variable of the model. Thus we normalize all vectors on the exchange rate ($s$) in Table 4 and on the domestic price ($p$) in Table 5 by setting the coefficients at *negative* one. In most cases the coefficient of relative price in Table 4 and the coefficient of exchange rate-adjusted foreign price ($sp^*$) in Table 5 is close to the unity, *supporting* the PPP hypothesis.

## [TABLE 4] Cointegration Test I

**Panel A** Trace and Maximum Eigenvalue Tests

| | | CPI | | | WPI | | |
|---|---|---|---|---|---|---|---|
| | | Trace | $\lambda_{max}$ | Lags | Trace | $\lambda_{max}$ | Lags |
| Germany | $r=0$ | 16.76* | 15.46* | 1-4 | 13.47+ | 11.60 | 1-8 |
| | $r\leq 1$ | 1.30 | 1.30 | | 1.87 | 1.87 | |
| Japan | $r=0$ | 15.63* | 15.41* | 1-9 | 13.51+ | 13.14+ | 1-8 |
| | $r\leq 1$ | 0.22 | 0.22 | | 0.37 | 0.37 | |
| UK | $r=0$ | 28.36** | 26.90** | 1-4 | 18.74* | 17.65* | 1-4 |
| | $r\leq 1$ | 1.46 | 1.46 | | 1.09 | 1.09 | |
| US | $r=0$ | 35.79** | 35.58** | 1-8 | 31.90** | 31.19** | 1-8 |
| | $r\leq 1$ | 0.21 | 0.21 | | 0.71 | 0.71 | |
| 7 Economies | $r=0$ | 34.03** | 33.98** | 1-8 | 25.94** | 25.29** | 1-4 |
| | $r\leq 1$ | 0.05 | 0.05 | | 0.65 | 0.65 | |

**Panel B** Cointegration Vectors

| | Exchange rate ($s$) | CPI-based relative price | Exchange rate ($s$) | WPI-based relative price |
|---|---|---|---|---|
| Germany | -1 | 1.091 | -1 | 1.152 |
| | | (0.083) | | (0.113) |
| Japan | -1 | 1.308 | -1 | 1.140 |
| | | (0.079) | | (0.076) |
| UK | -1 | 0.987 | -1 | 1.048 |
| | | (0.094) | | (0.144) |
| US | -1 | 1.023 | -1 | 0.935 |
| | | (0.020) | | (0.021) |
| 7 Economies | -1 | 1.083 | -1 | 1.030 |
| | | (0.034) | | (0.055) |

**Panel C** Error Correction Model

| | CPI | | | WPI | | |
|---|---|---|---|---|---|---|
| | Error correction term | $R^2$ | adj. $R^2$ | Error correction term | $R^2$ | adj. $R^2$ |
| Germany | -0.069 | 0.07 | 0.03 | -0.022 | 0.24 | 0.18 |
| | [-3.041] | | | [-1.186] | | |
| Japan | -0.081 | 0.13 | 0.05 | -0.054 | 0.26 | 0.20 |
| | [-3.531] | | | [-2.606] | | |
| UK | -0.109 | 0.13 | 0.09 | -0.067 | 0.09 | 0.05 |
| | [-4.772] | | | [-3.237] | | |
| US | -0.298 | 0.38 | 0.33 | -0.221 | 0.47 | 0.42 |
| | [-9.355] | | | [-7.028] | | |
| 7 Economies | -0.196 | 0.23 | 0.17 | -0.118 | 0.12 | 0.08 |
| | [-6.180] | | | [-4.242] | | |

Lags denote the augmented lag terms included. **=1% significance, *=5% significance, +=10% significance. We normalize all vectors on the exchange rate ($s$) by setting its coefficient at one. Figures in parentheses and brackets are the standard errors and t-statistics, respectively.

## [TABLE 5] Cointegration Tests II

### Panel A Trace and Maximum Eigenvalue Tests

| | | CPI | | | WPI | | |
|---|---|---|---|---|---|---|---|
| | | Trace | $\lambda_{max}$ | lags | Trace | $\lambda_{max}$ | lags |
| Germany | $r$=0 | 17.99* | 15.28* | 1-3 | 16.37* | 11.70 | 1-8 |
| | $r\leq$ | 2.71 | 2.71 | | 4.67* | 4.67* | |
| Japan | $r$=0 | 15.45* | 13.40+ | 1-4 | 14.64+ | 12.26* | 1-4 |
| | $r\leq$ | 2.05 | 2.05 | | 2.38 | 2.38 | |
| UK | $r$=0 | 29.23** | 26.27** | 1-8 | 19.60* | 17.33* | 1-2 |
| | $r\leq$ | 2.96+ | 2.96+ | | 2.27 | 2.27 | |
| US | $r$=0 | 39.69** | 38.51** | 1-4 | 30.75** | 29.41** | 1-4 |
| | $r\leq$ | 1.18 | 1.18 | | 1.34 | 1.34 | |
| 7 Economies | $r$=0 | 37.96** | 35.38** | 1-4 | 33.05** | 30.70** | 1-4 |
| | $r\leq 1$ | 2.58 | 2.5 | | 2.35 | 2.35 | |

### Panel B Cointegration Vectors

| | CPI | | WPI | |
|---|---|---|---|---|
| | $p$ | $sp^*$ | $p$ | $sp^*$ |
| Germany | -1 | 0.929 | -1 | 0.859 |
| | | (0.056) | | (0.071) |
| Japan | -1 | 0.838 | -1 | 0.967 |
| | | (0.057) | | (0.098) |
| UK | -1 | 0.996 | -1 | 0.975 |
| | | (0.048) | | (0.068) |
| US | -1 | 0.989 | -1 | 1.069 |
| | | (0.011) | | (0.017) |
| 7 Economies | -1 | 0.957 | -1 | 1.074 |
| | | (0.020) | | (0.045) |

### Panel C Error Correction Model

| | CPI | | | WPI | | |
|---|---|---|---|---|---|---|
| | Error corrction term | $R^2$ | adj. $R^2$ | Error corrction term | $R^2$ | adj. $R^2$ |
| Germany | -0.016 | 0.20 | 0.18 | -0.032 | 0.18 | 0.11 |
| | [-2.577] | | | [-3.153] | | |
| Japan | -0.005 | 0.16 | 0.12 | -0.011 | 0.09 | 0.05 |
| | [-0.854] | | | [-1.186] | | |
| UK | -0.016 | 0.25 | 0.19 | -0.019 | 0.10 | 0.08 |
| | [-2.500] | | | [-1.948] | | |
| US | -0.011 | 0.24 | 0.21 | -0.020 | 0.08 | 0.04 |
| | [-0.883] | | | [-0.985] | | |
| 7 Economies | -0.025 | 0.22 | 0.19 | -0.024 | 0.10 | 0.06 |
| | [-2.408] | | | [-1.856] | | |

Lags denote the augmented lag terms included. **=1% significance, *=5% significance, +=10% significance. We normalize all vectors on the domestic price ($p$) by setting its coefficient at *negative* one. Figures in parentheses and brackets are the standard errors and t-statistics, respectively.

Panel C reports the error correction model briefly. The $R^2$ and adjusted $R^2$ are not unsatisfactory for monthly data. If we had included other variables as well as the prices and exchange rates, the $R^2$ and adjusted $R^2$ would have been higher. The error correction term (speed of adjustment term) has a negative sign with a highly significant t-statistic in most cases, implying that changes in the exchange rate in Table 4 and changes in the domestic price in Table 5 adjust in an opposite direction to the previous period's deviation from equilibrium. For example, in the case of nominal effective exchange rate with respect to seven economies in Table 4 its coefficients are -0.196 (CPI) and -0.118 (WPI), implying that a given deviation from equilibrium would take about 3.3 and 5.5 months, respectively, to be reduced in half.

When we compare the results in Table 4 and those in Table 5, we find that the former is more acceptable than the latter, implying that to the Sri Lankan data the equation (1) is more suitable than the equation (2).

We try to test the relative PPP in addition to the absolute PPP although nominal exchange rates and relative prices are integrated of order one. Here we suffice to report one case of *NEER* and WPI as follows:[4]

$$\Delta NEER = \underset{(3.406)}{0.411}(\pi - \pi^*) + 0.037 \qquad (10)$$

$$R^2 = 0.897, \quad \text{adj } R^2 = 0.896, \quad D.W. = 2.035$$

where $\Delta NEER$ is the annual growth rate of *NEER*, $\pi$ is the WPI-based inflation rate of Sri Lanka and $\pi^*$ is the weighted average of WPI-based inflation rates of the seven foreign countries. However, in other cases the relative PPP does not hold this well; we understand the fact that the inflation rate in Sri Lanka has not been high over the sample period makes the relative PPP not to hold well.

Now we apply the unit root test for the real exchange rates to test the PPP formulation of equation (3). The autoregressive order of the unit root test are determined by minimizing the Akaike information criterion (AIC) and the results are given in Table 6. We report them over three sample periods, as we divide the whole sample into two sub-samples and show their results, too. We note that over the whole sample period the real exchange rates are stationary in all cases and that over two sub-sample periods the real exchange rates are also stationary in most cases.

In particular, the real effective exchange rates with respect to seven economies are stationary over all sample periods. According to Figure 5 the real effective exchange rates fell—that is, the rupee appreciated—for a while in early 1980s and returned to the previous level later.

The results in Table 6 are generally consistent with the results in Tables 4

[4] The number in the parenthesis is t-statistic.

**[TABLE 6]** Unit Root Tests for Real Exchange Rates and Real Effective Exchange Rate

| | CPI-based real exchange rates | | WPI-based real exchange rates | |
|---|---|---|---|---|
| | ADF | P-P | ADF | P-P |
| Whole sample period 1977.11-1996.12 | | | | |
| Germany | -3.74(2)** | -3.65(4)** | -2.98(2)* | -3.07(4)* |
| Japan | -3.14(2)* | -3.18(4)* | -3.37(2)* | -3.50(4)** |
| UK | -5.35(2)** | -5.36(4)** | -4.23(2)** | -4.32(4)** |
| US | -9.77(3)** | -9.89(4)** | -7.51(5)** | -7.84(4)** |
| 7 Economies | -6.69(3)** | -3.95(4)** | -5.03(2)** | -5.29(4)** |
| Sub-sample period 1977.11-1986.12 | | | | |
| Germany | -2.94(2)* | -2.96(4)* | -2.25(2) | -2.62(6)+ |
| Japan | -3.91(2)** | -4.23(4)** | -3.09(2)* | -3.39(4)* |
| UK | -4.79(2)** | -4.96(4)** | -3.50(2)** | -3.65(4)** |
| US | -9.00(2)** | -8.79(4)** | -6.13(2)** | -6.51(4)** |
| 7 Economies | -7.94(2)** | -8.14(4)** | -4.37(2)** | -4.74(4)** |
| Sub-sample period 1987.1-1996.12 | | | | |
| Germany | -4.09(2)** | -3.31(4)* | -3.77(1)** | -3.69(4)** |
| Japan | -2.45(1) | -2.12(4) | -2.13(1) | -2.24(4) |
| UK | -2.91(2)* | -2.63(2)+ | -3.92(3)** | -3.99(4)** |
| US | -0.84(3) | -0.35(4) | -1.21(2) | -1.60(4) |
| 7 Economies | -3.08(1)* | -2.66(2)+ | -3.01(1)* | -3.19(4)* |

The number of lags is shown in parentheses. **=1% significance, *=5% significance, +=10% significance.

and 5, *supporting* the PPP hypothesis.

While Bahmani-Oskooee (1995) reported that the real effective exchange rate of Sri Lanka over the period 1971-1990 was non-stationary, we have different results for a different period of more flexible exchange rate regime.

Our study sharply contrasts with, for example, recent studies on Turkey and several other Asian LDCs. Telatar and Kazdagli (1998) note that PPP does not hold in Turkey in 1980-1993 which "experiences high inflation and structural changes coupled with high growth rates simultaneously." Choo (1999) examines several Asian LDCs such as Bangladesh, Fiji, India, Indonesia, Malaysia, Pakistan, the Philippines, Thailand, and West Samoa over the period 1977-1996 and concludes that the real exchange rates have not been stationary. Like Sri Lanka most of these countries share many structural features with most low-income commodity-exporting LDCs: they have faced a high unemployment rate, a long-run secular decline in terms of trade, current account deficits; the GDP share of the primary sector declined and that of the manufacturing sector increased; and the growth rate has been rather high. Thus we note that Sri Lanka renders quite a rare PPP-supporting example.

## V. CONCLUSIONS

This paper re-examines the PPP hypothesis for a typical small open LDC, employing recently developed non-stationarity and cointegration tests. Using both CPI and WPI, using bilateral exchange rates vis-a-vis four industrial countries, and examining nominal and real effective exchange rates as well, we find that monthly data over the period 1977:11-1996:12 are generally supportive of the hypothesis in almost all cases in Sri Lanka.

Is the fact that the PPP hypothesis has held in Sri Lanka a good news? On one hand it is a good news to the PPP theory itself. On the other hand it is a bad news to the policy makers in Sri Lanka. They have intended that the nominal depreciation of the Sri Lankan rupee since the introduction of more flexible exchange rate regime in 1977 would bring about the real depreciation of their currency, which would further result in the improvement of the international competitiveness of Sri Lankan export. The economy faced a real appreciation awhile in early 1980s and late in 1990s. Of course, the PPP is a long-run phenomenon, the exchange rate policy is a medium and short-run one, and the long-run PPP and short-run real appreciation are not contradictory to each other. In view of the fact that the PPP has not held well and real depreciation or appreciation has occurred in several other Asian LDCs, the Sri Lankan experience is an interesting, unique one.

## REFERENCES

Abuaf, N., and P. Jorian (1990), "Purchasing Power Parity in the Long Run," *The Journal of Finance*, 45(1), 157-174.

Athukorala, P., and S. Jayasuriya (1994), *Macroeconomic Policies, Crises, and Growth in Sri Lanka, 1969-90*, The World Bank, Washington, D.C.

Bahmani-Oskooee, M. (1995), "Real and Nominal Effective Exchange Rates for 22 LDCs: 1971:1-1990:4," *Applied Economics*, 27, 591-604.

Bahmani-Oskooee, M., and H.J. Lee (1992), "Testing for Long Run Purchasing Power Parity: An Examination of Korean Won," *International Economic Journal*, 6(3), 93-103.

Balassa, B. (1964), "The Purchasing Power Parity Doctrine: A Reappraisal," *The Journal of Political Economy*, 72(4), 584-596.

Cheung, Y.W., and K.S. Lai (1993a), "Long-Run Purchasing Power Parity during the Recent Float," *Journal of International Economics*, 34(1/2), 181-192.

_____ (1993b), "A Fractional Cointegration Analysis of Purchasing Power Parity," *Journal of Business and Economic Statistics*, 11(1), 103-112.

_____ (1998), "Parity Reversion in Real Exchange Rates during the Post-Bretton Woods Period," *Journal of International Money and Finance*, 17(4), 597-614.

Choo, H.G. (1999), "Purchasing Power Parity, Real Exchange Rate, and World Oil Price in Ten Asian Less Developed Countries," *Papers Presented at the Annual Meeting of Korean Economic Association*, Seoul.

Conejo, C., and M.P. Shields (1993), "Relative PPP and the Long-Run Terms of Trade for Five Latin American Countries: A Cointegration Approach," *Applied Economics*, 25(12), 1511-1515.

Corbae, D., and S. Ouliaris (1988), "Cointegration and Tests of Purchasing Power Parity," *The Review of Economics and Statistics*, 70(3), 508-511.

Davutyan, N., and J. Pippenger (1985), "Purchasing Power Parity did not Collapse during the 1970s," *American Economic Review*, 75(4), 1151-1158.

Dickey, D.A., and W.A. Fuller (1979), "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association*, 74(366), 427-431.

_____ (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root," *Econometrica*, 49(4), 1057-1072.

Edison, H.J., and E.O. Fisher (1991), "A Long-Run View of the European Monetary System," *Journal of International Money and Finance*, 11(1), 53-70.

Edison, H.J., J.E. Gagnon, and W.R. Melick (1997), "Understanding the Empirical Literature on Purchasing Power Parity: The Post-Bretton Woods Era," *Journal of International Money and Finance*, 16(1), 1-17.

Engle, R.F., and C.W.J. Granger (1987), "Cointegration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, 55(2), 251-276.

Frenkel, J.A. (1978), "Purchasing Power Parity: Doctrinal Perspective and Evidence from the 1920s," *Journal of International Economics*, 8(1), 169-191.

_____ (1981), "The Collapse of Purchasing Power Parity during the 1970s," *European Economic Review*, 16(1), 145-165.

Frenkel, J.A., and A.K. Rose (1996), "A Panel Project on Purchasing Power Parity: Mean Reversion Within and Between Countries," *Journal of International Economics*, 40(1/2), 143-194.

Glen, J.D. (1992), "Real Exchange Rates in the Short, Medium, and Long Run," *Journal of International Economics*, 33(1/2), 147-166.

Grilli, V., and G. Kaminsky (1991), "Nominal Exchange Rate Regimes and the Real Exchange Rate," *Journal of Monetary Economics*, 27, 191-212.

Hsieh, D.A. (1982), "The Determination of the Real Exchange Rate," *Journal of International Economics*, 12(3/4), 355-362.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, 12(2/3), 231-254.

Johansen, S., and K. Juselius (1990), "Maximum Likelihood Estimation and Inference on Cointegration: With Applications to the Demand for Money," *Oxford Bulletin of Economics and Statistics*, 52(2), 169-210.

Kahn, B., and A. Parikh (1998), "Does Purchasing Power Parity Survive Political Shocks in South Africa?" *Weltwirtschaftliches Archiv*, 134(1), 99-116.

Karfakis, C., and D. Moschos (1989), "Testing for Long Run Purchasing Power Parity: A Time Series Analysis for the Greek Drachmas," *Economics Letters*, 30(3), 245-248.

Kim, Y. (1990), "Purchasing Power Parity in the Long Run: A Cointegration Approach," *Journal of Money, Credit, and Banking*, 22(4), 491-503.

Lal, D. (1985), "The Real Exchange Rate, Capital Inflows and Inflation: Sri Lanka 1970-1982," *Weltwirtschaftliches Archiv*, 121(4), 682-702.

Liu, P.C. (1992), "Purchasing Power Parity in Latin America: A Co-Integration Analysis," *Weltwirtschaftliches Archiv*, 128(4), 662-680.

Mahdavi, S., and S. Zhou (1994), "Purchasing Power Parity in High-Inflation Countries: Further Evidence," *Journal of Macroeconomics*, 16(3), 403-422.

Masih, R., and A.M.M. Masih (1995), "A Fractional Cointegration Approach to Empirical Tests of PPP: New Evidence and Methodological Implications from an Application to the Taiwan/US Dollar Relationship," *Weltwirtschaftliches Archiv*, 131(4), 673-694.

McNown, R., and M.S. Wallace (1989), "National Price Levels, Purchasing Power Parity, and Cointegration: A Test of Four High-Inflation Economies," *Journal of International Money and Finance*, 8(4), 533-545.

Meier, C.P. (1997), "Assessing Convergence to Purchasing Power Parity: A Panel Study for Ten OECD Countries," *Weltwirtschaftliches Archiv*, 133(2), 297-312.

Oh, K.Y. (1996), "Purchasing Power Parity and Unit Root Tests Using Panel Data," *Journal of International Money and Finance*, 15(3), 405-418.

Phillips, P.C.B., and P. Perron (1988), "Testing for a Unit Root in Time Series Regression," *Biometrica*, 75(2), 335-346.

Taylor, M.P. (1988), "An Empirical Analysis of Long-Run Purchasing Power

Parity Using Cointegration Techniques," *Applied Economics*, 20(10), 1369-1381.
Taylor, M.P., and P.C. McMahon (1988), "Long-run Purchasing Power Parity in the 1920s," *European Economic Review*, 32(1), 179-197.
Telatar, E., and H. Kazdagli (1998), "Re-examine the Long-Run Purchasing Power Parity Hypothesis for a High Inflation Country: The Case of Turkey 1980-93," *Applied Economics Letter*, 5(1), 51-53.
White, H., and G. Wignaraja (1992), "Exchange Rates, Trade Liberalization and Aid: The Sri Lankan Experience," *World Development*, 20(10), 1471-1480.