

CHAPETR 6

THE TIME SERIES ANALYSIS

6.1 Introduction

Neo-classical theories like those of Solow and Swan (1956) propound that labour productivity is one of the important determinants of growth. In fact, in the early works of 1990s, many studies explored the determinants of economic growth with human capital as one of the variables.

The role of human capital is considered an important determinant of economic growth. It leads to higher growth due to rise in the productivity of labour, and hence output. If there is a good amount of investment in health and educational institutions, this will boost the growth process. Some studies show that the poor countries have lower levels of human capital and consequently have greater difficulties compared with the developed nations. Hence, their levels of human capital must begin to converge with those of richer nations.

Nonetheless, there are arguments that explain the causality running from economic growth to health. They say that if there is more investment on health services as a part of GDP, it improves the nutritional level, sanitation and innovations in medical technology. This results in greater improvement in health status in the form of lower IMR, longer life expectancy and better standard of living.

It is, therefore, undoubtedly true from the early works in literature that economic growth and health are correlated with each other. There are, of course, other important factors that affect the two variables. However we are interested in understanding the association of economic growth and health. Additionally, the causality of economic growth and health is quite pervasive. As pointed above, labour productivity is considered as one of the determinant of economic growth, and labour productivity comes from education and health. Thus, if the economy is endowed with rich human capital, its growth increases. On the other hand, health improves with more investment on health services, education, etc. Therefore, there is also a need for the initial levels of income to

support the health services and thereby improve the quality of life to further increase growth. Hence, it cannot be definitely said whether, *ceteris paribus*, economic growth brings about good health or vice-versa, or are they both the cause and effect of each other. This shows the need to study the causal relationship between economic growth and health.

There is a vast literature on health economics that talks about the association between economic growth and health indicators. Studies have provided varied results on linkages of growth and health factors using different indicators like IMR and life expectancy, with different methods and techniques based on different datasets. However, the causality between economic growth and health status is still to be fully analysed. Directions of causality between health and income are difficult to measure and estimate.

Research Question and Sample Construction

The broad objective of this chapter is to investigate the association between health status and economic growth by using the time series data for India. In particular, an attempt has been made to understand the short run and long run relationship between the two. Additionally, the chapter explains the causality of the two indicators under study.

The study is based on the yearly data from 1970 to 2010. Each variable is collected as a yearly observation. Also the analysis has been done by using the log-transformed variables. This transformation has certain advantages. First, it captures the non-linearity, if any, and produces data with more normalized distributions. Second, the transformation results in elasticity directly that allows commenting on the magnitude of the impact of economic growth on health.

Explanatory and Dependent Variables

The primary dependent variables are the health indicators that are IMR and life expectancy at birth. Our study is mainly concerned with these two health system indicators because the data are more consistently defined, readily available and adopted in the literature of health economics. The main explanatory variable in this study is GDP at constant prices with the base year 2004-05.

6.2 Stationary Test: Augmented Dickey Fuller and Philips-Perron Test

In this study for Augmented Dickey Fuller (ADF) test the following equations have been used. Table 6.1 shows the results of ADF and Philips–Perron test (PP).

$$D(\lgdp) = \alpha + \alpha t + \gamma \lgdp_{t-1} + \sum \beta_i D(\lgdp_{t-i}) + u_t$$

$$D(\text{imr}) = \alpha + \alpha t + \gamma \text{imr}_{t-1} + \sum \beta_i D(\text{imr}_{t-i}) + u_t$$

$$D(\text{le}) = \alpha + \alpha t + \gamma \text{le}_{t-1} + \sum \beta_i D(\text{le}_{t-i}) + u_t$$

Table 6.1 Stationary Test

Series	Type	Equation	*TC (1%)	TC (5%)	TC (10%)	Test – Statistic (at level)	Test– Statistic at first difference
LGDP	ADF	$D(\lgdp) = \alpha + \alpha t + \gamma \lgdp_{t-1} + \sum \beta_i D(\lgdp_{t-i}) + u_t$	-4.20	-3.52	-3.19	-1.18	-7.95
	PP		-1.18	-4.20	-3.52	-3.19	-10.27
IMR	ADF	$D(\text{imr}) = \alpha + \alpha t + \gamma \text{imr}_{t-1} + \sum \beta_i D(\text{imr}_{t-i}) + u_t$	-3.03	-4.20	-3.52	-3.19	-7.12
	PP		-3.31	-4.20	-3.52	-3.19	-8.29
LE	ADF	$D(\text{le}) = \alpha + \alpha t + \gamma \text{le}_{t-1} + \sum \beta_i D(\text{le}_{t-i}) + u_t$	-2.99	-4.20	-3.52	-3.19	-8.26
	PP		-2.93	-4.20	-3.52	-3.19	-11.72

ADF: Augmented Dickey Fuller test, **PP :** Philips-Perron test.
For choosing lags, criteria used : Schwarz information criterion (SIC) and computations done on: Trend and Intercept.

Variables list: LGDP = Log (GDP); IMR = Infant Mortality Rate; LE = Life Expectancy

Source: Based on the author’s calculation. *TC: T Critical.

If variables in the regression model are not stationary, then it can be proved that the standard assumptions for asymptotic analysis will not be valid. In other words, the usual “*t*-ratios” will not follow a *t*-distribution, so we cannot legitimately undertake hypothesis tests about the regression parameters.

The null hypothesis of a unit root is rejected in favour of the stationary alternative, in each case if the test statistic is more negative than the critical value.

6.3 CO-INTEGRATION (Engle- Granger Approach, Static Model)

a) Testing of Co-integration between IMR and GDP

We have already found above that the variables are individually non-stationary. But it may happen that the linear combination turns to be stationary. As a result, the regression (1) below for IMR will be meaningful (that is, non-spurious). In this case we can say that a well-defined linear relationship exists among them in the long run. Thus, we proceed to test co-integration between the variables on 'levels' using Engle-Granger test based on the 'null hypothesis of stationary'.

The fitted regression to test for co-integration by applying the Ordinary Least Square (OLS) method is:

$$\text{imr}_t = \beta_0 + \beta_1 \text{lgdp}_t + \epsilon_t \quad (1)$$

Which comes to be:

$$\text{imr}_t = 499.4 - 42.8 \text{lgdp}_t + \epsilon_t$$

Table 6.2 shows that at 1 per cent, 5 per cent and 10 per cent significance level, the null hypothesis is rejected. Our conclusion is that the residuals from the regression of *imr* on *lgdp* are $I(0)$, that is, stationary. Hence, (1) is a co-integration regression and this regression is not spurious, even though individually the variables are non-stationary. Equation (1) shows the long run function and the long run coefficient is -42.8.

This regression is known as the 'potential co-integration regression'. Since we found that the *imr* and *lgdp* are individually non-stationary, there is a possibility that this regression is spurious. To test this, a unit root test (ADF) on the residuals (e_{imr}) is done, which is obtained from (1), that is,

$$e_{\text{imr}_t} = \text{imr}_t - b_0 - b_1 \text{lgdp}_t \quad (2)$$

Where b_0 , b_1 , and e_t are the estimates of the coefficients β_0 , β_1 , and ϵ_t respectively. This implies,

$$D(e_{\text{imr}}) = \lambda e_{t-1} + \sum \lambda D(e_{t-1}) \quad (3)$$

Where $D =$ Change.

The results are given below.

Table 6.2 Null Hypothesis: E_IMR Has a Unit Root

Exogenous: None

Lag Length: 0 (Automatic - based on AIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.824890	0.0652
Test critical values: 1% level	-2.624057	
5% level	-1.949319	
10% level	-1.611711	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(E_IMR)

Method: Least Squares

Sample (adjusted): 1971- 2010

Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
E_IMR(-1)	-0.180481	0.098900	-1.824890	0.0757
R-squared	0.075339	Mean dependent var		0.288482
Adjusted R-squared	0.075339	S.D. dependent var		4.857067
S.E. of regression	4.670522	Akaike info criterion		5.945101
Sum squared resid	850.7371	Schwarz criterion		5.987323
Log likelihood	-117.9020	Hannan-Quinn criter.		5.960367
Durbin-Watson stat	2.359203			

Source: Based on the author's calculation.

Error Correction Model (ECM)

The variables are found to be co-integrated, and so in the short run there must be disequilibrium. Thus, one can treat the error term in (2) as the “equilibrium error”, and is used to tie the short run behaviour of *imr* to its long run value. The ECM model corrects for the disequilibrium. The ECM takes the following form of equation:

$$D(imr_t) = \beta_1 D(lgdp_t) + \lambda(e_{t-1}) + V_t \quad (4)$$

Where D represents the difference from last period.

e_{t-1} = error correction term ($imr_{t-1} - \gamma lgdp_{t-1}$)

λ = speed of adjustment back to equilibrium

β_1 = impact multiplier, that it tells the short-run relationship between *imr* and *lgdp*

It is, thus, valid to use OLS and standard procedures for statistical inference on (4). The results are captured in the Table below which implies the equation to be:

$$\hat{D(imr)_t} = -23.21087 \hat{D(lgdp)_t} - 0.1620e_{t-1} \quad (5)$$

It is found that the coefficients of the error correction term have the desired sign (negative). About 0.16 of the deviation from *imr* from the long run equilibrium value is corrected every year. The significance of the error correction term at 10 per cent level confirms that *imr* and *lgdp* are cointegrated in the long run (in terms of years) and error correction takes place in the short run. Also, -23.21 measures the short run coefficient. However, the changes in *imr* do not make an impact on the changes in *gdp* in the short run.

Table 6.3 ECM, Dependent Variable: D(IMR1)

Method: Least Squares

Sample (adjusted): 1971 – 2010

Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGD)	-23.21087	12.00105	-1.934070	0.0606
E_IMR(-1)	-0.162058	0.097502	-1.662105	0.1047
R-squared	-0.044560	Mean dependent var		-1.975000
Adjusted R-squared	-0.072048	S.D. dependent var		4.417259
S.E. of regression	4.573620	Akaike info criterion		5.927194
Sum squared resid	794.8839	Schwarz criterion		6.011638
Log likelihood	-116.5439	Hannan-Quinn criter.		5.957726
Durbin-Watson stat	2.292889			

Source: Based on the author's calculation.

Granger Causality Test

We have tested the short run and long run relationship between IMR and GDP. These regressions only tell us about the relationship, whether it exists or not, and not the causation of the variables. Therefore, we need to test whether the *imr* is the causal factor for *lgdp* by Granger causality test. It involves checking the following equations:

$$lgdp_t = \sum \alpha_i imr_{t-i} + \sum \beta_j lgdp_{t-j} + u_{1t} \quad (6)$$

$$imr_t = \sum \lambda_i lgdp_{t-i} + \sum \gamma_j imr_{t-j} + u_{2t} \quad (7)$$

Where it is assumed that u_{1t} and u_{2t} are uncorrelated. Also, it is important to note that we are dealing with bilateral causality. Equation (6) depicts that the current $lgdp$ is related to the past values itself as well as that of imr . The equation (7) postulates that the current imr is related to its past value of itself and of the $lgdp$.

Results of Granger causality test are shown in Table 6.4. This test does not reject the null hypothesis of ' $lgdp$ does not Granger cause of imr ' and does not reject ' imr does not Granger cause of $lgdp$ ' at 10 per cent of significance. This implies that the causality is not clear.

Table 6.4 Pair-wise Granger Causality Tests (IMR and GDP)

Sample: 1970- 2010
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
IMR1 does not Granger Cause of LGDP	40	0.90132	0.3486
LGDP does not Granger Cause of IMR 1		2.69514	0.1091

Source: Based on the author calculation.

b) Testing of Co-integration between Life Expectancy (LE) and L(GDP)

The variables LE and LGDP are individually non-stationary. Thus, we further proceed to test for co-integration between them on 'levels' using Engle-Granger test based on the 'null hypothesis of stationarity' to know if there is any long run relationship between the two.

The fitted regression to test for co-integration by applying the Ordinary Least Square (OLS) method is:

$$le_t = \beta_0 + \beta_1 lgdp_t + \epsilon_t \quad (1)$$

Which comes to be :

$$le_t = 0.28 + 6.02 lgdp_t + \epsilon_t$$

This regression is known as the ‘potential co-integration regression’. Since we found that the *le* and *lgdp* are individually non-stationary, there is a possibility that this regression is spurious. To test this, a unit root test (ADF) is done on the residuals (*e_{le}*), which is obtained from (1), that is,

$$e_{le_t} = le_t - b_0 - b_1 lgdp_t \quad (2)$$

Where b_0 , b_1 and e_t are the estimates of the coefficients β_0 , β_1 and ϵ_t respectively.

This implies,

$$D(e_{le}) = \lambda e_{t-1} + \sum \lambda D(e_{t-1}) \quad (3)$$

Where D= Change. The results are given below.

Results in Table 6.5 show that the null hypothesis is rejected at 5 per cent significance level. Thus, our conclusion is that the residuals from the regression of *le* on *lgdp* are I(0); that is stationary. Hence, (2) is a co-integration regression.

Table 6.5 Null Hypothesis: E_LE Has a Unit Root

Exogenous: None
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*		
Phillips-Perron test statistic	-2.731871	0.0075		
Test critical values:				
1% level	-2.624057			
5% level	-1.949319			
10% level	-1.611711			
*MacKinnon (1996) one-sided p-values.				
Residual variance (no correction)		0.243978		
HAC corrected variance (Bartlett kernel)		0.324962		
Phillips-Perron Test Equation				
Dependent Variable: D(E_LE)				
Method: Least Squares				
Sample (adjusted): 1971 – 2010				
Included observations: 40 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
E_LE(-1)	-0.190534	0.070877	-2.688226	0.0105
R-squared	0.153371	Mean dependent var		0.031788
Adjusted R-squared	0.153371	S.D. dependent var		0.543659
S.E. of regression	0.500234	Akaike info criterion		1.477199
Sum squared resid	9.759116	Schwarz criterion		1.519421
Log likelihood	-28.54399	Hannan-Quinn criter.		1.492466
Durbin-Watson stat	2.115678			

Source: Based on the author’s calculation.

Error Correction Model (ECM)

The variables are found to be co-integrated and, therefore, in the short run there must be disequilibrium. Thus, one can treat the error term in (2) as the “equilibrium error”. It is used to tie the short run behaviour of le to its long run value. The ECM model corrects the disequilibrium.

The ECM takes the following form of equation:

$$D(le_t) = \beta_1 D(lgdp_t) + \lambda(e_{t-1}) + V_t \quad (4)$$

Where, D represents difference from the last period

e_{t-1} = error correction term ($le_{t-1} - \gamma lgdp_{t-1}$)

λ = speed of adjustment back to equilibrium

β_1 = impact multiplier, that is it tells the short-run relationship between le and $lgdp$

It is thus valid to use OLS and standard procedures for statistical inference on (4).

The results are captured in the Table below which implies the following equation:

$$\hat{D}(le_t) = 4.911562 D(lgdp_t) - 0.180956 e_{t-1} \quad (5)$$

Table 6.6 ECM, Dependent Variable: D(LE)

Method: Least Squares

Sample (adjusted): 1971 2010

Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGD)	4.911562	1.325706	3.704866	0.0007
E_LE(-1)	-0.180956	0.072068	-2.510901	0.0164
R-squared	-0.053057	Mean dependent var		0.350000
Adjusted R-squared	-0.080769	S.D. dependent var		0.483046
S.E. of regression	0.502175	Akaike info criterion		1.508969
Sum squared resid	9.582818	Schwarz criterion		1.593413
Log likelihood	-28.17939	Hannan-Quinn criter.		1.539502
Durbin-Watson stat	2.109297			

Source: Based on the author's calculation.

It is found that the coefficients of the error correction term have the desired sign (negative). About 0.18 of the deviation from *le* from the long run equilibrium value is corrected every year. The significance of the error correction term at 5 per cent level confirms that *le* and *lgdp* are cointegrated in the long run (in terms of years) and error correction takes place in the short run. Also, in equation (5) the value 4.9 measures the short run coefficient with significant t-value. This means that changes in *le* make changes in *gdp* in the short run.

Granger Causality Test

It involves checking the following equations:

$$lgdp_t = \sum \alpha_i le_{t-i} + \sum \beta_j lgdp_{t-j} + u_{2t} \quad (6)$$

$$le_t = \sum \lambda_i lgdp_{t-i} + \sum \gamma_j le_{t-j} + u_{2t} \quad (7)$$

Where it is assumed that u_{1t} and u_{2t} are uncorrelated. It is important to note that we are dealing with bilateral causality. Equation (6) depicts that the current *lgdp* is related to the past values itself as well as that of *le*. And, the equation (7) postulates that the current *le* is related to its past value of itself and of the *lgdp*.

The results of the Granger Causality Test are shown in Table 6.7. The Test rejects the null hypothesis “*lgdp* does not Granger cause *le*” and does not reject “*le* does not Granger cause *lgdp*” at 20 per cent level of significance. This implies that changes in *lgdp* cause a change in *le*.

Table 6.7 Pair-wise Granger Causality Tests

Sample: 1970 – 2010

Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LGD does not Granger Cause LIEXP	40	2.34459	0.1342
LIEXP does not Granger Cause LGD		1.70080	0.2002

Source: Based on the author’s calculation.

6.4 Auto Regressive Distributed Lags (ARDL) Approach to Co-integration

a) Testing of Co-integration between IMR and GDP

After passing the unit root test, it is possible to carry out the co-integration tests between GDP and IMR. The next section of the study investigates whether the series under scrutiny are co-integrated, so that a well-defined linear relationship exists among the variables in the long run. Many time series are non-stationary but move together over time, that is, there exist some influences on the series which implies that the two series are bound by some relationship in the long run. A co-integrating relationship may also be seen as a long term or equilibrium phenomenon since it is possible that co-integrating variables may deviate from their relationship in the short run. However, their association would return in the long run. Thus, we proceed to test co-integration between the variables on levels using autoregressive distributed lags approach to co-integration. It is based on the ‘null hypothesis of no co-integration’.

In case of formal null hypothesis, there exists no long-run equilibrium relationship, and the alternative hypothesis is the existence of a long run relationship (as per the following equation):

$$\text{Dimr}_t = \alpha_{0y} + \beta_{0y} \text{Dimr}_{t-1} + \beta_{1y} \text{Dl} \text{gdp}_{t-1} + \sigma_{0y} \text{imr}_{t-1} + \sigma_{1y} \text{l} \text{gdp}_{t-1} + \text{et}$$

This regression is known as the potential co-integration regression. The null hypothesis to be tested is of “non-existence of the long run relationship” defined by:

$$H_0: \sigma_{0y} = \sigma_{1y} = 0$$

$$H_1: \sigma_{0y} \neq \sigma_{1y} \neq 0$$

Results for the test of co-integration are presented below:

Table 6.8 Result of Test for Co-integration Using ARDL Approach

Testing for existence of a level relationship among the variables in the ARDL model:

F-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
35.1164	15.0519	15.0519	12.4510	12.4510
W-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
35.1164	15.0519	15.0519	12.4510	12.4510

Source: Based on the author’s calculation.

If the F statistic lies between the bounds, the test is inconclusive. If it is above the upper bound, the null hypothesis of no level effect is rejected. If it is below the lower bound, the null hypothesis of no level effect can't be rejected. The critical value bounds are computed by stochastic simulations using 20,000 replications.

The results show that the null hypothesis is rejected at 5 per cent and also at 10 per cent level of significance. The F value is 35.11 and the upper bound critical value at 5 per cent significance level is 15.05 and the upper bound critical value at 10 per cent significance level is 12.45. The F-value is sufficiently higher than the upper bound value in both the cases. There is presence of co-integration and regression equation is non-spurious. Hence, we there exists a long run relationship between *imr* and *lgdp*.

Once we have established that a long-run co-integration relationship existed using the following ARDL specification, in order to estimate the long-run coefficient, the following long-run model is used:

$$imr_t = \alpha_{0y} + \sigma_{0y} imr_{t-1} + \sigma_{1y} lgdp_t + \sigma_{2y} lgdp_{t-1} + et$$

Where error term is a white noise error and is derived as follows:

$$ECM_t = et = imr_t - (\alpha_{0y} + \sigma_{0y} imr_{t-1} + \sigma_{1y} lgdp_t + \sigma_{2y} lgdp_{t-1})$$

The results obtained for the long run effects are reported below:

Table 6.9 Estimated Long Run Coefficients Using the ARDL Approach

ARDL(1) selected based on Schwarz Bayesian Criterion

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*****
Dependent variable is IMR1
39 observations used for estimation from 1972 - 2010
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Regressor	Coefficient	Standard Error	T-Ratio[Prob]
C	-389.4943	88.2751	-4.4123[.000]
T	-5.8272	.57420	-10.1483[.000]
LGD	63.0051	10.4841	6.0096[.000]

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Source: Based on the author's calculation.

The estimated coefficient of the long-run relationship shows that *lgdp* has a significant impact on *imr* for India. The coefficient is significant at 1 per cent level of

significance and has a negative sign. The sign is also in consonance with the available literature. This means that economic growth has impact on health indicator over a period of time.

Error Correction Model (ECM)

We showed that the variables are found to be co-integrated. However, in the short run there may be disequilibrium. Thus, one can treat the error term shown above as the “equilibrium error”. It is used to tie the short run behaviour of *imr* to its long run value. The ECM model corrects the disequilibrium. The error correction model takes the following form of equation:

$$D(imr_t) = \alpha_{0y} + \lambda D imr_{t-1} + \beta_{1y} D lgdp_{t-1} + V_t \quad (1)$$

Where $(e_{t-1}) = ECM_{t-1}$

D represents the difference from last period.

e_{t-1} = error correction term

β_{1y} = impact multiplier, that it tells the short-run relationship between *imr* and *lgdp*

It is thus valid to use OLS and standard procedures for statistical inference on equation (1). The results of the short-run dynamic coefficients associated with the long-run relationships obtained from the ECM equation (1) are given in the Table below.

Table 6.10 Error Correction Representation for the Selected ARDL Model

ARDL(1) selected based on Schwarz Bayesian Criterion

 Dependent variable is dIMR1
 39 observations used for estimation from 1972 - 2010

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dT	-4.2681	.72651	-5.8748[.000]
dLGD	46.1483	9.3022	4.9610[.000]
ecm(-1)	-.73245	.12360	-5.9259[.000]

 List of additional temporary variables created:
 dIMR1 = IMR1-IMR1(-1)
 dT = T-T(-1)
 dLGD = LGD-LGD(-1)
 ecm = IMR1 + 389.4943*C + 5.8272*T -63.0051*LGD

 Source: Based on the author’s calculation.

$$ecm = IMR1 + 389.4943*C + 5.8272*T -63.0051*LGD$$

The equilibrium correction coefficient estimated value is -63.0051 which is significant even at 1 per cent level of significance and also has the correct sign (negative). Existence of a significant error correction term is evidence of long run causality from explanatory variable to the dependent health variable *imr*. The value of co-efficient implies a fairly high speed of adjustment to equilibrium after a shock. Short-run coefficient estimate of ECM model reveals the dynamic adjustment of the variables, that is, 73 per cent of the disequilibrium is corrected within one year. So it will take around a year to come back to steady state equilibrium. Signs of the short-run dynamic impacts are maintained as they were in the long-run. The estimated coefficients of the short-run relationship shows that *lgdp* has a very high significant impact on *imr* for India and the coefficient is significant at 1 per cent level of significance with a negative sign.

b) Testing of Co-integration for Life Expectancy and GDP

The null hypothesis is that there exists no long-run equilibrium relationship, and the alternative hypothesis is the existence of a long run relationship between life expectancy and GDP (as per the following equation):

$$Dle_t = \alpha_{0y} + \beta_{0y} Dle_{t-1} + \beta_{1y} Dlgdp_{t-1} + \sigma_{0y} le_{t-1} + \sigma_{1y} lgdp_{t-1} + et$$

This regression is known as the potential co-integration regression. The null hypothesis to be tested is of “non-existence of the long run relationship” defined by:

$$H_0: \sigma_{0y} = \sigma_{1y} = 0$$

$$H_1: \sigma_{0y} \neq \sigma_{1y} \neq 0$$

The results of the test of co-integration are presented below:

Table 6.11 Testing for Existence of a Level Relationship among the Variables in the ARDL

F-stat	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
18.0553	5.0519	15.0519	12.4510	12.4510
W-stat	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
18.0553	15.0519	15.0519	12.4510	12.4510

Source: Based on the author’s calculation.

Results show that the null hypothesis is rejected at 5 per cent and also at 10 per cent level of significance. The F value is 35.11 and the upper bound critical value at 5 per cent significance level is 15.05 and the upper bound critical value at 10 per cent significance level is 12.45. The F-value is sufficiently higher than the upper bound value in both the cases. There is presence of co-integration and regression equation is non-spurious. Hence, we conclude that there exists a long run relationship between *le* and *lgdp*.

We establish that a long-run co-integration relationship existed using the following ARDL (1) specification, in order to estimate the long-run coefficient, and now the following long-run model is used:

$$le_t = \alpha_{0y} + \sigma_{0y} le_{t-1} + \sigma_{1y} lgdp_t + \sigma_{2y} lgdp_{t-1} + et$$

Where, error term is a white noise error and is derived as follows:

$$ECM_t = et = le_t - (\alpha_{0y} + \sigma_{0y} le_{t-1} + \sigma_{1y} lgdp_t + \sigma_{2y} lgdp_{t-1})$$

The results obtained for the long run effects are reported below:

Table 6.12 Estimated Long Run Coefficients using the ARDL Approach

ARDL(1) selected based on Schwarz Bayesian Criterion

 Dependent variable is LIEXP
 39 observations used for estimation from 1972 - 2010

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
C	101.8267	12.5196	8.1334[.000]
T	.63079	.081981	7.6944[.000]
LGD	-5.9585	1.4901	-3.9988[.000]

Source: Based on the author's calculation.

The estimated coefficient of the long-run relationship shows that *lgdp* has a significant impact on *le* for India. The coefficient is significant at 1 per cent level of significance and has a negative sign. The latter is also in consonance with the literature. This means that economic growth has an impact on health indicator over a period of time.

Error Correction Model (ECM)

We showed that variables are found to be co-integrated. However, in the short run there may be disequilibrium. Thus, one can treat the error term shown above as the “equilibrium error”. It is used to tie the short run behaviour of LE to its long run value. The ECM model corrects the disequilibrium. The error correction model takes the following form of equation:

$$D(le_t) = \alpha_{0y} + \beta_{0y} Dle_{t-1} + \beta_{1y} Dlgdp_{t-1} + V_t \quad (2)$$

Where $(e_{t-1}) = ECM_{t-1}$

D represents the difference from last period.

e_{t-1} = error correction term

β_{1y} = impact multiplier, i.e., it tells the short-run relationship between *le* and *lgdp*

It is thus valid to use OLS and standard procedures for statistical inference on (1).

The results of the short-run dynamic coefficients associated with the long-run relationships obtained from the ECM equation (2) are given in the Table below.

Table 6.13 Error Correction Representation for the Selected ARDL Model

ARDL(1) selected based on Schwarz Bayesian Criterion

Dependent variable is dLIEXP

39 observations used for estimation from 1972 - 2010

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dT	.37751	.10599	3.5616[.001]
dLGD	-3.5660	1.2532	-2.8454[.007]
ecm(-1)	-.59847	.14084	-4.2492[.000]

List of additional temporary variables created:

dLIEXP = LIEXP-LIEXP(-1)

dT = T-T(-1)

dLGD = LGD-LGD(-1)

ecm = LIEXP -101.8267*C - .63079*T + 5.9585*LGD

Source: Based on the author's calculation.

$$ecm = LIEXP -101.8267*C - .63079*T + 5.9585*LGD$$

The equilibrium correction coefficient estimated value is $-.59847$ which is significant even at 1 per cent level of significance and also has the correct sign (negative). The existence of a significant error correction term is evidence of long run causality from explanatory variable to the dependent health variable life expectancy.

The signs of the short-run dynamic impact are maintained as they were in the long-run. The estimated coefficients of the short-run relationship shows that *lgdp* has a very high significant impact on life expectancy for India and the coefficient is significant at 1 per cent level of significance with a negative sign.

Therefore, there is a long run relationship between IMR and GDP, as well as between life expectancy and GDP. It shows the long run causality from explanatory variable (GDP) to the dependent health variables (IMR and life expectancy).

It is found that changes in IMR do not have an impact on changes in GDP in the short run. The estimated coefficient of the long-run relationship shows that GDP has a high significant impact on IMR in India.

Changes in LE do make an impact on changes in GDP in the short run. The estimated coefficient of the long-run relationship shows that GDP has a significant impact on life expectancy in India. Therefore, economic growth has an impact on health indicator over a period of time.

It is found by Granger Causality Test that changes in *gdp* cause a change in *le*. But the causality of *imr* and *gdp* is not clear from it.