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Investigating Indo-Pak Exchange Rate–Price Level Linkages Using Johansen Cointegration Technique

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Abstract

We examined the long-run relationship between the Rupee/Pakistani Rupee exchange rate (e_t) and relative price levels (p_t) of India and Pakistan using quarterly data for 1976:1–2008:3. The secondary datasets on exchange rates and wholesale/consumer price indices, sourced from various issues of the International Financial Statistics (IMF), form the empirical base. Both series were found to be non-stationary in levels and stationary at first differences, confirming their I(1) nature in each sub-periods. Johansen cointegration analysis was applied separately to the periods 1976:1–1998:3 and 1998:4–2008:3. For the first sub-period, no cointegration was detected, indicating the absence of a long-run equilibrium relation between exchange rate movements and relative price levels in the economy of Pakistan. This suggested that the Purchasing Power Parity (PPP) doctrine and the associated Law of One Price (LOOP) did not hold between India and Pakistan during that time. In contrast, for the second sub-period, one significant cointegrating vector was found, establishing a stable long-run relationship between e_t and p_t. The results imply that, from 1998:4 onwards, relative price differentials played a meaningful role in exchange rate determination, lending empirical support to PPP and LOOP in the India–Pakistan context during 1998:4–2008:3.

Keywords: Stationarity, Integrability Test, Correlogram Analysis, Johansen Cointegration Test.
JEL Classifications: F1, F3, F4, F310.

Introduction: Pakistan is a our neighbour of India and a member of the SAARC. Both the countries have been stressing upon expansion of bilateral trade recently. Inspite of political disturbances in Pakistan and military confrontations of these two countries several times, both the countries realize the importance of the given from expansion of trade between them.

Evolution of Exchange Rate System In Pakistan: Evolution of Pakistan's exchange rate policy began after its emergence as an independent country on August 14, 1947. Over a period of six decades, Pakistan moved from having a 'highly regulated exchange rate' policy to the 'market determined system'. During this period Pakistan's exchange rate system passed through different phases as stated below.

Phase I(1947-1970): PKR Pegged to the Pound- Starling: Pakistan's Currency, Rupee (PKR), was pegged to the pound starling. On July 22, 1970 a Fluctuating Tourist Rate was introduced based upon a 45% Export Bonus Voucher plus its salable premium.

Phase II (1971-1981): PKR Pegged to Dollar: The economic influence of the USA on Pakistan was getting more apparent. Again PKR, following the de-facto devaluation of the US Dollar, through its link to the Pound Starling, began to appreciate again the US Dollar. On September 17, 1971 Pakistan severed her currency's ties to the pound and pegged the PKR to the US. Dollar at the Official Rate of PKR 4.76 per Greenback.

Phase III (1982 - 1997): Basket Pegged System: Pakistan fell into a budget deficit in 1982 when the strengthening US. Dollar made remittances abroad through official channels slumped. The plunging black market rate indicated that the PKR pegged to the US. Dollar largely deviated from the underlying economic realities. Under these circumstances, the PKR was devalued when the currency was unstitched from its link to the US. Dollar and the Fixed official Rate was abolished. A Controlled Floating Effective Rate, initially at PKR 10.10/$, was established. It was linked to a Trade Weighted Basket of Currencies. India broadly moved to a market based exchange rate regime in 1993under liberalized management exchange rate system(LERMS) . For Pakistan adopted a managed flood system on 8th January, 1982. It moved to a fully market based exchange regime on 19th May,1999.

Phase IV (July 22, 1998 - May 18, 1999): Multiple Exchange Rate System: On July 22, 1998 the authorities, in order to alleviate the financial crisis in Pakistan, adopted a Multiple Exchange Rate System which comprised of an Official Rate, a Floating Interbank Rate (FIBR), and a Composite Exchange Rate. The Official Rate was pegged to US Dollar. The Composite Rate combined the Official and FIBR rates. Under this system, banks were allowed to quote their own exchange rates for currencies other than Dollar.

Phase V (May 19, 1999-July 19, 2000): Conventional Fixed Pegged System: With recovery of the economy from the crisis, three exchange rate were unified on May 19, 1999. The exchange rates of PKR had been de fact pegged to the US Dollar within a certain band. Thus, the exchange rate arrangement had been reclassified to the Conventional Fixed Pegged Arrangement from the Managed Float System.

Phase VI (July 20, 2000 – Present Day): Floating Rate System: The State Bank of Pakistan (SBP) removed the band of PKR 52.10- 52.30 to the Dollar. Since then Pakistan is maintaining the Floating Rate System. Under this exchange rate system, each bank quotes its own rate depending its short and long positions. Strong Competitions assured minimal variations in exchange rate among banks.

Under the prevailing Exchange Control Act, the State Bank of Pakistan (SBP) may authorize any person or institution to deal in foreign exchange. By virtue of this vested authority, SBP may determine the extent to which a bank would be authorized to deal in various currencies.

Review of Literature:

Cheung, Y.W., and K. S. Lai (1993) they explained the fractional cointegration to examine the long-run purchasing power parity (PPP) hypothesis, allowing deviations from equilibrium to follow a fractionally integrated process. Their analysis captured a broader range of mean-reversion behaviors compared to standard cointegration methods. Empirical results from data spanning 1914-1989 showed the PPP reversion was present in three of five countries, supporting PPP as a long-run phenomenon, though significant short-run deviations were observed. The findings highlighted the importance of fractional cointegration in evaluating long-run PPP.

Culver, S. E. & Papell, D. H. (1999) they examined the long-run Purchasing Power Parity (PPP) using procedures in which stationarity and cointegration are the null hypotheses. They suggested that we generally cannot reject stationarity of real exchange rates or cointegration among nominal exchange rates and price levels, supporting long-run PPP. In contrast, nominal exchange rates are non-stationary. A Monte Carlo analysis confirms the robustness of these findings.

Fisher, E.O. and J.Y. Park (1991) they examined the purchasing power parity using cointegration as the null hypothesis and finds support for a simple exchange-rate–price model for most currencies except the U.S. and Canadian dollars. Their analysis suggested that the monetary forces align major currencies with price

differentials, while error-correction dynamics stem from asset markets. Limited stationarity indicates evolving real economic factors affecting relative traded–non-traded goods prices.

Objective of the Study: The objective of the present study is to investigate into the nature of Rupee/Pakistani Rupee exchange rate variations over the period 1976:1-2008:3 and to examine if these exchange rates were in conformity with the 'Purchasing Power Parity Doctrine' at all. More specifically, the objective of the study is to examine.

i. the 'stationarity' and integrability' of Rupee/Pakistani Rupee exchange rate and relative price level time series over the period of study.
ii. if any long-run relationship between these variables did exist.
iii. if the long-run relations, in the event of its existence, were 'stable'.

We examined the existence of long-run relationship between exchange rate and relative price level in two different sub-periods. This involved the study of 'cointegration' for the confirmation of RPPP in any of the sub-period identified. Their existence of long-run relationship between exchange rate and relative price level in the second sub-period 1998:4 - 2008:3 has confirmed.

Our study of cointegration between exchange rate (e_t) and relative price level (p_t) in two different sub-periods viz 1976:1-1998:3 and 1999:4-2008:3. These two sub-periods were identified on the basis of the fact that the econometric relationship between e_t and p_t would be strikingly different from each other. Consequently, the nature of the cointegration between these two variables is expected to be different in two different sub-periods. The 'Johansen Cointegration Tests' are being adopted for this purpose.

Data & Methodology: Our study is based on secondary dataset. In our study datasets of Rupee/Pakistani Rupee exchange rate and relative price level in India and Pakistan have been used. We have used historical datasets on exchange rate and WPIs of both the currencies in our study. The base period is 2000 (2000=100). The dataset is quarterly by nature. These datasets have been collected from the different issues of International Financial Statistics (IFS), published by the International Monetary Fund (IMF). The period covers 1976:1 to 2008:3. Specified variables are e_t and p_t where

e_t = Rupee/Pakistani Rupee exchange Rate
p_t = Relative Price Level

Johansen Cointegration Test: Both the Johansen (1988) and the Stock and Watson(1988) methodologies rely heavily on the relationship between the rank of the matrix and the characteristic roots.

The Johansen cointegration test equation is presented below

$$\Delta y_t = \gamma + \pi y_{t-1} + \sum_{i=1}^{\rho-1} \pi_i \Delta y_{t-i} + \mu_t$$

where, γ is the vector of constants, y_t is the m dimensional vector of variables, (i.e., e_t, p_t in our analysis), ρ is the number of lags, μ_t is the error vector, which is multivariate normal and independent across observations.

$$\pi = -(1 - \sum_{i=1}^{\rho} A_i) \text{ and } \pi = -\sum_{j=i+1}^{\rho} A_i$$

Here, the rank of the matrix π is equal to the number of independent cointegrating vectors. Specifically,

If $\pi = 0$, the matrix is null and is the usual VAR model in first differences.

If π is of rank n, the vector process is stationary.

If $\pi = 1$, there is a single cointegrating vector.

If $1 < \pi < n$, there are multiple cointegrating vector.

Let the matrix be π and ordered the n characteristics roots be λ_1, λ_2, ……λ_k such that $\lambda_1 > \lambda_2 >$……λ_n. If the variables in y_t are not cointegrated, the rank of π is zero and all of these characteristic roots will be zero. Since Log (1) = 0 each of the expressions Log(1- λ_i) will equal to zero if the variables are

not cointegrated. Similarly, if the rank of π is unity, $0 < \lambda_1 < 1$, so the expression $Log(1- \lambda_1)$ will be negative and the other $\lambda_i = 0$, so that $Log(1- \lambda_2) = \log (1- \lambda_3) = \ldots\ldots = Log (1- \lambda_n) = 0$.

Here the number of distinct cointegrating vectors can be determined by checking the significance of the characteristic roots of π. The test for the number of characteristic roots that are significantly different from the unity can be obtained by using the following two test statistics:

i. the Trace Statistic,
ii. the Max-Eigen Statistic.

The Trace Statistic can be calculated in terms of the following expression:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} Log(1-\hat{\lambda}_i)$$

On the other hand, the Max-Eigen Statistic can be calculated as

$$\lambda_{trace}(r, r+1) = -TLog(1-\hat{\lambda}_{r+1})$$

where, $\hat{\lambda}_i$ = the estimated values of the characteristic roots (i.e., Eigen values) obtained from the estimated π matrix, T= the number of unstable observations.

The 'Trace Statistic' is used to test the null hypothesis that the number of distinct cointegrating vector is less than or equal to 'r' against the general alternative. The 'Max-Eigen Statistic' test the null hypothesis that the number of cointegrating vector is 'r' against the alternative of (r+1) cointegrating vectors. The critical values of the λ_{trace} and the λ_{max} statistic are calculated using the Monte Carlo approach.

SECTION -I

1.1 Time Plots of the Series: We explained graphically the time plots of the exchange rate (e_t) and relative price level (p_t) series are being presented through the Figures 1.1 - 1.2 for the period 1976:1-2008:3.

Figure: 1.1
Time Plot of Rupee/Pakistan Rupee Exchange rate (e_t)
Series [Period: 1976:1-2008:3]

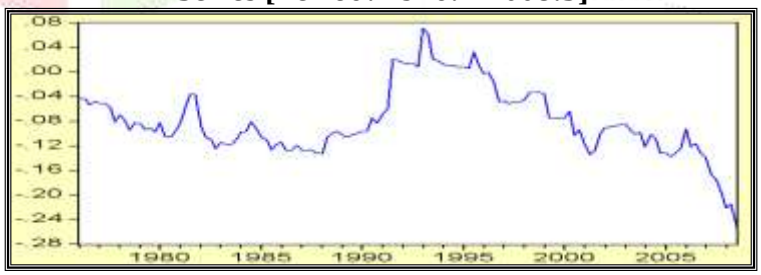


Figure: 1.2
Time Plot of Relative Price level (p_t)
[Period: 1976:1-2008:3]

1.2 Trend Analysis:

1.2.1 Nature of the Time Plot of Rupee/Pakistani Rupee Exchange Rate (e_t)

We observed from the time plot of e_t as given by the Figure 1.1 that

i. e_t declines steadily (i.e Indian currency appreciated against the Pakistani currency) between 1976 and 1978. However, e_t, with a minimal rise in 1979, declined until 1981.
ii. e_t displayed a rise between 1982 and 1984 with a tendency to reach a level higher than that in 1976. However, e_t fell in 1983 and almost maintained that level until 1985.
iii. in 1986 there was a very sharp fall in e_t (i.e Rupee appreciated strikingly against the Pakistani Rupee in 1986).
iv. since 1987 e_t displayed a rising trend with fluctuations until 1993. These fluctuations are not regular.
v. in 1993 exchange rate (e_t) rises and since then it displayed a tendency to maintain the 1993 level until 2002.
vi. in 2003 e_t fell and maintained that level with some minor fluctuations.

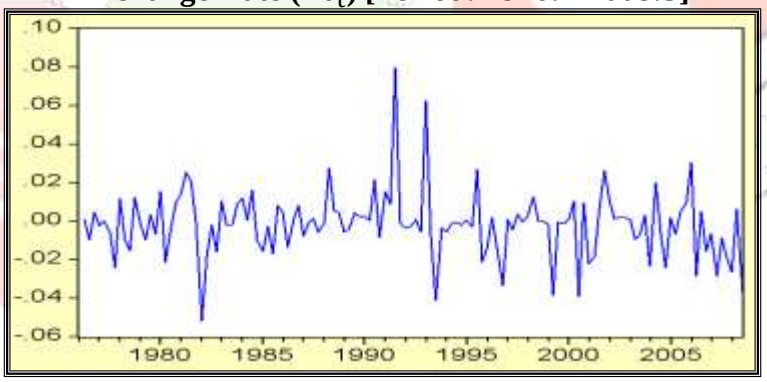
1.3 Nature of the Time Plot of the Relative Price Level (p_t)

The time plot of p_t as given in the Figure 1.2, represents some downward movements with fluctuation of higher amplitude between 1976 to 1985. However, between 1985-1986, it exhibited a sharp decline. Since then, there is a visible declining trend with minor fluctuations between 1986-2008. All these observations seem to testify for a possible 'non-stationary' nature of the series concerned.

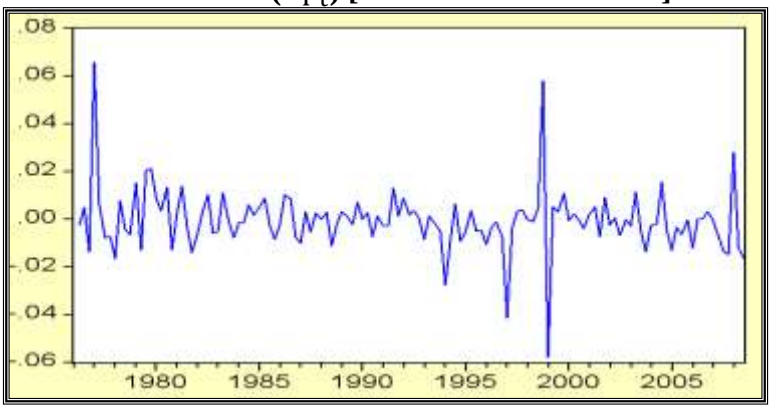
1.4 Integrability of e_t and p_t Series:

Time Plots of first differenced series of exchange rate (Δe_t) and relative price level (Δp_t) are shown in Figures 1.3 and 1.4.

Figures 1.3
Time Plot of First Differenced Series of Exchange Rate (Δe_t) [Period: 1976:1-2008:3]



Figures 1.4
Time Plot of First Differenced Series of Relative Price Level (Δp_t) [Period: 1976:1-2008:3]



1.4.1 Time Plots of First Differenced Series for e_t and p_t indicate that

I. the unconditional means of Δe_t and Δp_t are zero and, therefore, the values of Δe_t andΔp_t sequences fluctuate around zero. This means of the series are invariant with time. This is a pointer to the stationarity of the Δe_t and Δp_tseries.

II. Δe_t series exhibit fluctuations around zero mean with high amplitudes until 1998.

III. Since 1999 fluctuations occur with minor amplitudes. This indicates that the stochastic processes for Δe_t between 1976:1 and 1998 differ significantly from that which followed after 1999.

IV. These observations again hint at the possibility that the stochastic processes behind Δe_t in 1976-1998 and 1999-2008 were different by nature.

V. Δp_tseries exhibits fluctuations with high amplitudes in 1976-1998. Amplitudes of fluctuations declined a little between 1999-2008. Since 1999 the fluctuations were almost uniform.

SECTION - II

2.1 Test of Stationary of e_t and p_t through Correlogram Study:

The nature of stationarity and integrability of e_t and p_t has further been enquired into through the study of their respective correlograms. The figures 2.1 and 2.2 present correlograms of e_t at level and at first difference respectively. Again figures 2.3 and 2.4 present the correlograms of the p_t series at level and at first difference respectively.

Figure 2.1
Correlogram of Exchange Rate at Level [Period: 1976:1-2008:3]

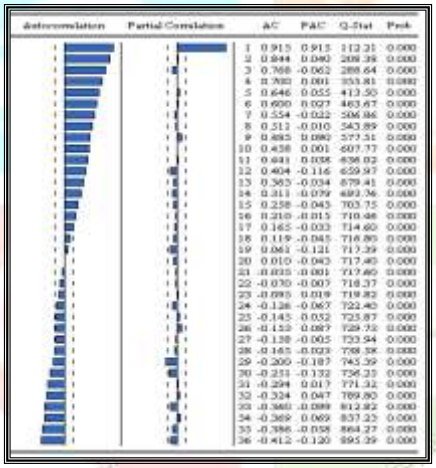


Figure: 2.2
Correlogram of Exchange Rate at 1st difference (Δe_t)[Period: 1976:1-2008:3]

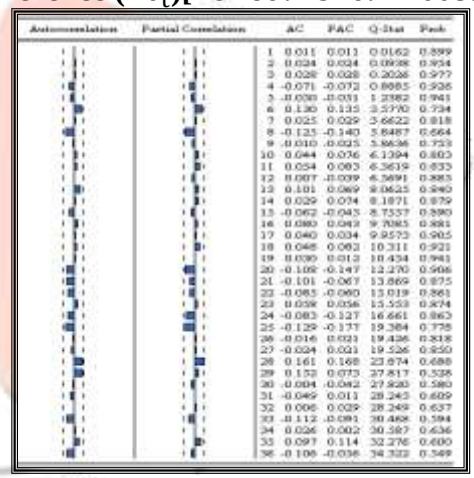


Figure 2.3
Correlogram of Relative Price Level (p_t) at Level [Period: 1976:1-2008:3]

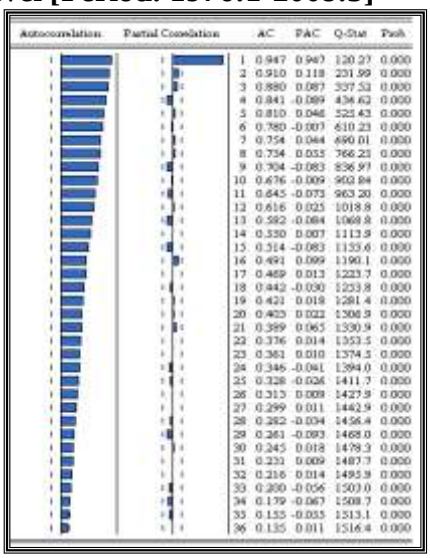
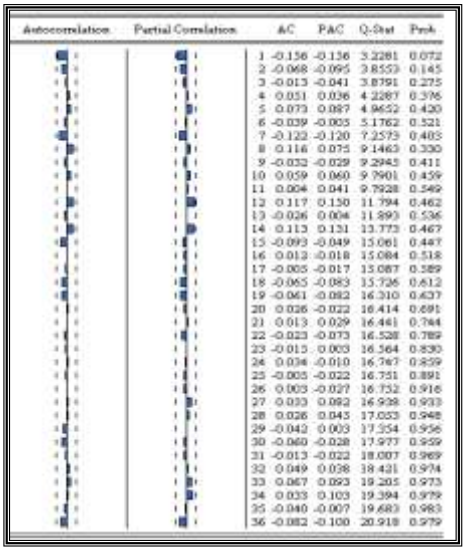


Figure 2.4
Correlogram of Relative Price Level at 1st difference (Δp_t) [Period: 1976:1-2008:3]



2.1.1 Findings from the figures 2.1 and 2.2

(A) It is observed from the correlogram of e_t given by the figure 2.1 that

i. the ACF of e_t displays a long ladder-like dying out pattern of solid spikes as the lag length increases. Corresponding Q-stat. are found to be significant even at 1% level.
ii. the PACF contains only one significant spike (even at 1% level) at lag one and all other lags contain very insignificant spikes.

All these features of the correlogram confirm the non-stationarity of the e_t series at level.

(B) The integrability of e_t series is being enquired into through the examination of the correlogram of e_t series at first difference as given by the figure 2.2. It is observed from the figure 2.2 that for the first differenced filtered series of e_t.

i. the ACF is marked by the absence of any dying out pattern of spikes.
ii. no singularly significant large spike appears at the first lag of the corresponding PACF.

These features of the correlogram, as given in the Figure 2.2, confirm that the first differenced series of e_t is stationary. Consequently, e_t series is I (1).

2.2 Findings from the figures 2.3 and 2.4

(A) It is observed form the Figure 2.3, which presents the correlogram of p_t at level, that

i. the ACF exhibits a long dying out pattern of solid spikes over the extending lags.
ii. the PACF is marked by the presence of a singular significant spike at lag one with insignificant spikes at all other lags.

These features of the Figure 2.3 confirm the 'non-stationarity' of the series p_t at level. The integrability of the series p_t is being examined through the study of the correlogram of the first differenced series of p_t as given by the Figure 2.4.

(B) It is observed from the correlogram of the first differenced series for p_t as given by the Figure 2.4 that

i. the ACF of the series p_t is free from any dying out pattern of spikes, and
ii. the PACF of the series is marked by the absence of any singularly significant spike at lag one.

These features of the correlograms of p_t confirm that

i. the first differenced series for p_t (i.e, Δp_t) is stationary, and therefore,
ii. p_t attains stationarity upon first differencing. Consequently, p_t is also I(1).

SECTION - III

3.1 The Johansen Cointegration Tests for the sub-periods 1976:1-1998:3

Results of the Johansen Cointegration Tests for e_t and p_t at level over the sub-period 1976:1-1998:3 are being presented through the Table 3.1 below.

Table 3.1
Results of the Johansen Cointegration Tests for e_t and p_t at level sub-period: 1976:1-1998:3
Trend Assumption: Linear Deterministic Trend (Restricted)
Lag Interval in first difference:

I Unrestricted Cointegration Rank λ_{trace} Test Variables Involved: e_t and p_t at level					
Null Hypothesis	Alternative Hypothesis	Eigen Value	Trace Statistic (λ_{trace})	Critical Values 5%	1%
r=0	r>0	0.145	18.135	25.32	30.45
r≤1	r>1	0.048	4.296	12.25	16.26

II Unrestricted Cointegration Rank λ_{max} Test Variables Involved: e_t and p_t at level					
Null Hypothesis	Alternative Hypothesis	Eigen Value	Maximum Eigen Statistic (λ_{max})	Critical Values 5%	1%
r=0	r=0	0.145	13.839	18.96	23.65
r=1	r=2	0.048	4.296	12.25	16.26

3.1.1 Finding from the table -3.1

Results of the Johansen Cointegration Test, as given in the Table 3.1, show that in the sub-period 1976:1-1998:3

i. for the null hypothesis r=0 against the alternative hypothesis r>0, $\lambda_{trace}(0)$ = 18.135 is lower than the corresponding 5% and 1% critical values. It is not, therefore, possible to reject the null hypothesis of 'no cointegration' between e_t and p_t at level even at 5% level of significance.

ii. for the null hypothesis r≤1 against alternative hypothesis r>1, the value of $\lambda_{trace}(1)$ statistic is 4.296 which is lower than 1% and even 5% levels of significance. So the null hypothesis of r≤1 cannot be rejected even at 5% level.

iii. for the null hypothesis r=0 against alternative hypothesis r=1, under λ_{max} test, $\lambda_{max}(0,1)$ value is 13.839. It is clearly lower than the corresponding 1% and 5% critical values. It implies that the null hypothesis of 'no cointegration' between e_t and p_t cannot be rejected even at even 5% level.

iv. for the null hypothesis r=1 against the alternative hypothesis r=2, under λ_{max} test, $\lambda_{max}(1,2)$ = 4.296 falls short of the corresponding critical values at 5% and 1% levels. Consequently, the null hypothesis of 'no cointergation' between e_t and p_t appears to be accepted at even 5% level.

3.1.2 Overview of the findings from the Johansen Cointegration Tests:

It is observed from the findings of the Johansen Cointegration Test results in the sub-period 1976:1-1998:3.

i. there does not exist any cointegration between exchange rate (e_t) and relative price level(p_t) at level even at 5% level of significance.

ii. e_t and p_t are, therefore, not CI(1,0).

3.2 The Johansen Cointegration Tests for the second sub-period 1998:4-2008:3:

The Johansen Cointegration Test results for the level data of exchange rate (e_t) and relative price level (p_t) over the Sub-Period 1998:4-2008:3 have been presented through the Table 3.2 below.

Table 3.2
Results of the Johansen Cointegration Tests
for e_t and p_t at level sub-period: 1998:4-2008:3
Trend Assumption: Linear Deterministic Trend (Restricted)
Lag Interval in first difference:

I Unrestricted Cointegration Rank λ_{trace} Test Variables Involved: e_t and p_t at level					
Null Hypothesis	Alternative Hypothesis	Eigen Value	Trace Stat. (λ_{trace})	Critical Values 5%	1%
r=0	r>0	26.947	26.947	25.32	30.45
r≤1	r>1	2.739	2.739	12.25	16.26

II Unrestricted Cointegration Rank λmax Test Variables Involved: e_t and p_t at level					
Null Hypothesis	Alternative Hypothesis	Eigen Value	Maximum Eigen Stat. (λ_{max})	Critical Values 5%	1%
r=0	r=1	24.207	24.208	18.96	23.65
r=1	r=2	2.739	2.739	12.25	16.26

3.2.1 Findings from the table -3.2

It is observed from the table -3.2 that over the sub-period 1998:4-2008:3 in case of the Johansen Cointegration Tests

i. for r=0 against r>1, λ_{trace} (0) = 26.947 exceeds the corresponding critical value at 5% level. This implies that the null hypothesis of the 'absence of cointegration' (r=0) between e_t and p_t at level has been rejected at 5% level.
ii. for r≤1 against r>1, λ_{trace}(1) = 2.739 falls short of the corresponding critical value even at 5% level. This implies that the 'null hypothesis of not more than 'one cointegrating relation' is accepted even at 5% level.
iii. for r=0 against r=1, λ_{max} (0,1) = 24.908 exceed the corresponding critical value at 5% level of significance. Therefore, the null hypothesis of non-existence of cointegration between the variables (e_t and p_t) is not accepted at 1% level.
iv. for r=1 against r=2, λ_{max} (1,2) = 2.739 falls short of the corresponding critical value even at 5% level. Consequently, the null hypothesis of the existence of only one cointegrating relation appears to be accepted even at 5% level.

3.2.2 Overview of the findings from the Johansen Cointegration Test for the second sub-period 1998:4 – 2008:3

It is observed for the second sub-period 1998:4-2008:3

i. there exists cointegration between e_t and p_t at level.
ii. e_t and p_t are CI (1,0).
iii. there exists one and only one cointegrating relation between e_t and p_t at level.

SECTION - IV

4.1 Economic implications and findings of cointegration study for the first sub-period: Absence of cointegration between exchange rate(e_t) and relative price level(p_t) at level in the first sub-period 1976:1-1998:3 implies that there did exist no long-run relationship between exchange rate quoted for the currencies of the countries concerned and the relative price levels prevailing in different quarters of the sub-period. It further implies that the exchange rates between the currencies were not linked to their relative purchasing power. Thus purchasing power of currencies, as revealed by the relative price levels prevailing in the two countries, did not matter at all in the determination of the rate of exchange for the currencies. Thus the 'Law of One Price' (LOOP) as dictated by the 'Purchasing Power Parity Doctrine' was not established by the quoted exchange rates between the currencies concerned over the sub-period 1976:1-1998:3.

4.2 Economic implications and findings of cointegration study for second sub-period:

The existence of cointegration between e_t and p_t at level implies that there did exist a long run relationship between exchange rate of currencies concerned with the relative price levels prevailing over the sub-period 1998:4 – 2008:3. This further implies that exchange rates for the currencies were in parity with the relative purchasing power of the currencies concerned. Moreover, existence of one cointegrating relation between the currencies establishes that exchange rates were uniquely related to their relative purchasing power.
It, therefore, follows that exchange rates in this sub-period 1998:4-2008:3 were so determined as to establish the 'Law of One Price' (LOOP) in the realm of trade between the countries concerned.

SECTION - V

5.1 Summary of Findings:

The study is devoted to examining the cointegration between exchange rate (e_t) and relative price level (p_t) at level over two sub-periods, namely, 1976:1–1998:3 and 1998:4 – 2008:3. It has been confirmed that

(i) e_t and p_t were I(1) variables in both the sub-periods.

(ii) there did exist no cointegration i.e. long-run equilibrium relation between exchange rate and relative price level in the sub-period 1976:1–1998:3. Consequently, exchange rates quoted for the currencies over the sub-period 1976:1-1998:3 were not at all related to the relative purchasing power of currencies concerned. So the doctrine of purchasing power parity did not hold good and the determination of exchange rates for the currencies failed to establish the 'Law of One Price' (LOOP) in international trade between India and Pakistan in the sub-period 1976:1-1998:3.

(iii) there did exist 'cointegration' i.e. long-run equilibrium relation between exchange rate and relative price level in the sub-period 1998:4-2008:3. This implies that the purchasing power of currencies significantly determined the exchange rates quoted for the currencies over this sub-period. Thus exchange rates in this period were so determined as to establish the 'Law of One Price' (LOOP) in international trade in the long-run. Consequently, the 'Purchasing Power Parity Doctrine' seemed to hold good in the determination of exchange rates between Rupee and Pakistani Rupee in the sub-period 1998:4- 2008:3.

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