CHAPTER - 4

STATIONARITY AND INTEGRABILITY OF TIME SERIES OF EXCHANGE RATE (e_t) AND RELATIVE PRICE LEVEL(p_t)

4.1 Introduction:

Econometric analysis of time series data involves the use of data from the past to quantify historical relationship. If the future is akin to the past, then these historical relationships can be used to forecast the future. If the future differs fundamentally from the past, then these historical relationships might not be reliable guides to the future.

In the context of time series regression analysis, the concept of *stationarity* is used is to examine if such historical relationships can be generalized to the future. A time series Y_t is *stationary* if its probability distribution does not change over time. More formally, Y_t is *stationary* if the joint probability distribution of $(Y_{s+1}, Y_{s+2},\ldots\ldots\ldots\ldots\ldots\ldots,Y_{s+T})$ does not depend on s. Otherwise Y_t is said to be *nonstationary*.

In the event of the time series being non-stationary, future is not like the past. Thus the historical relationship obtained from the past does not remain valid in future. In such case, as Nelson and Ploser (1982) hold, regression analysis becomes '*spurious*'. It, therefore, becomes pertinent to enquire into the nature of the stochastic process of the macroeconomic time series like exchange rate (e_t) and relative price level (p_t) in our study and examine if these series at level were '*stationary*' or if these define some *random walk* non-stationary stochastic processes.

If these series display *random walk* processes, then it would require appropriate filtering through differencing in order to generate stationary series. However, the *order of differencing* or *integration* for the two series involved may not be identical. Thus

objective of our study this Chapter is also to enquire into the *integrability* of the series involved. *Stationarity and integrability* of the series will be examined through

i. the time plots of the series and the corresponding trend analysis, and
ii. appropriate stationarity tests like the ADF and Phillips-Perron Tests.
iii. Correlogram study.

4.2 Time plots of the series

Time plots of the exchange rate (e_t) and relative price level (p_t) series are being presented through the Figures 4.1-4.2 for the period 1976:1-2006:1.

Figure: 4.1

Time Plot of Rupee/Nepalese Rupee Exchange rate (e_t)

[Period: 1976:1-2006:1]

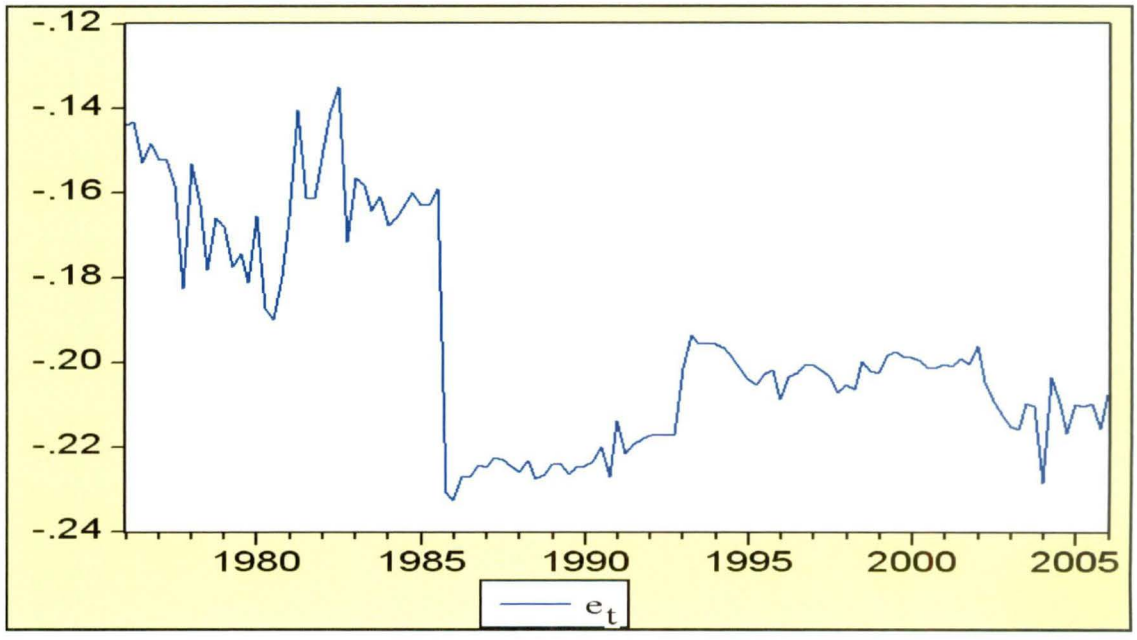
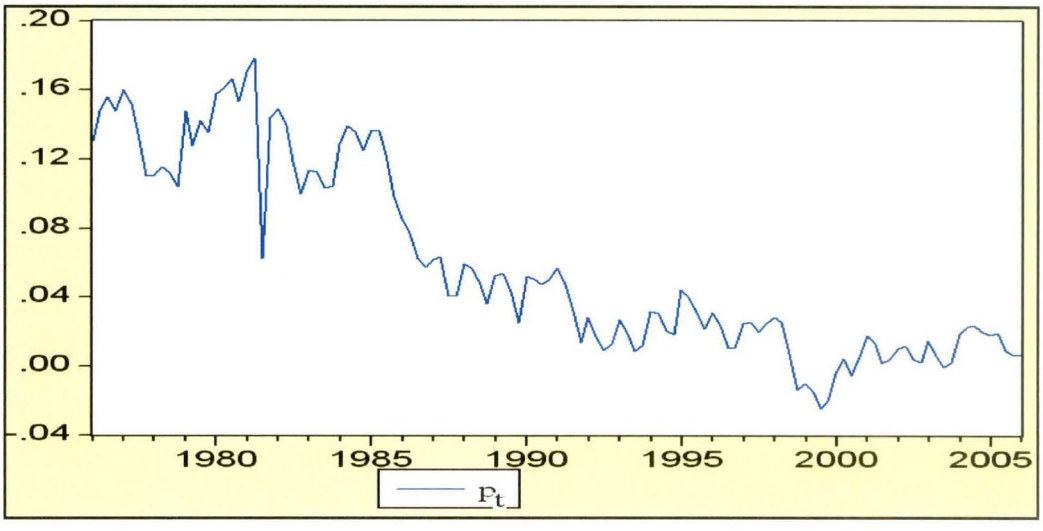


Figure: 4.2

Time Plot of Relative Price level (p_t)

[Period: 1976:1-2006:1]



4.3 Trend Analysis:

4.3.1 Nature of the Time Plot of Rupee/Nepalese Rupee Exchange Rate (e_t)

It is observed from the time plot of e_t as given by the Figure 4.1 that

i. e_t declines steadily (i.e Indian currency appreciated against the Nepalese 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 Nepalese 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.

The peculiar feature of fluctuations in e_t observed here relates to the exchange rate practices followed in these two countries concerned during 1970s, especially in India. Both the countries practiced fixed exchange rate management. Since 1975 monetary authorities in both the countries followed multi-currency pegging system in lieu of a link with any single currency. The monetary authorities in both the countries kept on severing, from time to time, its rates for the purchase and sale of major currencies for spot delivery since 1985. Till 1990, in every quarter exchange rate varied though these variations were little.

As both the countries, especially India, were stepping away from fixed exchange rate system, Rupee/Nepalese Rupee exchange rate tended to get related to relative price level. In the very first opportunity in 1986, the exchange rate underwent spectacular depreciation (i.e. Rupee appreciated) in order to be in parity with the relative price level. This is marked by a sharp fall in exchange rate. However, such appreciation of Rupee (Indian currency) is marked by '*overshooting*' since the appreciation of Rupee is followed by a spell of depreciations since 1987 to 1993:1.

Since 1993 India and Nepal steadily moved forward to the '*market determination*' system of exchange rate. By 1994 the exchange rate system become virtually flexible. During the period 1993-2002, exchange rate which was closely related to relative price level, exhibited some minor fluctuations around a stable level.

All these observations indicate that the economic systems and exchange rate practices varied strikingly over the period concerned. Thus the processes generating the exchange rate data did not remain '*stationary* over the period of study implying *non-stationarity* of the data set concerned.

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

The time plot of p_t as given in the Figure 4.2, 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 1986-2006. All these observations seem to testify for a possible '*non-stationary*' nature of the series concerned.

4.4 Test of Stationarity: Augmented Dickey-Fuller (ADF) Unit Root Test

Stationarity of exchange rate (e_t) and relative price level (p_t) series has been studied through the Augmented Dickey Fuller (ADF) tests. The basic ADF equation estimated with appropriate changes under different assumptions are

$$\Delta e_t = \alpha_1 + \beta_1 t + \gamma_1 e_{t-1} + \delta_{1t} \sum_{i=1}^{k} \Delta e_{t-1} + \varepsilon_{1t} \tag{4.1}$$

$$\Delta p_t = \alpha_2 + \beta_2 t + \gamma_2 p_{t-1} + \delta_{2t} \sum_{i=1}^{k} \Delta p_{t-1} + \varepsilon_{2t} \tag{4.2}$$

where $\Delta e_t = (e_t - e_{t-1})$ and $\Delta p_t = (p_t - p_{t-1})$ etc.

$\varepsilon_{1t} \sim iidN\ (0, \sigma^2_{\varepsilon_1})$ and $\varepsilon_{2t} \sim iidN\ (0, \sigma^2_{\varepsilon_2})$

The optimal lag (k) may be determined through *Akaike Information Criterion, Schwartz Information Criterion, Haunan-Quinn Information criterion* etc.

4.5 Results of the ADF Tests

Results of ADF Unit Root Tests on e_t and p_t series concerned are being presented through the Table 4.1 below.

Table 4.1

Results of ADF Tests on Exchange Rate (e_t) and Relative Price Level (p_t)

[Period: 1976:1-2006:1]

Variable	Null Hypothesis	Lag Length*	ADF Test Stat.	Prob.	Mac-Kinnon Critical Value**		
					1%	5%	10%
e_t	e_t has unit root Exogenous: Constant	0	-2.759	0.067	-3.486	-2.886	-2.580
	e_t has unit root Exogenous: Constant, Linear Trend	0	-3.042	0.125	-4.037	-3.448	-3.149
	e_t has unit root Exogenous: None	0	0.188	0.739	-2.584	-1.943	-1.615
p_t	p_t has unit root Exogenous: Constant	2	-1.467	0.547	-3.486	-2.886	-2.580
	p_t has unit root Exogenous: Constant, Linear Trend	2	-2.207	0.481	-4.038	-3.448	-3.149
	p_t has unit root Exogenous: None	2	-1.947	0.050	-2.585	-1.943	-1.615

**MacKinnon (1996) one-sided p-values. * based on SIC, Max Lag = 12

4.6 Finding from the ADF Tests(Table 4.1)

It is observed from the ADF Unit Root Test results as presented through the Table 4.1 that

i. the hypothesis of '*unit roots*' in e_t and p_t cannot be rejected even at 10% level in the presence of '*intercept*' term and '*time* ' variable in the maintained regression equation.
ii. the hypothesis of '*unit root*' in e_t and p_t is accepted in the presence of '*intercept*' term alone without '*linear trend*' and even in the absence of any '*intercept*' term and '*linear trend*' in the maintained regression equations.

All these observations indicate that

i. e_t and p_t series contain '*unit roots*' and, therefore, these series are '*non-stationary*' by nature.
ii. e_t and p_t series do not entail any '*deterministic trends*', and on the contrary,
iii. e_t and p_t series contain '*non-stationary*' stochastic trends.

The ADF tests do not confirm whether the observed '*non-stationarity*' of e_t and p_t series is the '*inherent*' nature of the series concerned or if it is due to any *structural shift* in the process. We, therefore, seek to examine if the observed '*non-stationarity*' of the series concerned is due to '*structural shift*'. *Phillips-Perron Unit Root Tests*' are being performed for this purpose.

4.7 Results of Phillips –Perron Unit Root Tests

Results of Phillips-Perron Unit Root tests are being presented through the Table 4.2

Table 4.2

Results of Phillips –Perron Unit Root Tests on Exchange Rate (e_t) and Relative Price Level (p_t) at Level

[Period: 1976:1-2006:1]

Variable	Null Hypothesis	Lag Length	Phillips-Perron Test Stat.	Prob*.	Mac-Kinnon Critical Value**		
					1%	5%	10%
e_t	e_t has unit root Exogenous: Constant	3	-2.511	0.115	-3.486	-2.886	-2.580
	e_t has unit root Exogenous: Constant,Linear Trend	1	-2.843	0.185	-4.037	-3.448	-3.149
	e_t has unit root Exogenous: None	10	0.502	0.822	-2.584	-1.943	-1.615
p_t	p_t has unit root Exogenous: Constant	6	-1.442	0.559	-3.486	-2.886	-2.580
	p_t has unit root Exogenous: Constant,Linear Trend	7	-3.990	0.011	-4.038	-3.448	-3.149
	p_t has unit root Exogenous: None	5	-1.622	0.099	-2.585	-1.943	-1.615

*Mackinnon(1996) One-sided P-values **Newey-West using Bartlett kernel

4.8 Finding From the Phillips-Perron Test (Table 4.2)

The Table 4.2 shows that

i. the null-hypothesis of '*unit roots with exogenous constant*' in the maintained regression equations for the series e_t and p_t cannot be rejected even at 10% level.

ii. the null-hypothesis of '*unit roots with exogenous constant and linear trend*' in the maintained regression equation is rejected at 5% for p_t series but accepted for e_t series at 5% level.

iii. the null-hypothesis of '*unit roots with 'no intercept term and linear trend'* in the maintained regression equation has also been rejected for p_t even at 10% level but accepted for e_t at 10% level.

These observations indicate that

i. e_t is non-stationary at level,

ii. 'non-stationarity' of p_t series depends on the nature of the maintained regression equation.

a. p_t is '*stationary*' when maintained regression equation is taken with or without intercept along with a linear trend.

b. again p_t is found to be '*non-stationary*' when the maintained regression equation contains only the intercept term.

These observations hint at the existence of *non-stationarity* in p_t because of the presence of '*structural shift*' in it. This seems to confirm our earlier observation on the nature of the time plot of p_t in Section 4.3.2.

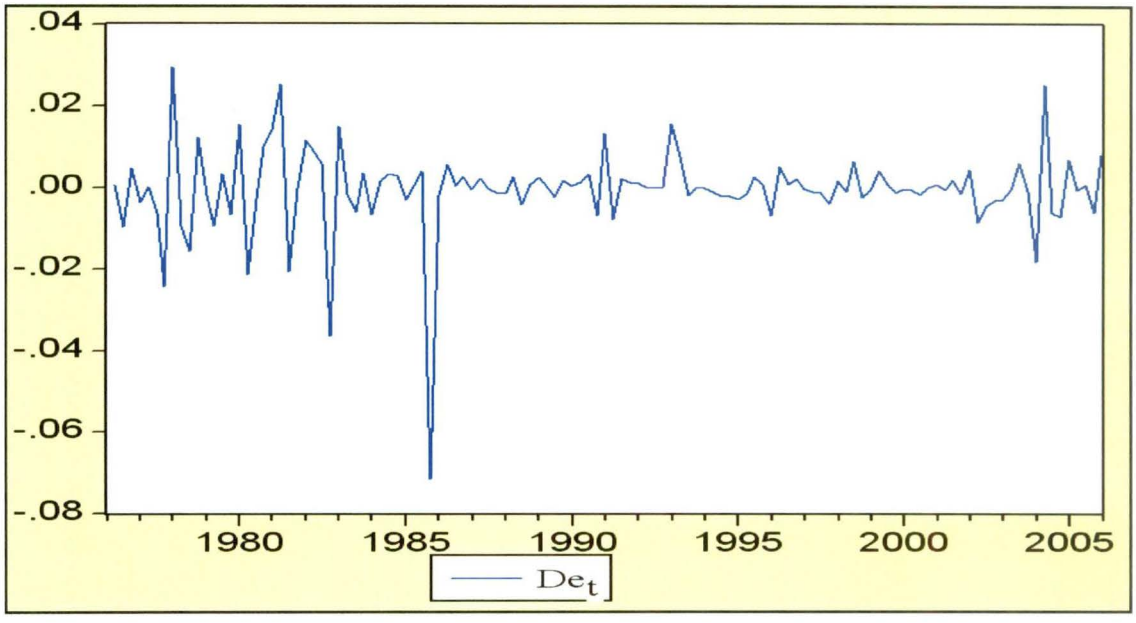
4.9 Integrability of e_t and p_t Series: Time Plots of First Differenced Series:

Time Plots of first differenced series of exchange rate (e_t) and relative price level (p_t) are shown in Figures 4.3-4.4.

Figures 4.3

Time Plot of First Differenced Series of Rupee/Nepalese Rupee Exchange Rate (e_t)

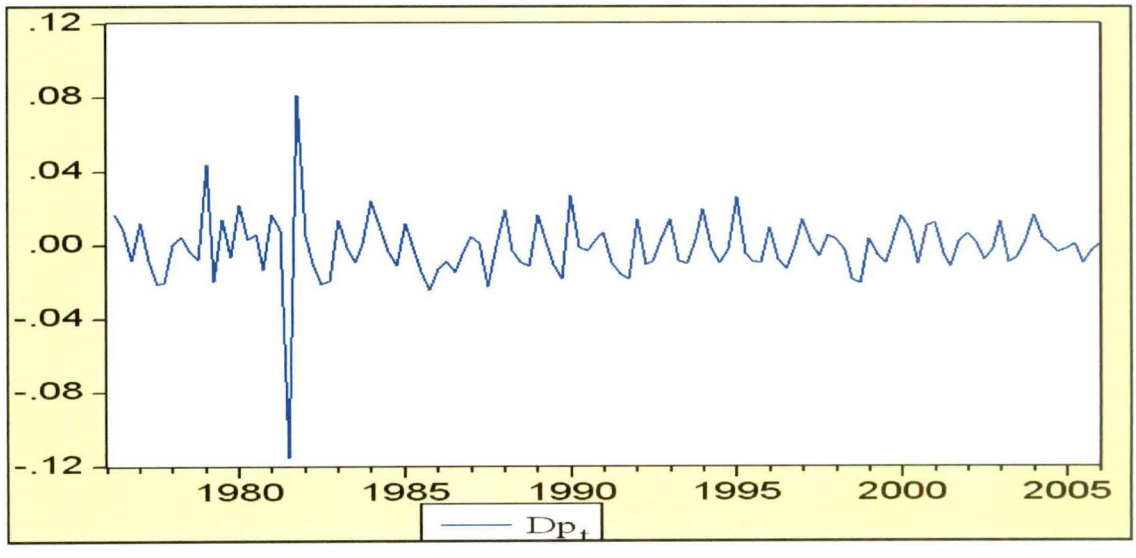
[Period: 1976:1-2006:1]



Figures 4.4

Time Plot of First Differenced Series of Relative Price Level (p_t)

[Period: 1976:1-2006:1]



Time plots of first differenced series for e_t and p_t indicate that

i. the unconditional means of De_t and Dp_t are zero and, therefore, the values of De_t and Dp_t sequences fluctuate around zero. This means of the series are invariant with time. This is a pointer to the *stationarity* of the De_t and Dp_t series.

ii. De_t series exhibit fluctuations around zero mean with high amplitudes until 1986. Since 1987 fluctuations occur with minor amplitudes. This indicates that the stochastic processes for De_t between 1976:1 and 1986:4 differ significantly from that which followed after 1986.

iii. De_t again exhibited high amplitude fluctuations between 1990 and 1992. Nature of fluctuation between 1993 and 2006 differed significantly from those which occurred in 1990-1992.

These observations again hint at the possibility that the stochastic processes behind De_t in 1987-1992 and 1993-2006 were different by nature.

iv. Dp_t series exhibits fluctuations with high amplitudes in 1976-1982. Amplitudes of fluctuations declined a little between 1983-1992. Since 1993 the fluctuations were almost uniform.

These observations also hint at the possibility of structural breaks in p_t series and the stationarity of Dp_t series.

4.10 Integrability of e_t and p_t Series ADF and PP Tests

Stationarity of first differenced series of exchange rate (De_t) and relative price level (Dp_t) has been studied with the Augmented Dickey–Fuller (ADF) test. The basic ADF Test equations are

$$De_t = \alpha_3 + \gamma_3 e_{t-1} + \delta_{3i} \sum_{i=1}^{k} \Delta e_{t-1} + \varepsilon_{3t} \qquad (4.4)$$

$$Dp_t = \alpha_4 + \gamma_4 p_{t-1} + \delta_{4i} \sum_{i=1}^{k} \Delta p_{t-1} + \varepsilon_{4t} \qquad (4.5)$$

where $De_t = \Delta e_t = (e_t - e_{t-1})$ and $Dp_t = \Delta p_t = (p_t - p_{t-1})$ etc.

$\varepsilon_{3t} \sim iidN\ (0, \sigma^2_{\varepsilon_3})$ and $\varepsilon_{4t} \sim iidN\ (0, \sigma^2_{\varepsilon_4})$

These basic equations have been estimated with some maintained alternative assumptions like

i. $\alpha_3 \neq 0,\ \alpha_4 \neq 0,\ \gamma_3 = 0,\ \gamma_4 = 0,$

ii. $\alpha_3 \neq 0,\ \alpha_4 \neq 0,\ \gamma_3 \neq 0,\ \gamma_4 \neq 0,$

iii. $\alpha_3 = 0,\ \alpha_4 = 0,\ \gamma_3 = 0,\ \gamma_4 = 0,$

Results of such ADF tests are being presented through the Table 4.3.

Table:- 4.3

Results of ADF Unit Root Tests on e_t and p_t at First Difference [1976:1-2006:1]

Variable	Null Hypothesis	Lag Length*	ADF Test Stat.	Prob.	Mac-Kinnon Critical Value**		
					1%	5%	10%
De_t	De_t has unit root Exogenous: Constant	0	-13.646	0.000	-3.486	-2.886	-2.580
	De_t has unit root Exogenous: Constant, Linear Trend	0	-13.637	0.000	-4.037	-3.448	-3.149
	De_t has unit root Exogenous: None	0	-13.657	0.000	-2.584	-1.943	-1.615
Dp_t	Dp_t has unit root Exogenous: Constant	1	-11.333	0.000	-3.486	-2.886	-2.580
	Dp_t has unit root Exogenous: Constant, Linear Trend	1	-11.317	0.000	-4.038	-3.448	-3.149
	Dp_t has unit root Exogenous: None	1	-11.230	0.000	-2.585	-1.943	-1.615

**Mac Kinnon (1996) One sided P-Values * Based on SIC, Max Lag = 12

(A) The Table 4.3 shows that

i. the hypothesis of *'unit roots'* for De_t series is rejected even at 1% level in the presence of an *'intercept term'* and a *'linear trend'* in the maintained regression equation.

ii. the hypothesis of *'unit roots'* for De_t series is rejected even at 1% level both in the presence and absence of an *'intercept term'* in the maintained regression equation.

iii. the hypothesis of *'unit root'* in Dp_t series is rejected even at 1% level when the estimated maintained regression equation contains an *'intercept term'* and *'linear trend'* term in it.

iv. the hypothesis of *unit root* for Dp_t is also rejected even at 1% level when the maintained regression equation is estimated with and without an *'intercept'* term given that no *'time'* variable appears in it.

All these observations indicate that

a) De_t and Dp_t are *stationary*. So both De_t and Dp_t are I(0) variables.

b) e_t and p_t are *'Differenced Stationary'* and these are not *'Trend Stationary'* series.

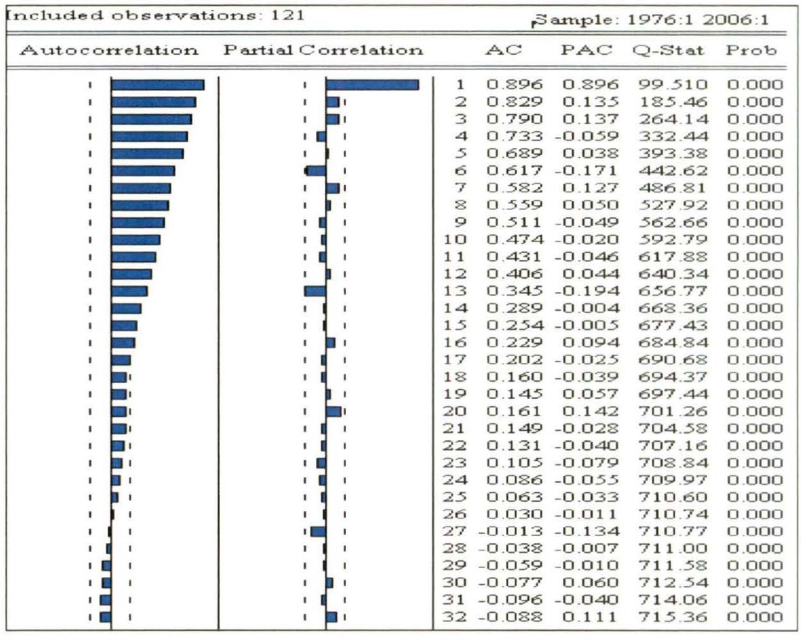
c) e_t and p_t are I(1) variables. Therefore, e_t and p_t represent *First Order Integrable Series,*

4.11 Test of Stationary 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 4.5 and 4.6 present correlograms of e_t at level and at first difference respectively. Again Figures 4.7 and 4.8 present the correlograms of the p_t series at level and at first difference respectively.

Figure 4.5

Correlogram of Rupee/ Nepalese Rupee (e_t) Series at Level [Period: 1976:1-2006:1]

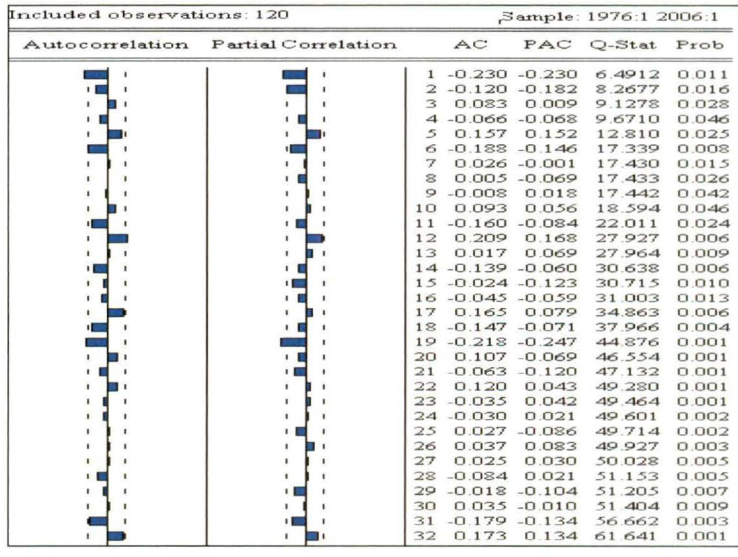


Included observations: 121 — Sample: 1976:1 2006:1

	Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
			1	0.896	0.896	99.510	0.000
			2	0.829	0.135	185.46	0.000
			3	0.790	0.137	264.14	0.000
			4	0.733	-0.059	332.44	0.000
			5	0.689	0.038	393.38	0.000
			6	0.617	-0.171	442.62	0.000
			7	0.582	0.127	486.81	0.000
			8	0.559	0.050	527.92	0.000
			9	0.511	-0.049	562.66	0.000
			10	0.474	-0.020	592.79	0.000
			11	0.431	-0.046	617.88	0.000
			12	0.406	0.044	640.34	0.000
			13	0.345	-0.194	656.77	0.000
			14	0.289	-0.004	668.36	0.000
			15	0.254	-0.005	677.43	0.000
			16	0.229	0.094	684.84	0.000
			17	0.202	-0.025	690.68	0.000
			18	0.160	-0.039	694.37	0.000
			19	0.145	0.057	697.44	0.000
			20	0.161	0.142	701.26	0.000
			21	0.149	-0.028	704.58	0.000
			22	0.131	-0.040	707.16	0.000
			23	0.105	-0.079	708.84	0.000
			24	0.086	-0.055	709.97	0.000
			25	0.063	-0.033	710.60	0.000
			26	0.030	-0.011	710.74	0.000
			27	-0.013	-0.134	710.77	0.000
			28	-0.038	-0.007	711.00	0.000
			29	-0.059	-0.010	711.58	0.000
			30	-0.077	0.060	712.54	0.000
			31	-0.096	-0.040	714.06	0.000
			32	-0.088	0.111	715.36	0.000

Figure 4.6

Correlogram of Rupee/ Nepalese Rupee (e_t) Series at First Difference [Period: 1976:1-2006:1]



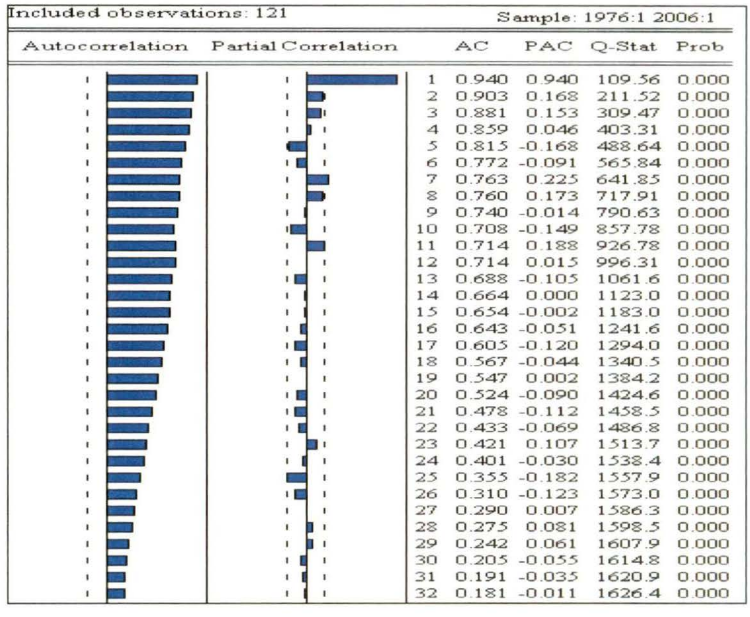
Included observations: 120 — Sample: 1976:1 2006:1

	Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
			1	-0.230	-0.230	6.4912	0.011
			2	-0.120	-0.182	8.2677	0.016
			3	0.083	0.009	9.1278	0.028
			4	-0.066	-0.068	9.6710	0.046
			5	0.157	0.152	12.810	0.025
			6	-0.188	-0.146	17.339	0.008
			7	0.026	-0.001	17.430	0.015
			8	0.005	-0.069	17.433	0.026
			9	-0.008	0.018	17.442	0.042
			10	0.093	0.056	18.594	0.046
			11	-0.160	-0.084	22.011	0.024
			12	0.209	0.168	27.927	0.006
			13	0.017	0.069	27.964	0.009
			14	-0.139	-0.060	30.638	0.006
			15	-0.024	-0.123	30.715	0.010
			16	-0.045	-0.059	31.003	0.013
			17	0.165	0.079	34.863	0.006
			18	-0.147	-0.071	37.966	0.004
			19	-0.218	-0.247	44.876	0.001
			20	0.107	-0.069	46.554	0.001
			21	-0.063	-0.120	47.132	0.001
			22	0.120	0.043	49.280	0.001
			23	-0.035	0.042	49.464	0.001
			24	-0.030	0.021	49.601	0.002
			25	0.027	-0.086	49.714	0.002
			26	0.037	0.083	49.927	0.003
			27	0.025	0.030	50.028	0.005
			28	-0.084	0.021	51.153	0.005
			29	-0.018	-0.104	51.205	0.007
			30	0.035	-0.010	51.404	0.009
			31	-0.179	-0.134	56.662	0.003
			32	0.173	0.134	61.641	0.001

Figure 4.7

Correlogram of Relative Price Level (p_t) at Level

[Period: 1976:1-2006:1]



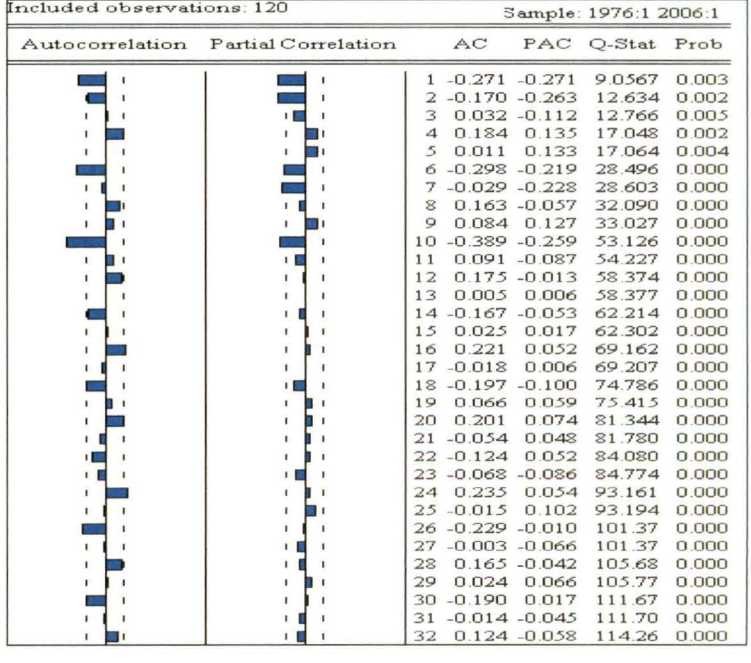
Included observations: 121 — Sample: 1976:1 2006:1

	Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1			0.940	0.940	109.56	0.000
2			0.903	0.168	211.52	0.000
3			0.881	0.153	309.47	0.000
4			0.859	0.046	403.31	0.000
5			0.815	-0.168	488.64	0.000
6			0.772	-0.091	565.84	0.000
7			0.763	0.225	641.85	0.000
8			0.760	0.173	717.91	0.000
9			0.740	-0.014	790.63	0.000
10			0.708	-0.149	857.78	0.000
11			0.714	0.188	926.78	0.000
12			0.714	0.015	996.31	0.000
13			0.688	-0.105	1061.6	0.000
14			0.664	0.000	1123.0	0.000
15			0.654	-0.002	1183.0	0.000
16			0.643	-0.051	1241.6	0.000
17			0.605	-0.120	1294.0	0.000
18			0.567	-0.044	1340.5	0.000
19			0.547	0.002	1384.2	0.000
20			0.524	-0.090	1424.6	0.000
21			0.478	-0.112	1458.5	0.000
22			0.433	-0.069	1486.8	0.000
23			0.421	0.107	1513.7	0.000
24			0.401	-0.030	1538.4	0.000
25			0.355	-0.182	1557.9	0.000
26			0.310	-0.123	1573.0	0.000
27			0.290	0.007	1586.3	0.000
28			0.275	0.081	1598.5	0.000
29			0.242	0.061	1607.9	0.000
30			0.205	-0.055	1614.8	0.000
31			0.191	-0.035	1620.9	0.000
32			0.181	-0.011	1626.4	0.000

Figure 4.8

Correlogram of Relative Price Level (p_t) at First Difference

[Period: 1976:1-2006:1]



Included observations: 120 — Sample: 1976:1 2006:1

	Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1			-0.271	-0.271	9.0567	0.003
2			-0.170	-0.263	12.634	0.002
3			0.032	-0.112	12.766	0.005
4			0.184	0.135	17.048	0.002
5			0.011	0.133	17.064	0.004
6			-0.298	-0.219	28.496	0.000
7			-0.029	-0.228	28.603	0.000
8			0.163	-0.057	32.090	0.000
9			0.084	0.127	33.027	0.000
10			-0.389	-0.259	53.126	0.000
11			0.091	-0.087	54.227	0.000
12			0.175	-0.013	58.374	0.000
13			0.005	0.006	58.377	0.000
14			-0.167	-0.053	62.214	0.000
15			0.025	0.017	62.302	0.000
16			0.221	0.052	69.162	0.000
17			-0.018	0.006	69.207	0.000
18			-0.197	-0.100	74.786	0.000
19			0.066	0.059	75.415	0.000
20			0.201	0.074	81.344	0.000
21			-0.054	0.048	81.780	0.000
22			-0.124	0.052	84.080	0.000
23			-0.068	-0.086	84.774	0.000
24			0.235	0.054	93.161	0.000
25			-0.015	0.102	93.194	0.000
26			-0.229	-0.010	101.37	0.000
27			-0.003	-0.066	101.37	0.000
28			0.165	-0.042	105.68	0.000
29			0.024	0.066	105.77	0.000
30			-0.190	0.017	111.67	0.000
31			-0.014	-0.045	111.70	0.000
32			0.124	-0.058	114.26	0.000

4.12 Findings From the Figures 4.5 and 4.6

(A) It is observed from the correlogram of p_t given by the Figure 4.5 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-statistics 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 4.6. It is observed from the Figure 4.6 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 4.6, confirm that the first differenced series of e_t is stationary. Consequently, e_t series is I (1).

4.13 Findings from the Figures 4.7 and 4.8

(A) It is observed form the Figure 4.7, 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 4.7 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 4.8.

(B) It is observed from the correlogram of the first differenced series for p_t as given by the Figure 4.8 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, Dp_t) is *stationary*, and therefore,
ii. p_t attains *stationarity* upon first differencing. Consequently, p_t is also I(1).

4.14 Review of the Findings:

The findings in our study through ADF and Phillips Perron Unit Root Tests and through the examinations of relevant correlograms of the variables confirm that over the period 1976:1-2006:1

i. both the Rupee/ Nepalese Rupee exchange rate (e_t) and the relative price level (p_t) series are non-stationary at level and these, therefore, exhibit random walk processes.
ii. both the series attain stationarity upon filtering through first differencing Consequently, both the series are integrated of order one i.e, $e_t \sim I(1)$ and $p_t \sim I(1)$.