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The Long run Impact of Investment on Output in the Presence of Cointegration in Bangladesh

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Abstract

The major objective of this paper is to examine the long run impact of investment on the output level in Bangladesh. After presenting a brief overview on the various growth models the paper tested the time series properties of the variables by applying the augmented Dickey Fuller test. Then to check the cointegration and causality between the considered variables Johansen and Juselius cointegration technique and Granger causality tests are applied to the annual date for the Bangladesh economy from 1973 to 2007. It has found that both the variables are nonstationary at their level but stationary at the first differences. The cointegration tests suggest that there is a stable long run relationship between investment and output in Bangladesh and the results from Granger causality suggest both way causality between investment and output. This result is also supported by the error correction model and is also showing that the impact on investment on output is not instantaneous i.e., current investment not only affect current output but also the future output as well, which is supported by both the endogenous and exogenous growth models.

Introduction

Economic growth is the central objective of our historical era. The analysis of growth dates back to the Adam Smith's the Wealth of Nations and the fortitude of apposite means of growth is still contentious. Over the course of time different school of thought and economists like Frank Ramsey (1928), Allyn Young (1928), Frank Knight (1944), Joseph Schumpeter (1934) and Harrod (1939) & Domar (1946) analyzed growth process of the capitalist economies in various lines, identifying different determinants of economic growth. They have raised and explained many of the fundamental ingredients that are prevalent in the modern theories of growth. In the 1950's and 1960's the neoclassical growth model of

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Solow-Swan variety became dominant in the thinking of the economists. In the 1970s and in the early 1980s, growth theories lose interest of the economists. Analysis of the short-term fluctuations of the economy becomes the prime area of attraction of the economists as experienced by many developed countries. However, due to the publication of Romer (1986) and Lucas (1988), growth theories back in fashion in the mainstream economics in the late 1990s. These growth theories are known as 'endogenous growth models'. There are distinctive feature of these growth models of neoclassical and endogenous variety, which differs from that of classical growth model as explained by Smith, Ricardo, Malthus and Marx, the main thinkers of the classical school. These models are based on micro foundations to analyze macroeconomic issues. They explain the basic approaches of competitive behavior and equilibrium dynamics, the role of diminishing returns and its relation to the accumulation of physical and human capital, the interplay between per capita income and the growth rate of population, the role of technology and technological change in the growth process, discovery of new techniques and the monopoly power as an incentive for technological progress (Barro and Matin: 2004).

Though there is a debate on the determining factors of the growth, it is widely recognized that the investment has positive impact on output growth. In the Keynesian framework increase in investment has additive effect on aggregate demand, which led to decrease in inventory and consequently increase in the output level (Froyen: 2002). The classical economists explained the economic growth into the class division between the labor and capitalist class. Labor as a class gets subsistence wage and consume all of their income and thus has no contribution to growth. Capitalist, who extract surplus value created by labor, save a fraction of their profit and invests a part in directly productive activities and the remaining part to discover new technologies for reaping more benefit. Hence in the Classical model investment positively affect technology which led to the upward shift of the aggregate production function and so the level of output (Duncan and Foley: 1999).

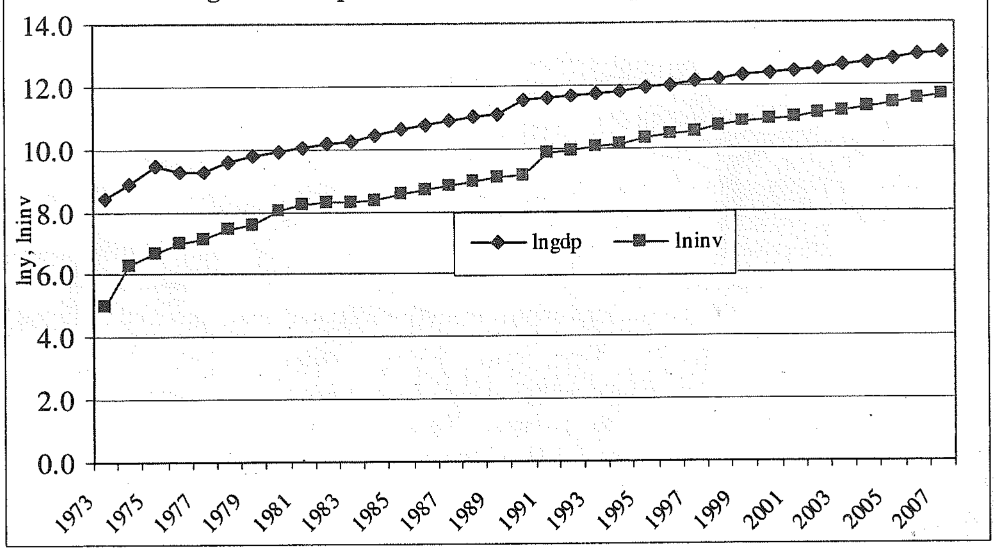
The Harrod (1939) and Domar (1946) models of growth has attracted a great deal of attention as they appear immediately after Great Depression. They were biased by Keynesian analysis in examining economic growth. The principal conclusion of their model was that the new investments representing net addition to the capital stock is the engine of economic growth. However, empirical evidence for Harrod and Domar was not strong enough, which led to the emergence of Solow (1956) and Swan (1956) model. The model was based on new classical production of Cobb Douglas variety and assumes diminishing returns to each input and constant returns to all inputs together. The empirical evidence found that growth of the output is exogenously determined and most part can be explained by Solow residual. That is accumulation of capital stock has only the level affect on output, thus is not denying explicitly the role of investment.

The lack of wide empirical evidence lead to the almost demise of the growth theories in the 1970s, when short run fluctuations of output due to mainly the oil shocks was the main area of concentration by the economists. However, after a span of around ten years in the 1980s the publications of Romer (1986) and Lucas (1988) give the new birth of the growth theory. The central attention of the periods onward is the long run economic growth of the countries. This area of research was built on the work of Arrow (1962), Sheshinski (1967) and Uzawa (1965) and ignored the diminishing returns to capital by using a broad class of capital goods using the concept of human capital along with the tangible capital goods. These models are based on micro foundations that individual investors invests a portion of their capital besides directly productive activities to research and development which thought to constitute social overhead capital and thus have positive impact on output.

Thus the above discussion provides an indication that investment which resulted from the accumulation of capital has causal impact on output growth. The causality may run other direction as well. The output growth led the country to invest a large portion of their income to save and so to invest on research and development.

Bangladesh, a resource scarce country is striving to achieve economic growth since its independence in 1971. In a war damaged economy most of the industrial base was the property of the central government. In the socialistic attitude in economic management on the period led the government to nationalize all heavy industrial states. The rebuilding and using these states and so new addition to the capital stock was the sole responsibility of the state. Therefore, historically public investment constitutes the lions share in the total investment, even though in the 1980s, on being advised by the World Bank and IMF Bangladesh has adopted economic liberalization as a strategy to rapid economic growth. Private investment in this period becomes substantial in the business and industrial sector. However, the crucial difference between the two is that private investment is more biased to directly productive activities as the private investors are driven by profit motivation. While the pubic investment is more on social overhead capital which have spill over effect to long run economic growth. The following figure gives some insights on the behavior of Bangladesh's investment and output over the long period of 1973 to 2007.

Figure 1 Output-Investment Relationship in Bangladesh



It is clear from the figure that although output and investment drift apart at times, there is a tendency that they are moving in the same way implying that they are cointegrated. However, this needs to be taken properly by using recent econometric development in the literature.

The major objective of this paper is to examine the long run relationship between output and investment in Bangladesh i.e. to see whether they are cointegrated or not. It also sheds lights on the causal relationship between the considered variables. To examine the dynamic linkages between output and investment the paper has taken into account of various modeling issues that arise in causality framework. The study considers the stationary properties of the data on output and investment by applying the Augmented Dicky Fuller test. Then the Johansen and Juselius test has been applied to examine the cointegration i.e. the long run relationships between the variables. Finally, the Error Correction models and Granger causality test has been applied to test the short run dynamics of long run relationships between output and investment.

The paper is divided into five sections. After introducing the issues in section 1, section 2 sets out the framework for testing stationarity, cointegration, error correction models and causality between the variables. Section 3 discusses the time series properties of the variables, reports and interprets the results. Finally, section 4 concludes the paper with policy implications.

Data and Methodology

Data[1]

This study is based on the annual data for the period 1973 to 2007 taken from the various issues of Bangladesh Economic Survey published by the Bangladesh Bureau of Statistics. The paper considers private and public investment to sum total investment and the gross domestic product (GDP) stands for the output in the economy.

The Analytical Framework

Granger Causality Test

The basic idea of the Granger Causality is that a variable X causes another variable Y if Y can be explained better by the present and lagged values of X than by the past values of Y alone assuming that both X and Y are stationary variables. This test relied on the assumption that information relevant to the prediction of the respective variables is contained solely in the time series data on these variables (Gujrati, 2003). In a two variables system the test is based on the following set of equations:

$$Y_t = \alpha + \sum_{i=1}^{m} \beta_i Y_{t-1} + \sum_{i=1}^{n} \varphi_i X_{t-1} + \varepsilon_t \text{ ....(1)}$$

[1] An exploratory analysis of data is presented in Appendix A.

$$X_t = \chi + \sum_{i=1}^{m} \phi_i X_{t-1} + \sum_{i=1}^{n} \mu_i Y_{t-1} + v_t \quad \text{..............(2)}$$

where, ε_t and v_t are white noise error term and assumed to be stationary, and m & n are the number of lags to be specified. Equation (1) postulates that current Y is related to past values of itself as well as that of X and equation (2) proposes a similar behaviour for X. Given the above specification the statistical significance of the coefficients implies the causal relationship between the variables. In addition, the framework can be generalized to include more variables in the system.

To apply the Granger causality test we need to estimate the unrestricted and restricted version of equations. Then we rely on the following statistic:

$$F = [(RSS_r - RSS_{ur})/m] / [RSS_{ur} / (n - k)]$$

Which follows F distribution with m and (n – k) df. Here m is equal to the number of lagged X terms included in the equation (1) and k is the number of parameters estimated in the unrestricted equation. X is said to Granger cause Y if the computed F statistics is significant at the conventional level. The same procedure can be applied to test causality from Y to X (Gujrati: 2003).

Cointegration Test and Error Correction Models

One of the important features of the most economic time series is inertia or sluggishness i.e. they have the tendency to move together. Therefore it is necessary to test for the possible cointegration of the variables. If two variables are cointegrated there is the possibility that there is causality between them in Granger sense as least in one direction (Miller, 1990). The causality or the short run relationship between the variables can be seen from the error correction specification.

The presence of cointegration between variables provides the basis for modeling both the short run and long run relationship simultaneously. If two variables Y_t and X_t are cointegrated, then according to Granger representation theorem (Engle and Granger, 1987) the relationship between them can be expressed as the error correction mechanism as follows:

$$\Delta Y_t = \lambda_1 Z_{t-1} + \sum_{i=1}^{k} \delta_i \Delta X_{t-i} + \sum_{j=1}^{k} \pi_j \Delta Y_{t-j} + u_{1t} \quad \text{........(3)}$$

$$\Delta X_t = \lambda_2 Z_{t-1} + \sum_{i=1}^{k} \tau_i \Delta X_{t-i} + \sum_{j=1}^{k} \zeta_j \Delta Y_{t-j} + u_{2t} \quad \text{........(4)}$$

where, $Z_t = Y_t - \gamma X_t$, and u_{1t} and u_{2t} are white noise error terms. In the above equations, the series Y_t and X_t are cointegrated when at least one of the coefficients λ_1 or λ_2 is not zero. This error correction model allows us to study the short run dynamics of the long run relationship between Y_t and X_t. If λ_1 ` " 0 and $\lambda_2 = 0$, then $X_t$ will lead $Y_t$ in the long run. The opposite will occur if $\lambda_2$ ` " 0 and $\lambda_1 = 0$. If both λ_1 ` " 0 and λ2 ` " 0, then feedback relationship exists between Y_t and X_t , which will adjust in the long run. In addition short run dynamics between Y_t and X_t are characterized by the coefficients δ_i's and ζ_j's. If δ_i's are not all zero, movements in the X_t will lead to Y_t in the short run. If $æ_j$'s are not all zero, movement in the Y_t will cause X_t in the short run (Woolridge: 2003).

Empirical Methodology

To apply the cointegration test and to estimate error correction models we first examine the time series properties of each variable by unit root tests. This is accomplished by applying augmented Dickey-Fuller (ADF) test, which is based on the following regression equation with a constant and a trend of the form:

$$\Delta Y_t = a_1 + a_2 t + bY_{t-1} + \sum_{i=1}^{m} \rho_i \Delta Y_{t-i} + \upsilon_t \quad ....(5)$$

where, "$Y_t = Y_t - Y_{t-1}$ and Y is the variable under consideration, m is the number of lags in the dependent variable, is chosen by Akaike information criterion and υ_t is the stochastic error term. The null hypothesis of a unit root implies that the coefficient of Y_{t-1} is zero. The rejection of null hypothesis implies the stationarity of the series and no differencing in the series is necessary to induce stationary. Otherwise differencing of the series is necessary to make them stationary.

In the second steps we searched for cointegration between variables. This can be done either by Engle-Granger two steps cointegration procedure or by Johansen-Juselius cointegration technique. We relied on Johansen-Juselius cointegration technique. This test involves checking two test statistics to identify the number of cointegrating vectors, namely the trace statistic and the maximum eigenvalue test statistic. The Trace test statistic for the null hypothesis that there are atmost *r* distinct cointegrating vectors is

$$\lambda_{trace} = T \sum_{i=r+1}^{N} \ln(1-\lambda_i) \quad ....(6)$$

where, λ_i's are the N-*r* smallest squared canonical correlations between X_{t-k} and ΔX_t (where X_t = $(GDP_t\ Investment_t)'$ and where all variables in X_t are assumed I(1)), corrected for the effects of the lagged differences of the X_t process.

The maximum eigenvalue statistic for testing the null hypothesis of at most *r* cointegrating vectors against the alternative hypothesis of $r + 1$ cointegrating vectors is given by

$$\lambda_{\max} = -T \ln(1-\lambda_{r+1}) \text{..............}(7)$$

Johansen (1988) shows that equations (6) and (7) have non-standard distributions under the null hypothesis and provide approximate critical values for the statistic, generated by Monte Carlo methods.

The third step is the estimation of error correction model as specified in equation (3) and (4). Finally, standard F test has been used to examine the causality and feed back relationship between the time series.

Discussion of the Results

Based on the above discussed methodology the investment and income series have been tested for the unit roots suggested by ADF test. The test is used to check whether the considered series are stationarity or not. Here we have applied the test to both the original series (in logarithmic form) and to the first differences. Further, both the models with and without trend are tested. The exact lag length which is crucial in time series analysis is determined by Akaike information criterion. The results are reported in table -1.

Table 1 Unit Root Tests (ADF) for the period 1976-2004

Without Trend		
Variables	**Series in Levels**	**First Differences**
LY	-2.53	-5.67***
LI	-3.92	-8.80***
With Trend		
Variables	**Series in Levels**	**First Differences**
LY	-3.50	-5.82**
LI	-7.69	-8.78**

Note: i) *** and ** indicates significance at 1% and 5% respectively.

ii) The optimal lag length has been considered to be 4 according to the Akaike information criterion.

The ADF test result indicates that both the GDP and investment series non-stationary at their levels both in inclusion of trend or non inclusion of trend in the model. However, taking first difference makes them stationary implying that the variables LY and LI are integrated of order one i.e. I(1). The integration of order one of the variables indicate that is necessary to apply cointegration tests to determine whether there exist a stable long run relationship among them in Bangladesh. We applied the Johansen and Juselius approach to establish the cointegrating vectors. The result is presented in the following table-2.

Table 2 Johansen and Juselius Test of Cointegration

Data Vector	Lag	Hypothesis	ë Trace	`ë Max
LY, LI	1	r<=0	18.48	17.42
		r<=1	1.06**	1.06**

Notes: i) we have experimented with a number of lags and found 4 to be the optimal lag length. The null hypothesis states that there doesn't exist at most *r* cointegrating relationship among the variables. ii) ** indicates significance at 5% level.

Table-2, presents the maximum eigen-value and trace tests of Johansen and Juselius (1990). These are complementary versions of the same test to determine the cointegration rank, *r*. Both the eigen value and trace statistic suggests that GDP and investment are cointegrated in Bangladesh implying that the considered variables maintain a stable long run relationship meaning that investment has long run impact on output in Bangladesh. However, in the short run they may drift apart i.e. they may in disequilibrium. To take care for this disequilibrium we need see the short run dynamics between the variables, which can be explored by error correction mechanism. The result is shown in table-3.

Table 3 Estimation of Error Correction Model

Independent Variable	Dependent Variable	
	D(LY)	D(LI)
Zt-1	0.204727	0.253187
	[3.47826]	[2.55549]
D(LY(-1))	-0.299867	0.316056
	[-2.51603]	[1.57543]
D(LY(-2))	-0.501121	-0.053572
	[-4.30434]	[-0.27337]
D(LI(-1))	0.15771	-0.030571
	[1.50455]	[-0.17326]
D(LI(-2))	-0.151318	-0.080081
	[-2.50040]	[-0.78613]
C	0.224607	0.143938
	[9.01783]	[3.43322]

Note: i) Figures in the parentheses represents t statistic.

Table 3 reveals that the coefficient of the error correction term is statistically significant in the two equations implying that the changes in investment causally affect output in the short run. It is also seen from the table that the coefficients in the lag terms are also positive and statistically significant. The implication is that investment has positive impact on output and the impact is not instantaneous. That is current may have positive impact on future output as well, which is very likely and is theoretically and empirically supported by both the endogenous and exogenous growth models. It is also interesting to see that there is both way causal relationship between investment and output. This result is also supported by the Granger causality test as shown in the following table-4.

Table 4 Direction of Causality (Granger Causality Test)

Null Hypothesis	Obs	F-Statistic	Probability
LI does not Granger Cause LY	33	3.04153***	0.00378
LY does not Granger Cause LI		8.33314**	0.00145

Note: *** and ** indicate significance at 1% and 5% respectively.

Conclusion and Policy Implications

The paper examines the dynamic linkage between investment and output in Bangladesh over a long period of time by applying standard techniques of time series analysis i.e. cointegration, error correction models and Granger causality tests. It is evident that both the data series are integrated of order one, i.e. they are non stationary at their levels and first difference makes them stationary. Then Johansen Juselius technique established that the considered variables are cointegrated, implying that there is a stable long run relationship between the two. However, to take care for the short run disequilibriating relationship we have estimated the error correction model, which shows that the impact of investment on output is not instantaneous. That is investment affect output even in the second lag (as we find a statistically significant coefficient). The error correction model also shows a bidirectional causality between the variables, which is also supported by the Granger causality test. The implication of the result is that investment needs to be increased to maintain sustained growth of output as explained by both the endogenous and exogenous growth models. However, one caveat needs to be mentioned that this study did not decompose the separate effects of public and private investment on output or not attempted to examine whether the public investment crowds out the private investment. These omitted issues may be addressed in the further research.

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Appendix A Exploratory Analysis of the Data

Since the estimation procedure will be in logarithmic functional form, the data analysis is for the log of variables. The line graphs of the variable are as follows:

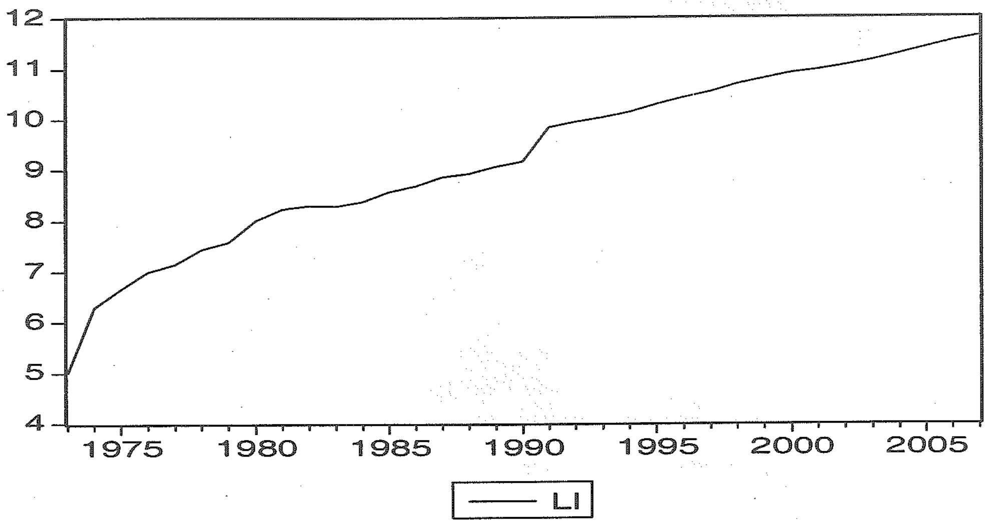
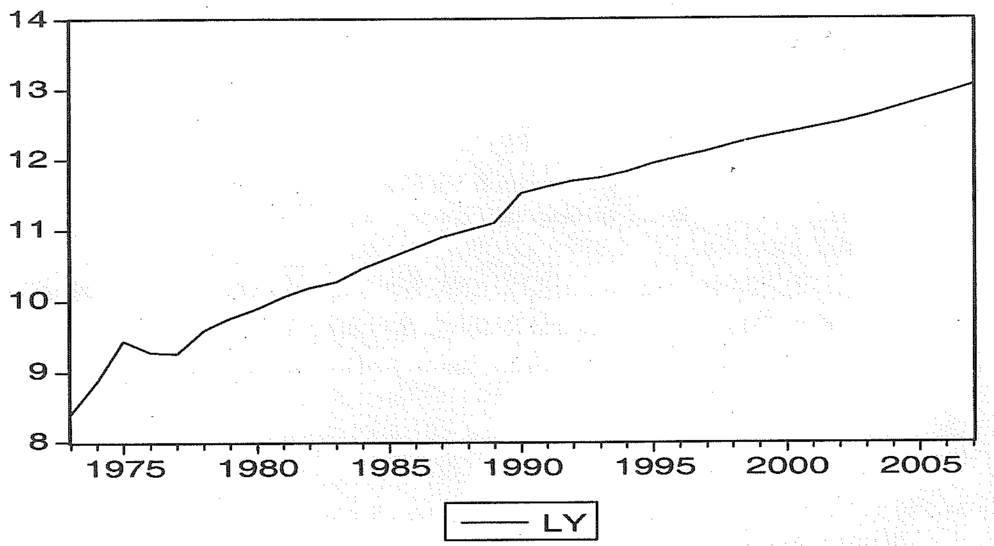
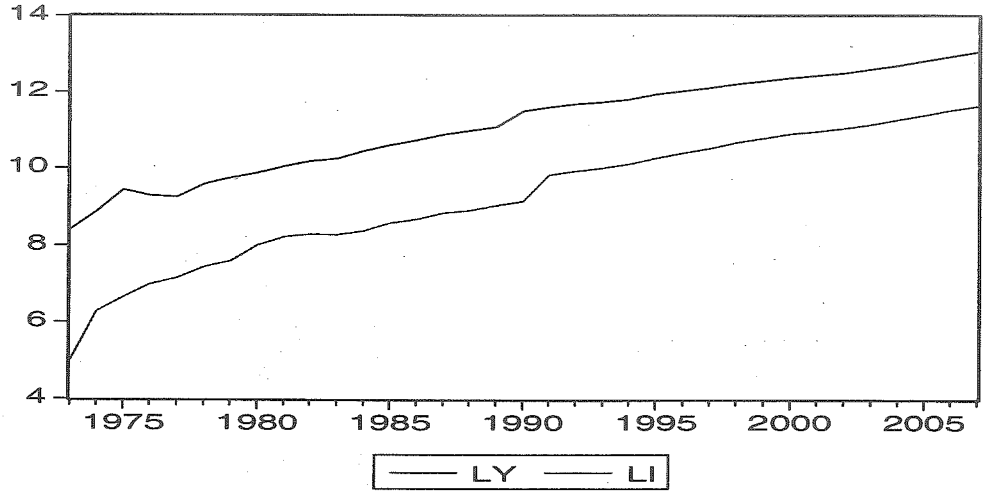


Figure-1



Figure–2



Figure–3

The visual plot of the data is usually the first step in the analysis of any time series. The first impression that we get from these graphs is that all the time series shown in figures 1 and 2 seems to be trending upward, albeit with fluctuations.

The descriptive statistics for the variables are as follows:

Table 1 Descriptive Statistics of the Variables

	LY	LI
Mean	11.15028	9.261363
Median	11.51621	9.153029
Maximum	13.05515	11.64158
Minimum	8.414274	5.010635
Std. Dev.	1.305558	1.700389
Skewness	-0.351059	-0.485594
Kurtosis	1.954576	2.441083
Jarque-Bera	2.312744	1.831074
Probability	0.314626	0.400302
Sum	390.2597	324.1477
Sum Sq. Dev.	57.95236	98.30495
Observations	35	35

From the above table it is clear that, the mean and median are fairly close to each other suggesting that these data are more or less normal. The values of the skewness are moderate and the values of the kurtosis are below three, suggesting that the variables have a flat distribution relative to normal. The Jarque-Bera test results suggest that we do not reject the null hypothesis of normal distribution for at 5% level of significance.

Appendix B Test of Stationarity (Autocorrelation Function (ACF) and Correlogram)

Before pursuing formal tests, we proceed with the graphical representation of the so called 'sample correlogram' based on autocorrelation function, that gives us an initial clue about stationarity.

Figure 4 Correlogram of LY, 1973 to 2007

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th>lag</th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |****** |</td><td>. |****** |</td><td>1</td><td>0.835</td><td>0.835</td><td>26.554</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>2</td><td>0.699</td><td>0.005</td><td>45.717</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>3</td><td>0.600</td><td>0.051</td><td>60.294</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. *| . |</td><td>4</td><td>0.496</td><td>-0.063</td><td>70.570</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. *| . |</td><td>5</td><td>0.391</td><td>-0.061</td><td>77.172</td><td>0.000</td></tr>
<tr><td>. |**. |</td><td>. | . |</td><td>6</td><td>0.304</td><td>-0.016</td><td>81.310</td><td>0.000</td></tr>
<tr><td>. |**. |</td><td>. | . |</td><td>7</td><td>0.227</td><td>-0.030</td><td>83.689</td><td>0.000</td></tr>
<tr><td>. |* . |</td><td>. | . |</td><td>8</td><td>0.156</td><td>-0.027</td><td>84.859</td><td>0.000</td></tr>
<tr><td>. |* . |</td><td>. | . |</td><td>9</td><td>0.094</td><td>-0.028</td><td>85.298</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>10</td><td>0.051</td><td>0.011</td><td>85.434</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>11</td><td>0.014</td><td>-0.018</td><td>85.444</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>12</td><td>-0.011</td><td>0.009</td><td>85.451</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>13</td><td>-0.027</td><td>0.000</td><td>85.496</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>14</td><td>-0.036</td><td>0.006</td><td>85.575</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>15</td><td>-0.034</td><td>0.021</td><td>85.650</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>16</td><td>-0.026</td><td>0.017</td><td>85.695</td><td>0.000</td></tr>
</table>

Figure 5 Correlogram of LI 1973-2007

Autocorrelation	Partial Correlation	lag	AC	PAC	Q-Stat	Prob
. |****** |	. |****** |	1	0.809	0.809	24.908	0.000
. |***** |	. | . |	2	0.673	0.054	42.670	0.000
. |**** |	. | . |	3	0.554	-0.013	55.094	0.000
. |*** |	. | . |	4	0.451	-0.018	63.580	0.000
. |*** |	. | . |	5	0.353	-0.041	68.963	0.000
. |**. |	. | . |	6	0.271	-0.019	72.235	0.000
. |*. |	. | . |	7	0.193	-0.038	73.963	0.000
. |*. |	. | . |	8	0.134	-0.004	74.830	0.000
. |*. |	. | . |	9	0.097	0.021	75.298	0.000
. |*. |	. | . |	10	0.074	0.019	75.580	0.000
. | . |	. | . |	11	0.050	-0.016	75.713	0.000
. | . |	. | . |	12	0.028	-0.015	75.758	0.000
. | . |	. | . |	13	0.014	-0.002	75.769	0.000
. | . |	. | . |	14	-0.001	-0.015	75.769	0.000
. | . |	. | . |	15	-0.003	0.019	75.769	0.000
. | . |	. | . |	16	-0.003	0.008	75.770	0.000

The correlogram up to 16 lags for both series is shown in figures 4 and 5 respectively. From the figures we see that the autocorrelation coefficient starts at a very high value at lag 1 and declines very slowly, implying that all these time series are nonstationary. They may be nonstationary in mean or variance or both.