4.1 Introduction

Governments in developing countries spend considerable resources in human capital investment like education, health and so on (Podrecca and Carmeci, 2001). The relatively rapid increase in higher education graduates in Iran in recent years presents a formidable task for trying to measure its economic growth impact.

In this chapter, researcher estimates the effect of educated manpower (human capital) on the economic growth of Iran. Initially researcher explores the econometrics method, which he wants to use for estimation. Then researcher describes the empirical models and introduces data according to statistical population and models variables. Finally he estimates models and present conclusion.

4.2 Empirical Models

The efforts to study the effects of the higher education indices on the economic growth have been continued since 1960. The economists have tested various methods to measure the effects of the human capital indices on the economic growth. All of them have used production function in order to test their assumptions though various methods were being used. The preliminary attempts were made to measure the effect of education on the economic growth by Denison, which is known as growth accounting method. Denison method was based on the conception of production function which was used for the description of the economic growth in the united states of America.

Due to the result of the research, manpower and physical capital are notable to explain the economic growth by themselves. There are also a number of other elements which have not been mentioned in the model. These elements which were being known as the residual elements led the economic researchers to attempt to find how many of these elements are concerned with the educational effect.

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After 1980 when the World Development Report of the World Bank was reported, the studies based on the econometrics methods had a dramatic and considerable leap to measure the effect of the educational indexes on the economic growth. In 1983, Walters and Rubinson\(^3\) formed a production function as the same as Cobb–Douglas’s by using Granger method in which there were merely three variables: physical capital, manpower and education. They measured the increase of the effect of manpower’s higher training on the economic growth. Easterline (1981)\(^4\) studied the relationship between the education and the economic growth in 25 countries of the world. He found that the developing of technology caused by the modern economic growth depends on more learning and motivation resulted from the educational development.

Since 1960’s, in general, the suggested researches concerning the human capital and the economic growth have been divided into two main groups. The main difference between these two groups has been according to the estimation method and the kind of indicating variable of human capital. The first group has studied the relation between education and the economic growth in the frame of the production function with the conventional variables. The study of the second group was based on the entrance of including the unconventional variables in the production function in order to give a direct estimation of the educational indices share in the economic growth.

Considering the various researches done, in the field of using the human capital variable in the production function, in all over the world, the suggested model in this study is according to Cobb–Douglas (1928)\(^5\) production function, which is known as the best function in conformity and consistency with the economic situations.


because of the consistency of its functional form and also the fluency of the internal relations of the variables. On the other hand, due to the homogeneity of this function, by using Olar Theorem we can use this function easily to distribute the production between the production’s factors and through its augmented form we can separate the manpower into two parts expert and non–expert and estimate the share of each separately.

The production function is generally as follows:

\[ GDP = f(K, L) \quad (4.1) \]

Where GDP is the real gross domestic product; K is the physical capital; and L is the number of employee.

In fact the equation (4.1) is the same classic production function which has been used frequently in the classic analysis of the economic growth. In this study, this model has been taken as the classical analysis of the economic growth.

If the mentioned function is considered as the various models of econometrics, we will have:

\[ GDP = AK^\alpha L^\beta e^{itu} \quad (4.2) \]

In which e is brought as a disturbance term in the model. If we take logarithm from the mentioned function, we will have:

\[ \ln GDP = \ln A + \alpha \ln K + \beta \ln L + u \quad (4.3) \]

In order to determine the effect of the expert employee and the other human capital indices on the economic growth we have used Cobb–Douglas augmented production function, so that:
\[ GDP = f(K, EL, NEL) \quad (4.4) \]

Where GDP is the real gross domestic product; K is the physical capital; EL is the expert employee (employee with higher education); and NEL is the non-expert employee.

If we consider the mentioned function with regards to the error term in the econometrics models, we will have:

\[ GDP = AK^\alpha EL^\beta NEL^\gamma e^u \quad (4.5) \]

Now if we account the linear logarithm of the above function, we will have:

\[ \ln GDP = \ln A + \alpha \ln K + \beta \ln EL + \gamma \ln NEL + u \quad (4.6) \]

On the other hand, in order to determine the effect of the higher education and research expenditure on the economic growth, we consider the current expenditure variable of the higher education and researches in Cobb–Douglas augmented production function, so that:

\[ GDP = f(K, L, RC) \quad (4.7) \]

Where GDP is the real gross domestic product; K is the physical capital; L is the number of employee; and RC is the higher education and research expenditure.

If we write the above function as the econometrics models, we will have:

\[ GDP = AK^\alpha L^\beta RC^\gamma e^u \quad (4.8) \]

And if we take the logarithm of the above function, we will have:
\[ \ln GDP = \ln A + \alpha \ln K + \beta \ln L + \gamma \ln RC + u \quad (4.9) \]

Concerning the selection of the indicator variables of the human capital in the present study, we have benefitted from James Raymo’s\(^6\) study in 1995 about the elements of the high growth in Japan and also considering the studies on econometrics was very useful in this study. In (4.6) model, separating the employed manpower in to expert and non–expert and in (4.9) model, selecting the variable of higher education and research expenditure is used as the echo of the higher education quality from Raymo’s model.

4.3 Econometric Method

One of the most important statistic data used in empirical analysis is the time series. According to Maddala (2001)\(^7\) a time series is a sequence of numerical data in which each item is associated with a particular instant in time. An analysis of a single sequence of data is called univariate time series analysis. An analysis of several sets of data for the same sequence of time periods is called multivariate time series analysis or, more simply, multiple time series analysis. The purpose of time series analysis is to study the dynamics or temporal structure of the data.

In the researches, the time series is assumed to be stationary. If the time series is non-stationary, the common statistical tests based on t, F, \(X^2\) and similar tests are doubted and also a problem called suprious regression may appear. In such regression, the coefficient of determination (\(R^2\)) might be so high that the researcher understands the relation between the variables wrongly, though there might be no relation between the pattern variables. Therefore, it is necessary to be aware of the difficulties in using the non-stationary time series data and the possibility of suprious regression in empirical tasks.


\(^7\) Maddala, G. S. (2001), Introduction to Econometrics, John Wiley and Sons Ltd, Third edition.
4.3.1 Stationarity and Non-Stationarity

According to Tavakkoli (1997)\textsuperscript{8} a time series is stationary if:

1- Its mean remains the same for all the time points ($t_i$). That means if the mean is shown by $\mu$ we will have:

$$E(X_t) = \mu \quad \forall_t$$  \hspace{1cm} (4.10)

2- Its variance too remains the same for all the points in the period of time. That means if the variance is shown by $\sigma^2$ we should have:

$$Var(X_t) = E[(X_t - \mu)^2] = \sigma^2 \quad \forall_t$$  \hspace{1cm} (4.11)

3- The Covariance between the two values of the time series depends on their distance not the time of their occurrence. Thus, if Covariance between the two values of the time series with K time distance is shown by $\gamma_k$ we will have:

$$Cov(X_t, X_{t-k}) = E[(X_t - \mu)(X_{t-k} - \mu)] = \gamma_k \quad \forall_t$$  \hspace{1cm} (4.12)

$$Cov(X_{t+j}, X_{t+j-k}) = Cov(X_t - X_{t-k}) - \gamma_k$$  \hspace{1cm} (4.13)

Therefore, the common estimators lead to the accepted estimations of the mean, variance and covariance so,

$$\hat{\mu} = \frac{1}{T} \sum_{t=1}^{T} X_t$$  \hspace{1cm} (4.14)

$$\hat{\sigma}^2 = \frac{1}{T} \sum_{t=1}^{T} \frac{(X_t - \hat{\mu})^2}{T}$$  \hspace{1cm} (4.15)

The veracity of the pre-supposition on stationarity is very important for analyzing the time series. For instance the violation of the first hypothesis means that the process of producing the time series data has a structure in which there is a particular mean for each and every period of time. If the series has \( n \) observations, \( n \) various means should be estimated. In other words, when one mean is estimated for each period of time which has only one observation, it is obvious that no useful work can be done in this situation.

In fact a stochastic process is a probob one in which there is a particular probability rule. The stationary stochastic process is a subset of the stochastic process which has the three mentioned conditions. The presupposition of the stationarity is not always true, however, according to the empirical studies, their acceptance often become the basis of making the statistical models which make the predication possible (Newbold and Bos 1994)\(^9\). The Autoregressive Model \( AR(1) \) is the simplest model of the stationary time series while \( |\rho| < 1 \).

\[
Y_t = \rho Y_{t-1} + U_t, \quad |\rho| < 1, \quad U_t \sim \mathcal{N}(0, \sigma^2) \quad (4.17)
\]

4.3.1.1 Non–Stationary

Violation of each of the mentioned conditions in a time series, shows the non-stationary of the time series. As Cuthertson and others remark (1992)\(^10\), stationary time series tend to turn to its mean and fluctuate around the mean in a quite fix time limit while a non-stationary time series has different means during the time.

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The time series in econometrics usually have trend and are non-stationary. Trend is meant that the time series tend to increase or decrease. This trend can merely be concerned with the effects of the time series stochastic entity and shocks.

One trend in non-stationary series is the algebraic trend. If $y_t$ is inferred as the linear function of time with random white noise process, a non-stationary series will be made with the algebraic trend.

$$ Y_t = \alpha + \beta t + u_t \quad (4.18) $$

In fact if the time series mean is not fixed and is depend on time itself, such model will be made:

$$ Y_t = \mu_t + u_t \quad (4.19) $$
$$ \mu_t = \alpha + \beta t \quad (4.20) $$
$$ Y_t = \alpha + \beta t + u_t \quad (4.21) $$

The process which has the fixed mean ($\alpha$) around a trend line ($\beta t$) can be regarded stationary (Spano, 1986\textsuperscript{11} and Mills, 1993\textsuperscript{12}).

### 4.3.1.2 Suprious Regression

Time series are mostly non-stationary in macroeconomics. Now-a-days nonstationarity is an accepted feature for the variables of the macroeconomic. Using the common methods of econometrics for the stationary series such as the Ordinary Least Squares (OLS), usually leads to the wrong interpretation of the results (Rao 1995\textsuperscript{13}). Using these methods usually cause the estimation of the high level of meaningful coefficient and coefficient of correlation. According to Granger and Newbold (1974\textsuperscript{14}), if the assumed relation of two completely separate non-stationary

\begin{itemize}
\end{itemize}
series \((X_t, Y_t)\), is tested through OLS method in the regression \(Y_t = \alpha + \beta X_t + u_t\), that has no relation in real between, the null hypothesis will be 76 per cent failed. And when these are five thoroughly separate variables in the model, the failure of the nall hypothesis will be reached 96 per cent. This is because when the variables of a model are not stationary, the critical values of T and F- statistics are no longer the figures of common tables. For instance, according to Granger and Newbold (1974) the T critical values for five per cent confidence level instead of 1.96 is 11.2 and according to Philips’s method (1986) it is 15 with fifty observations (Greene 1993). Because of \(1.96 < t < 11.2\) we may wrongly accept that the right side variables define the dependent variable meaningfully while there is no relation between them at all.

Charemza and Deadman (1992) represent the suprious relation by giving a fine example. It is supposed that \(Y_t, X_t\) are defined in order as:

\[
Y_t = 1, Y_2 = 2, \ldots, Y_n = n, \quad n = 30 \\
X_t = 1, X_2 = 4, \ldots, X_n = n^2, \quad n = 30
\]

It means that \(Y_t, X_t\) are two algebraic process, the first and second degree in which no linear relation is seen. The result of the regression equation of \(Y_t\) over \(X_t\) and estimation of the parameters would be:

\[
Y_t = 5.92 + .03 X_t \quad (4.22) \\
(9.9) \quad (21.2) \\
R^2 = .94 \quad DW = .06
\]

The simple example represents how the regression of two algebraic trends through which the space is left in the course of time can simply lead to wrong interpretation.

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15 Ibid
For instance we may neglect the smallness of the Durbin–Watson statistic and due to the quite big $t$- statistic and also very high coefficient of correlation we might assume that $Y_t$ is finely explained by $X_t$ and that (4.22) equation is a fine fit of the real $Y_t$ while the relation is thoroughly suprious.

### 4.3.1.3 Stationary Test

On hand using the method of OLS estimation in the empirical tasks is based on the hypothesis that the time series variables are stationary. On the other hand, it is believed that most of these variables are not stationary in macroeconomics. Therefore, before using these variables one should ascertain whether they are stationary or non-stationary. One simple and usual way to change a non-stationary series into a stationary one is to find the first difference of the figures of non-stationary series. By first difference it is meant to account the difference of two series observations. For example in $Y_t$ non-stationary time series first difference is defined as:

$$
\Delta Y_t = Y_t - Y_{t-1} \quad (4.23)
$$

The differentiation of non-stationary time series usually changes to stationary. A non-stationary time series is called integrated of $d$ degree when it is changed to a stationary time series with $d$ times first difference which is shown as $[I (d)]$. (Engle–Granger 1987)$^{19}$.

A non-stationary series which becomes stationary by one time differentiation is called integrated of first degree because the difference forms a series which tend to a fixed mean.

In fact $Y_t \sim I(1)$ the time series is not stationary however, $\Delta Y_t$ is a stationary time series (Banerjee and others 1994)$^{20}$. Hence, we can estimate the time series with

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$\Delta Y_t$. Thus, determining the integration degree of the series is the primary step for the econometrics with macroeconomic variables so that we know how many times the first difference cause stationary series.

### 4.3.1.4 Unit Root Test for Stationarity

Unit Root Test is one of the most common tests which now-a-days is used for determining the stationarity of a time series process. The basis of the unit root test is that when $\rho = 1$ the first order autoregressive process,

$$Y_t = \rho Y_{t-1} + U_t \quad (4.24)$$

is non-stationary. Thus, if the $\rho$ coefficient of the equation is estimated through the OLS method and its equality with 1 is tested, stationarity or non-stationarity of a time series process will be proved. However, faces a problem that is, the suggested $t$-statistic by OLS method with the hypothesis of $\rho = 1$ and with common $T$ distribution is not in a big sample, therefore, $T$ critical values can not be used to perform the test.

To tackle this problem some tests are made among which Dickey–Fuller (DF) and Augmented Dickey–Fuller (ADF) are the most common. The two mentioned tests are the most current and simplest tests of determining the integration degree of non-stationary series (Maddala 2001). In a research by Dejong and others (1992) the validity of the various tests are evaluated in order to determine the integration. According to this research, the ADF test is probably the most useful one in practice.

### 4.3.1.5 Dickey–Fuller Test (DF)

According to Noferesti (1999) consider the following first order autoregressive process:

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To test whether the $Y_t$ time series has a unit root or it is non-stationary the following hypothesis is formed:

$H_0 : \rho = 1$

$H_1 : \rho < 1$

The $\rho$ parameter can be estimated as follows by the OLS method:

$$\hat{\rho} = \frac{\sum_{t=2}^{n} (Y_t - \bar{Y})(Y_{t-1} - \bar{Y})}{\sum_{t=2}^{n} (Y_{t-1} - \bar{Y})^2}$$  \hspace{1cm} (4.26)$$

The estimator is so that when $n$ increases the probability distribution of:

$$\sqrt{n} (\hat{\rho} - \rho)$$  \hspace{1cm} (4.27)$$

statistic tendency to a normal probability distribution with the null mean and $1 - \rho^2$ variance. Considering that the null hypothesis is true, the $\sqrt{n} (\hat{\rho} - \rho)$ Statistic close not possess the normal probability distribution. Therefore, for performing the test, $t$ critical values and the ones given by normal distribution can not be used.

The following statistic is suggested by Dickey and Fuller (1979)\(^24\) according to the $\hat{\rho}$ estimator to perform unit root test:

$$n (\hat{\rho} - 1)$$  \hspace{1cm} (4.28)$$

the above statistic has a limiting distribution and its critical values for the unit root test ($\rho = 1$) is obtained and charted through the Simulation Method by Dickey and Fuller.

It is noteworthy that when \(|\rho| > 1\) and the process is stationary, the probability distribution of the \(\hat{\rho}\) estimator is in the form of \(\sqrt{n} (\hat{\rho} - \rho)\). The fact in which \((\hat{\rho} - \rho)\) is multiplied in the \(\sqrt{n}\) coefficient means that \((\hat{\rho} - \rho)\) distribution is centralized move and move on its mean with the \(n\) increase. Thus, the estimator is consistent. The \(n(\hat{\rho} - 1)\) statistic too in which \(\rho = 1\) is centralized move and move with the \(n\) increase when \(|\rho| > 1\), the speed of the centralization process is in accordance with the \(\sqrt{n}\) increase, however when \(\rho = 1\), the speed is matched with the \(n\) increase which is much faster. That is why the \(\hat{\rho}\) estimator related to the OLS method is called super consistent only when \(\rho = 1\).

The usual accounted values of \(T\)-statistic through OLS method are known as \(\tau\) statistic when \(\rho = 1\). In fact instead of using the \(t\) statistic the suggested \(\tau\) statistic by Dickey and Fuller should be used according to the (4.28) equation. In econometrics literatures the \(\tau\) statistic is known as DF test as it has been created by these two people. The adjusted table by Dickey and Fuller for \(\tau\) critical values has been clearly developed by Mackinnon and by using the Monte-Carlo Simulation and now-a-days the software package such as Eviews and Microfit suggest the Dickey-Fuller and Mackinnon critical values for DF test. If absolute value of the calculated \(\tau\) statistic is bigger than that of the suggested \(\tau\) critical value by DF or Mackinnon, the null hypothesis \((H_0)\) will be rejected and that means the time series is stationary but if the opposite happens that is, the absolute value of the calculated \(\tau\) is smaller than that of the suggested critical value, hypothesis \(H_0: \rho = 1\) will be accepted so the \(Y_t\) time series is non-stationary.

Usually by decline \(Y_{t-1}\) from the both ends of (4.24) relation, the following equation is obtained:

\[
Y_t - Y_{t-1} = (\rho - 1)Y_{t-1} + U_t
\]

\[
\Delta Y_t = \delta Y_{t-1} + U_t \quad (4.29)
\]
The null and alternative hypotheses are adjusted as following for the nonstationarity test:

\[ H_0 : \delta = 0 \]
\[ H_1 : \delta < 0 \]

The ordinary statistic for testing of \( \delta = 0 \) is the same \( t \)-statistic in other word \( \tau \) is used in \( \rho = 1 \) test. When (4.24) equation is estimated as (4.29) the estimated \( \delta \) is usually negative thus, a quite big negative \( \tau \) represents the stationarity of \( Y_t \) time series.

It is noteworthy that the unit root test is not on the basis of the usual and standard distributions. Its critical values are obtained by simulation and these values, have been obtained according to particular assumptions.

It is supposed that the equation has no intercept and no time trend. It is also supposed that error terms are distributed independently. In case of rejecting any of the above hypotheses, simulation will obtain various critical values for \( \tau \). Thus, for Dickey-Fuller test, the regression relation is estimated in any of the three following forms in which \( t \) is the time trend, \( \rho = 1 \) or \( \delta = 0 \) that is, the null hypothesis is the same unit root (non-stationarity).

\[ I) \quad Y_t = \rho Y_{t-1} + U_t \quad \text{or} \quad \Delta Y_t = \delta Y_{t-1} + U_t \quad (4.30) \]

\[ II) \quad Y_t = \alpha + \rho Y_{t-1} + U_t \quad \text{or} \quad \Delta Y_t = \alpha + \delta Y_{t-1} + U_t \quad (4.31) \]

\[ III) \quad Y_t = \alpha + \beta_t + \rho Y_{t-1} + U_t \quad \text{or} \quad \Delta Y_t = \alpha + \beta_t + \delta Y_{t-1} + U_t \quad (4.32) \]

The actual process of the production of the time series data might be according to one of the above equation (I, II or III) and the researcher also choose one of the three equations to test the time series stationarity. It is observed that various combinations might exist of what is real and what is considered by the researcher. For instance equation III may be estimated by the researcher, however, in fact merely one of the four following status can be true:

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A) $\alpha = 0$ and $\beta = 0$
B) $\alpha = 0$ and $\beta \neq 0$
C) $\alpha \neq 0$ and $\beta = 0$
D) $\alpha \neq 0$ and $\beta \neq 0$

Therefore, if (A) is true, the right process of the production of data will be equation I, but when equation III is used, intercept and an irrelevant time trend will enter the model. Depending on which of the A to D cases are true and which equation from I to III is used by the researcher different compounding would be developed.

According to the assumption that the null hypothesis is true ($\rho = 1$) and (A) is the actual process of the production of data, Dickey and Fuller have brought out the limiting distribution of the $\tau$ statistic of OLS method. They brought out critical values for $\tau$ statistic related to $\rho = 1$ test have been called $\tau_1$, $\tau_2$, $\tau_3$ for any of the three above equations. Now if the absolute value of the calculated quantity of $\tau$ statistic is more than that of represented critical value of $\tau$ by Dickey-Fuller, the null hypothesis will be rejected and $\rho < 1$ hypothesis will be accepted. That is, the considered time series is stationary. However if absolute value of $\tau$ is smaller than that of the critical value, the time series will have unit root and so will be non-stationary.

### 4.3.1.6 Augmented Dickey–Fuller Test (ADF)

For the non-stationarity test first it was assumed that the time series under discussion possess a first order autoregressive process $[AR (1)]$ and then $\rho = 1$ was tested accordingly. Now if this assumption is not true and the time series has $P$ order autoregressive process $[AR (P)]$, estimating relation for the $\rho$ test will not possess a valid dynamism specification, which leads to the autocorrelation of regression error terms. In the case of autocorrelation of the error terms, the DF test can not be used any more for stationarity as the limiting distribution and the critical values given by Dickey-Fuller are not true. In 1981 Dickey and Fuller\(^\text{25}\) represented that when $U_t$

disturbance terms are autocorrelated and the augmented Dickey-Fuller pattern is used, the limiting distribution and critical values given by them continue to be true.

Suppose $U_t$, disturbance term related to the (4.32) regression equation ($\Delta Y_t = \alpha + \beta_t + \delta Y_{t-1} + U_t$) possess a process of $P$ order stationarity autoregression:

$$U_t = \theta_1 U_{t-1} + \theta_2 U_{t-2} + \cdots + \theta_p U_{t-p} + \epsilon_t$$  \hspace{1cm} (4.33)

in which $\epsilon_t$ is a IID process (that is, $\epsilon_t$s have been distributed similarly and separately).

Now if (4.33) equation is replaced in (4.32), we will have:

$$\Delta Y_t = \alpha + \beta_t + \delta Y_{t-1} + \theta_1 U_{t-1} + \theta_2 U_{t-2} + \cdots + \theta_p U_{t-p} + \epsilon_t$$  \hspace{1cm} (4.34)

If $\rho = 1$ hypothesis is true $U_t = Y_t - Y_{t-1}$ will be resulted from (4.30) equation. According (4.34) equation will be:

$$\Delta Y_t = \alpha + \beta_t + \delta Y_{t-1} + \theta_1 (Y_{t-1} - Y_{t-2}) + \cdots + \theta_p (Y_{t-p} - Y_{t-p-1}) + \epsilon_t$$ 

$$= \alpha + \beta_t + \delta Y_{t-1} + \theta_1 \Delta Y_{t-1} + \cdots + \theta_p \Delta Y_{t-p} + \epsilon_t$$

$$= \alpha + \beta_t + \delta Y_{t-1} + \sum_{i=1}^{p} \theta_i \Delta Y_{t-i} + \epsilon_t$$  \hspace{1cm} (4.35)

Dickey and Fuller indicated that for $\rho = 1$ test in other words, $\delta=0$ in (4.35) equation, the evaluated $T$-statistic has the same $\tau_3$ limiting nonstandard distribution. Thus, the critical values for the $\delta=0$ test and $\tau_3$-statistic are the same. The number of the lag terms which should be noticed in the (4.35) equation are determined experimentally because the level of autoregressive process to the disturbance term usually is not clear.
The aim is that the lag terms should be added to the (4.35) equation until the $\varepsilon_s$ are not correlated. The null hypothesis is continued to be the same $\rho = 1$ or $\delta = 0$, that is, the presence of the unit root test (in other word the $Y_t$ is non-stationary) and the statistic of test is $\tau_3$. In order to distinguish it, it is necessary to evaluate an equation such as (4.35) for the stationarity test. By having a look at the $D.W.$ statistic concerned with the evaluated equation (4.32), if accordingly the presence of the autocorrelation between the error terms becomes clear we can use $\Delta Y_{t-1}$ to remove the autocorrelation. We according to the statistic of $D.W.$ add the sentences one by one to remove the autocorrelation in the error terms of regression. These tests are also called the integration tests because the DF and ADF test can determine whether a time series is integrate or not.

4.3.2 Integration

The tendency to move in the same direction is found in most of the time series of macroeconomics. The reason is that there is a mutual trend among them. If the time series variables, which are non-stationary, are used in estimation the coefficients of pattern, it may be resulted in a suprious regression. Because the tendency is seen, in the variables which possess the trend, even in some cases in which there are not any meaningful economic relation it shows a strong correlation.

In the traditional method, in order to avoid a suprious relation in the time series variables, there should be asserted a time trend variable ($t$) among the independent pattern variables. Adding this variable directly in the regressive equation is resulted in the detrend and causes the effect of the trend on the pattern variables to be omitted. So the estimated coefficients of the pattern show the pure effect of the variables on each other.

A group of econometrists have questioned the discussed traditional method. According to them, the method is accepted if the time trend of the variables are definite and not the stochastic one. When the time series variables are the stationary - trend, the suprious regression can be prevented by adding a time trend among the variables. However, a regression with these variables can be performed on the time
trend so their residuals without any trend can be used as the stationary variables in the estimation of the pattern coefficients. As a result, the suprious regression can be avoided. However, when the time series variables are not stationary – trend, adding the time trend $T$ to the variables or reducing the absolute trend from the variables is resulted in the stationarity of these variables. So applying the common methods of econometrics through the nonstationarity statistical data causes the $F$ and $t$-tests not to have enough validity so the researcher is led to the improper inferences about the intensity and the value of the relationship between the variables. In order to distinguish whether an estimated regression is suprious or not, the coefficient of determination ($R^2$) should be higher than the statistic of Durbin-Watson test. In this case the only solution to achieve the stationary variables is using the difference of each variable in the regression. So we can prevent the suprious regression.

Now the question is whether there will be any other problems or not if we use the first order difference or most of the time series variables. It should be responded that when we use the differences in estimating a pattern coefficient, we lose so many valuable information related the variables level. Thus, although the stationarity condition of the time series variables in a regressive equation can be obtained through differentiating. But we can not do anything special to solve the long-run information concerned with the variables level. So in this case the integrated method can help us to estimate the regression, assuring that it is not a suprious one, which is done according to the time series variables.

4.3.2.1 The Definition of Integration

Suppose that the theory of economy remarks that there is an equilibrium relation between the two variables $X$ and $Y$.

$$Y^* = \beta X^* \quad (4.36)$$

$X^*$ and $Y^*$ the $X$ and $Y$ equilibrium values. So when $Y$ moves on its own equilibrium path constantly, according to the definition of the equation (2.36) it is expected:
But practically the equilibrium values of \(X\) and \(Y\) is not usually perceptible and the value of each is only available at the \(t\) time. So even if there is an equilibrium equation between \(X\) and \(Y\) according to the theory of economy, the values of \(X_t\) and \(Y_t\) is not necessarily true in the equation (4.37) in any \(t\) cross section. So in the situations, which the variables of \(X\) and \(Y\) have not reached to their long lasting and constant equilibrium values, a equation such as the following can only be mentioned:

\[ Y_t = \beta X_t + U_t \]  
(4.38)

in which the \(U_t\) can be regarded as the error of non-equilibrium. So it can be stated that if the equilibrium meaning related to the two variables of \(X\) and \(Y\), it is expected that the error term to the \(U_t\) non-equilibrium fluctuates about its mean and a systematic tendency to its smallness is seen in the period of time. The minimum condition which is necessary, in this regard, for the equilibrium is that the involved variables related the equilibrium equation (4.38) in the period of time should not be separated and spaced. In such cases, it is said idiomatically that the two variables \(X\) and \(Y\) are integrated. So the integrative economic means that two or many time series variables are related to each other, according to the theoretical base, to form a long-run equilibrium relation. Although these time series may have the stochastic trend (non-stationary), they follow each other properly in the period of time so that the difference between them is stable (stationary). Thus the meaning of integration represents a long-run equilibrium relation in which the economic system moves towards it during the period of time.

Now we turn to the definition of integration according to its theoretical basis. We have previously mentioned that if it is necessary to differentiate a time series with \(d\) times in order to keep it stationary, it contains \(d\) unit root and it is said that it is an integrated one with the \(d\) rank or \(I(d)\). Now consider the two time series \(X_t\) and \(Y_t\) which are both \(I(d)\). As usual every linear combination of \(X_t\) and \(Y_t\) is also \(I\) \((d)\). But if
the fix coefficients such as $\alpha$ and $\beta$ are existed so that the disturbance term related to $X_t$ and $Y_t$, that is, $U_t = Y_t - \alpha + \beta X_t$ possess an integrated rank less than $d$, for example $I(d-b)$ and $(b>0)$, then Engle and Granger (1987) defines that $X_t$ and $Y_t$ are the integrated one with $(d,b)$ rank. So the two time series $X_t$ and $Y_t$ are the integrated ones with $d$ and $b$ rank, that is, $I(d,b)$ if:

1) The integrated rank in both is the same and equals to $I(d)$.

2) There is a linear combination of them in which the integration is of $(d-b)$ rank, that is $I(d-b)$ and $(b>0)$.

Considering the mentioned definition, if both $X_t$ and $Y_t$ are from the similar integrated rank $I(1)$ and $U_t \sim I(0)$, the two integrated time series will be of $I(1,1)$ rank. This definition can be augmented in more than two time series (Engle and Granger 1987).

So far, many different kinds of methods have been suggested for integration test. A simple method for this purpose is Dickey and Fuller (DF) and Augmented Dickey and Fuller (ADF) on the $U_t$ terms estimated through an integrated regression which is known as the Engle-Granger (EG) and Augmented Engle-Granger (AEG) test.

4.3.2.2 Engle-Granger (EG) and Augmented Engle-Granger (AEG) Test for Integration

The EG and AEG test method defines that we should first estimate a regression such as the (4.29) with the OLS method. So we can have its error terms as result. Thus through the method of DF or ADF we estimate the non-stationary of the error terms. If the error terms are stationary, we will arrive at the result that the discussed variables are integrated. As an example, consider the time series $X_t$ and $Y_t$ are both integrated of the $I(1)$ rank. In order to test the integration of these two variables, we estimate the following equation with the OLS method.

$$Y_t = \beta X_t + U_t$$

The null hypothesis, which states the integration between the two variables $X_t$ and $Y_t$ is written as follow:
\[ H_0: U_t \sim I(1) \]

That means is, the two variables \( X_t \) and \( Y_t \) are not integrated. The alternative hypothesis states that:
\[ H_1: U_t \sim I(0) \]
That means, the two variables are integrated. Now we can use DF test or ADF to test the non-stationarity of the disturbance term of \( U_t \) as it has been explained above. But the main point is that because the real value of \( \beta \) is not clear and we use its estimation in estimating the values of \( U_o \) the critical values of DF and ADF are not suitable to test the non-stationarity of \( U_t \). There are two major reasons for it. The first one is that the structures of OLS method select such estimation for the coefficients which the error terms have the smallest sample variance. Thus even if the variables are not integrated, this makes the error terms seem more stationary. So using the normal critical values of Dickey – Fuller causes the null hypothesis to be more rejected. The second reason is that the distribution of its test statistic is influenced by number of explanatory variables which is brought in regression. Considering the mentioned points, Engle and Granger have accounted the critical values of DF and ADF for the integrated test. Therefore, DF and ADF tests are being known as the EG and AEG tests.

It is noteworthy the integrated test based on the non-stationarity test in the disturbance terms of regression with ADF method is based on the assumption that the present variables in the regressive equation are all \( I(1) \). So that’s why in this test the null hypothesis is considered the one with the disturbance terms \( I(1) \), that is, \[ H_0: U_t \sim I(1) \] and the alternative hypothesis states that the disturbance terms is \( I(0) \), this is, \[ H_1: U_t \sim I(0) \]. But in some cases, some of these variables may be \( I(2) \) in regression which contradicts with the \( I(1) \) hypothesis of the variables, if some of the variables are \( I(2) \), there is still the possibility of the integration of variables provided that between the variables of \( I(2) \) there should be a linear combination of \( I(1) \) to develop a linear combination of \( I(0) \) with the other variables of \( I(1) \). In this case Haldrup (1994) shows that the critical values of ADF makes a regressive correlation
for each distributive variables of $I(1)$ and $I(2)$. So if there is a combination of the variables $I(1)$ and $I(2)$ in the integrated regression, we should use the critical values given by Haldrup. [See Table in appendix A]. in this table, number of distributive variables of the equation which are $I(1)$ have been represented with $m_1$ and other distributive variables which are $I(2)$ have been represented with $m_2$.

4.3.3 Dynamic Models

Integration among a series of economic variables means a long-run equilibrium relation between the variables while we can perfectly develop a consistent estimation from the model coefficients by using OLS method. For instance, when the integration of the two variables $X_t$ and $Y_t$ is approved in accordance with the necessary tests, we come to the conclusion that there is a long-run equilibrium relation, such as the following, between the two variables.

$$Y_t = \beta X_t + U_t \quad (4.39)$$

We can estimate $\beta$ parameter in OLS method. As it has been mentioned at the beginning of the discussion concerning the integration issue, when there is $U_t \sim I(0)$ the estimator of OLS is a super consistent. The reason to assign the term, super consistent, in this regard is when the sample size (n) increases, $\beta$ with the $\frac{1}{n}$ rate is inclined towards its own real value. However, when the regressive equation variables are stationary, concerning the ordinary assumption, the integration rate is $\frac{1}{\sqrt{n}}$. So we see when the variables are integrated, the speed of $\beta$ integration is much faster than its real value.

Unfortunately when the sample size is small, the OLS method in estimating the long-run equation can not be suggested because of not considering the present short term dynamic reactions among the variables, it dose not represent an unbiased estimate. Consequently performing a hypothesis test by using the statistics of an
ordinary test is not valid. Inder (1993)\textsuperscript{26} and Banerjee and others (1994)\textsuperscript{27} by using Monte-carlo simulation method, shown that, in the small samples it is possible bias of estimation is more considerable. Stock (1987)\textsuperscript{28} indicated that the value of this bias proportionate with $\frac{1}{n}$, it is so significant in the small samples (small n). Thus it seems logical to consider the estimation of such a complete model which contains the short term dynamism in itself and causes the model coefficients to be estimated much more acutely.

4.3.3.1 Autoregressive Distributed Lag Model (ARDL)

According to Bauwens, Lubrano and Richard (1999)\textsuperscript{29} ARDL is certainly one of the most widely used models in applied econometrics. According to Pesaran and Shin (1995),\textsuperscript{30} econometric analysis of long-run relations have been the focus of much theoretical and empirical research in economics. In the case where the variables in the long-run relation of interest are trend stationary, the general practice has been to de-trend the series and to model the de-trended series as stationary distributed lag or ARDL models. Estimation and inference concerning the long-run properties of the model are then carried out using standard asymptotic normal theory.

It is the simplest type of the dynamic model which can be adjusted for the long - run stationarity equation in order to achieve estimation nearly unbiased from the coefficient of the long-run model is the following dynamic model.

$$Y_t = \gamma_0 X_t + \gamma_1 X_{t-1} + \alpha Y_{t-1} + U_t \quad (4.40)$$


\textsuperscript{29} Bauwens, Luc, Michel Lubrano, and Jean-Francois Richard (1999), \textit{Bayesian Inference in Dynamic Econometric Models}, Oxford University Press, First Published.

Doing a brief algebraic process we can write the following equation:

\[ Y_t = \beta X_t + \theta_1 \Delta X_t + \theta_2 \Delta Y_t + V_t \]  \hspace{1cm} (4.41)

In which:

\[ \beta = \frac{\gamma_0 + \gamma_1}{1 - \alpha} \]

\[ \theta_1 = -\frac{\gamma_1}{1 - \alpha} \]

\[ \theta_2 = -\frac{\alpha}{1 - \alpha} \]

\[ V_t = \frac{U_t}{1 - \alpha} \]

So the estimation of the long-run value of \( \beta \) coefficients from the stationarity equation (4.40) equals with the estimation of \( \beta \) coefficients from the dynamic equation (4.41). The variables \( \Delta X_t \) and \( \Delta Y_t \) in this equation cause the bias concerning the \( \beta \) parameter to be eliminated in accordance with a small sample. As it is noticed in (4.41) equation, the short term model is inclined to the long-run model if \( \alpha < 1 \).

It is preferred that in order to decrease the bias regarding the estimation of the model coefficients in small samples, we should take, so far as possible, the dynamic model which considers so many lags for the variables. So instead of estimating (4.40) equation, it is preferred to estimate the following equation:

\[ A(L) Y_t = \beta(L) X_t + U_t \]  \hspace{1cm} (4.42)
In this equation, $A(L)$ the lag function is taken as $1 - \alpha_1 L - \alpha_2 L^2 - \ldots - \alpha_p L^p$ and $\beta (L)$ the lag function is taken as $\gamma_0 + \gamma_1 L + \gamma_2 L^2 + \cdots + \gamma_q L^q$ and $L^r X_t = X_{t-r}$. In order to find the estimation of long-run parameter of $\beta$, we can account the $\hat{\beta}$ value through (4.42) equation as the following:

$$\hat{\beta} = \frac{\sum_{q=0}^{q} \hat{\gamma}_q}{1 - \sum_{i=1}^{p} \hat{\alpha}_i} \quad (4.43)$$

The standard deviation of $\hat{\beta}$ can also be accounted by using algorithm so the $T$-statistic value regarding the long-run estimated coefficient is also countable. Inder (1993)\(^{31}\) shows that the $T$ statistics of this type, possess the limited normal distribution and the $t$ - test on the basis of the ordinary critical values, have a desirable power. Thus by using $\hat{\beta}$ we can perform many valid tests about the presence of a long-run relation.

Besides presenting an unbiased estimation from $\beta$ long-run parameter along with its valid $T$- statistic, the estimation of the equation (4.42) paves the way to perform the unit root test of the nonintegrated null hypothesis. Because the dynamic model (4.42) tends towards the long-run equilibrium, the sum total $\alpha_i (I = 1, \ldots, p)$ should be less than one. Now if we divide $(\sum \hat{\alpha}_i - 1)$ to the sum total of the standard deviation of these coefficients, a test statistic of the $t$ – statistic type will be resulted that we can compare its value with the presented critical values by Benerjee, Dolado and Mestre (1992)\(^ {32}\) to perform the test.

We can specify the number of the optimum lags for each regressive variable by using one of the standards of Akaike Information Criterion (AIC), Schwaz-Bayesian Criterion (SBC), Hannon-Quinn Criterion (HQC) or $R^2$. The Microfit package has

---


made the possibility to estimate an autoregressive distributed lag model ARDL 
\((p,q_1,q_2, \ldots, q_k)\) as follows:

\[
Q(L,P)Y_t = \sum_{i=1}^{k} \beta_i(L,q_i) X_{it} + \delta W_t + U_t \tag{4.44}
\]

in which:

\[
Q(L, P) = 1 - Q_1 L - Q_2 L^2 - \cdots - Q_p L^p
\]

\[
\beta_i(L,q_i) = 1 - \beta_{11} L - \beta_{i2} L^2 - \cdots - \beta_{iq} L^q
\]

is for \(i = 1, 2, \ldots, K\). \(L\) is a lag operator, \(W_t\) is a vector of the define variables (non-stochastic) such as intercept of trend variable, dummy variables or exogenous variables with the stable lags. The Microfit package first estimate the equation (4.35) with OLS method for all the possible compounds of \(P = 0, 1, 2, \ldots, m\) and \(q_i = 0, 1, 2, \ldots, m\) and \(i = 1, 2, \ldots, k\) value, that is, it estimates \((m+1)^{k+1}\) time. The maximum lags (m) are being determine by the researcher and the estimation is being done in the time limit of \(t = m+1\) to \(t= n\). So in the second stage the researcher, considering the standard of AIC, SBC, HQC or \(\bar{R}^2\), is allowed to select one out of the estimated regression \((m+1)^{k+1}\). In the third stage the Microfit package accounts the coefficients concerning with the long-run model and the standard deviation of asymptote concerning with the long-run coefficients which are selected according to the ARDL model. The long-run coefficients of the regressive variables are evaluated according to the following equation:

\[
\hat{\phi}_i = \frac{\hat{\beta}_{i0} + \hat{\beta}_{i1} + \cdots + \hat{\beta}_{i\hat{p}}}{1 - \hat{\alpha}_1 - \hat{\alpha}_2 - \cdots - \hat{\alpha}_{\hat{p}}} \tag{4.45}
\]

And

\[
i = 1, 2, \ldots, k
\]

in which \(\hat{p}\) and \(\hat{\phi}_i\) (with \(i = 1, 2, \ldots, k\)) are selected values of \(p\) and \(q_i\) according to the mentioned standards.
4.4 Estimation Models and Interpretation

4.4.1 Time Series Analysis

4.4.1.1 Statistical Population

In the presented models is has been attempted to bring out the statistical data from one source so far as possible in order to lessen the error probability. However, due to the shortage of the required information, various sources have been used out of necessity.

Statistical population is macro data connected with gross domestic product, physical capital and employed manpower which required higher education, lacking of higher education and current expenditure of higher education and researches. The above – mentioned data is as annual time series and duration of this study is 1971 to 1996. The source used for the data regarding the gross domestic product is the statistical set of time series of socio-economics data till 1996 in the management and programming organization of Islamic Republic of Iran. However, the studies source for the time series data of physical capital and employment are Amini, Nahavandi and Saffaripour (1998), the current expenditure of higher education and researches, Vahidi (1996), as well as, the statistical annals of statistical center of Iran. All information has been accounted according to the constant prices in 1990.

4.4.1.2 Presentation of Model Variables

1) Real Gross Domestic Product (GDP): Gross domestic product Measure of all goods and services produced within the country in one year. Real GDP measured in units of constant value (Dornbusch R. Fischer S. and Startz R. 2001).

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34 Vahidi, P. (1986), Analysis of Cost in Higher education, Program and Budget Organization of Islamic Republic of Iran.
2) Physical Capital ($K$): Physical capital is the total values of the capital equipment such as buildings, installations and machinery in various economic sections.

3) Labor ($L$): By labor researcher mean all the employees above ten years who are considered employed according to the public census of the country.

4) Educated Manpower ($EL$) and Non-Educated Manpower ($NEL$): Among the employees, those who have higher education are considered as the educated manpower, and the rest are non-educated manpower.

5) Current Expenditure of Higher Education and Research ($RC$): The current expenditure of the higher education are not used for the capitalization but for doing a series of educational works such as equipment and the educational materials, educational and non-educational expenditure for the staff and all the expenditures used to promote the educational quality during a year.

Table (4.1)
Model Variables

<table>
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<tr>
<th>Year</th>
<th>GDP</th>
<th>K</th>
<th>EL</th>
<th>NEL</th>
<th>L</th>
<th>RC</th>
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<td>7893646</td>
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<td>7998.3</td>
<td>189363</td>
<td>8230247</td>
<td>8419610</td>
<td>138.55</td>
</tr>
<tr>
<td>Year</td>
<td>GDP</td>
<td>Total Employed</td>
<td>Physical Capital</td>
<td>Labor Productivity</td>
<td>Capital Productivity</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-----</td>
<td>----------------</td>
<td>------------------</td>
<td>-------------------</td>
<td>---------------------</td>
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</tr>
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<td>8427179</td>
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<tr>
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<td></td>
</tr>
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<td>596136</td>
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<td>699766</td>
<td>11757874</td>
<td>12457640</td>
<td></td>
</tr>
<tr>
<td>1991</td>
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<td>14929.9</td>
<td>809001</td>
<td>12357950</td>
<td>13166951</td>
<td></td>
</tr>
<tr>
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<td>16332.5</td>
<td>897603</td>
<td>12529367</td>
<td>13426970</td>
<td></td>
</tr>
<tr>
<td>1993</td>
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</tr>
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Sources: (1) Management and Programming Organization of Islamic Republic of Iran, Statistical Set of Time Series of Socio-Economics Data.
(2) Statistical Center of Iran, Statistical Annals.

**Figure (4.1)**
GDP Trend
Figure (4.4)
Educated Manpower Trend

Figure (4.5)
Non-Educated Manpower Trend
4.4.1.3 Unit Root Test
To do the unit root test, the ADF was used. As it was mentioned before, this is the most useful test in practice. To determine the stationarity, each and every variable was tested through ADF in the form of logarithm and the results has been mentioned in table 4.2. Due to the ADF statistic and its comparison with the critical values of each variable, all variables possess unit root (non-stationarity) except the variable of the current expenditure of higher education and researches ($LnRC$) in which the unit root hypothesis is not accepted in five per cent at the significance level, that is $LnRC$ is stationary. To eliminate the stationarity, the first difference of each variable was obtained and the ADF test was done again and the value of the statistic was compared with the critical values. The unit root hypothesis was not accepted for labor ($LnL$), educated manpower ($LnEL$) and non-educated manpower ($LnNEL$) variables in five per cent confidence level. Thus, these variables become stationary by one time first differentiation. The real gross domestic product ($LnGDP$) and physical capital ($LnK$) variables possess unit root in five per cent at the significance level and are non-stationary. To remove the non-stationarity of these variables, for second time their first difference were obtained and the ADF test was done by comparing this statistic with the critical values in five per cent at the significance level. The unit root was not accepted. Thus, these variables are stationary by two times first difference.

**Table (4.2)**

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Due to the results of the unit root test and non-stationarity of a number of variables, on the level and some on the first difference, it is difficult to estimate the suggested models according to the methods like Johansen-Josilius as the data are compound in the degrees of non-stationarity. However, for estimation we can use the two – steps method of Engle-Granger and dynamic model of ARDL.

### 4.4.2 The Estimation of Models

In order to determine a suitable method to estimate the suggested models, first the stationarity status of the used variables was studied due to the presented models and data in the previous section, then the best method for estimation was selected according to the test results. Unit root test and models estimation has been done with Microfit (4.0) software.

#### 4.4.2.1 The Estimation of the Model with Two Steps Engle – Granger's Method
In Engle-Granger method, first we estimate the regression through OLS method and then we get its error terms. Then we test, through ADF the non-stationarity of the error terms. If the error terms are stationary, we will conclude that the studied variables are integrated so there will be a long-run equilibrium relation between them.

It is noteworthy that the integration test based on the non-stationarity test of the disturbance term, through ADF method, is based on the assumption that the present variables in the regression equation are all \( I(1) \). But if some of the variables are \( I(2) \), there will be still the possibility of integration among the variables provided that there should be a linear combination \( I(1) \) among the variable \( I(2) \) to generate a linear combination \( I(0) \) with the other variables of \( I(1) \). In such case we can not use the ordinary critical values any more and we should use the estimated critical values suggested by Haldrup\(^\text{36}\) (Noferesti 1999)\(^\text{37}\). These values are brought in appendix A.

4.4.2.1.1 The Classical Model's Estimation

The classical model is as follows:

\[
\ln GDP = \ln A + \alpha \ln K + \beta \ln L \quad (4.46)
\]

The result arises from the estimation of the model, through OLS method, shown on Table 4.3. As the table shows, the results seem to be desirable but this regression may be a spurious regression. In order to study the presence of a spurious regression, the unit root test of ADF was done and the result of it has been presented in Table 4.4.

**Table (4.3)**

Ordinary Least Squares Estimation

---


Dependent variable is Ln GDP

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln K</td>
<td>.36070</td>
<td>.061256</td>
<td>5.8883 [.000]</td>
</tr>
<tr>
<td>Ln L</td>
<td>.51019</td>
<td>.034034</td>
<td>14.9906 [.000]</td>
</tr>
<tr>
<td>Intercept</td>
<td>.0045909</td>
<td>.0018136</td>
<td>2.5314 [.019]</td>
</tr>
<tr>
<td>Shock</td>
<td>.22052</td>
<td>.057237</td>
<td>3.8528 [.001]</td>
</tr>
</tbody>
</table>

R-squared     .96552  R-bar-squared .96082
S.E. of regression .057112  F-stat. F(3,22) 205.3460 [.000]
Mean of dependent variable 11.9661  S.D. of dependent variable .28852
Residual sum of squares .071760  Equation log-likelihood 39.7105
Akaike Info. Criterion 35.7105  Schwarz Bayesian criterion 33.1943
DW-statistic 1.1439

Diagnostic Tests

<table>
<thead>
<tr>
<th>Test statistics</th>
<th>LM version</th>
<th>F version</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: serial correlation</td>
<td>CHSQ(1)=4.1273 [.042]</td>
<td>F(1,21)=3.9626 [.060]</td>
</tr>
<tr>
<td>B: functional form</td>
<td>CHSQ(1)=4.0958 [.043]</td>
<td>F(1,21)=3.9267 [.061]</td>
</tr>
<tr>
<td>C: normality</td>
<td>CHSQ(2)=.70801 [.702]</td>
<td>Not applicable</td>
</tr>
<tr>
<td>D: heteroscedasticity</td>
<td>CHSQ(1)=.45919 [.496]</td>
<td>F(1,24)=.43149 [.518]</td>
</tr>
</tbody>
</table>

A: Lagrange multiplier test of residual serial correlation.
B: Ramsey’s RESET test using the square of the fitted values.
C: Based on a test of skewness and kurtosis of residuals.
D: Based on the regression of squared residuals on squared fitted values.

Source: Author calculation by Microfit (4.0). See appendix B14.
95% critical value for the Dickey – Fuller statistic = -4.5852  
LL = Maximized log-likelihood  
SBC = Schwarz Bayesian Criterion  
AIC = Akaike Information Criterion  
HQC = Hannan – Quinn Criterion  
Source: Author calculation by Microfit (4.0). See appendix B14.

The value of the test statistics is -4.2206. As the critical value of ADF is a 95 per cent limits of confidence equal with -4.5852, the unit root test hypothesis (non-stationarity) of the residual is accepted, therefore, the regression of Table 2.2 is a suprious one.

4.4.2.1.2 The Estimation of Cobb-Douglas Production Function in the Conventional and Augmented Form

The Cobb - Dougls model is as follows:

\[
\ln GDP = \ln A + \alpha \ln K + \beta \ln EL + \gamma \ln NEL
\]  
(4.47)

The result arises from the estimation of the model, through OLS method, shown in Table 4.5. As the table shows, the results seem to be desirable but this regression may be a suprious regression. In order to study the presence of a suprious regression, the unit root test of ADF was done and the result of it has been presented in Table 4.6.

### Table (4.5)
**Ordinary Least Squares Estimation**

**Dependent variable is Ln GDP**

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln K</td>
<td>.31756</td>
<td>.047273</td>
<td>6.7176 [.000]</td>
</tr>
<tr>
<td>Ln EL</td>
<td>.45176</td>
<td>.10233</td>
<td>4.4146 [.000]</td>
</tr>
<tr>
<td>Ln NEL</td>
<td>.20633</td>
<td>.072594</td>
<td>2.8422 [.010]</td>
</tr>
<tr>
<td>Intercept</td>
<td>-.024047</td>
<td>.0069681</td>
<td>-3.4511 [.002]</td>
</tr>
</tbody>
</table>
Diagnostic Tests

<table>
<thead>
<tr>
<th>Test statistics</th>
<th>LM version</th>
<th>F version</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: serial correlation</td>
<td>CHSQ(1)=1.2044 [.272]</td>
<td>F(1,20)=.97145 [.336]</td>
</tr>
<tr>
<td>B: functional form</td>
<td>CHSQ(1)=1.2358 [.266]</td>
<td>F(1,20)=.99803 [.330]</td>
</tr>
<tr>
<td>C: normality</td>
<td>CHSQ(2)=.89754 [.638]</td>
<td>Not applicable</td>
</tr>
<tr>
<td>D: heteroscedasticity</td>
<td>CHSQ(1)=.15848 [.691]</td>
<td>F(1,24)=.14719 [.705]</td>
</tr>
</tbody>
</table>

A: Lagrange multiplier test of residual serial correlation.
B: Ramsey’s RESET test using the square of the fitted values.
C: Based on a test of skewness and kurtosis of residuals.
D: Based on the regression of squared residuals on squared fitted values.

Source: Author calculation by Microfit (4.0). See appendix B15.

Table (4.6)
Unit Root Tests for Residual

<table>
<thead>
<tr>
<th>Intercept</th>
<th>Ln K</th>
<th>Ln EL</th>
<th>Ln NEL</th>
<th>Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Statistic</td>
<td>LL</td>
<td>AIC</td>
<td>SBC</td>
<td>HQC</td>
</tr>
<tr>
<td>DF</td>
<td>-2.7113</td>
<td>37.2651</td>
<td>36.2651</td>
<td>35.6761</td>
</tr>
<tr>
<td>ADF (1)</td>
<td>-3.4181</td>
<td>39.0581</td>
<td>37.0581</td>
<td>35.8800</td>
</tr>
</tbody>
</table>

95% critical value for the Dickey – Fuller statistic = -5.0236

LL = Maximized log-likelihood  AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion  HQC = Hannan – Quinn Criterion

Source: Author calculation by Microfit (4.0). See appendix B15.
The value of the test statistics is -3.4181. As the critical value of ADF is a 95 per cent limits of confidence equal with -5.0236, the unit root test hypothesis (non-stationarity) of the residual is accepted, therefore, the regression of the table (2.4) is a suprious one.

4.4.2.1.3 The Estimation of Cobb-Douglas Production Function in the Non-Conventional Form

The Cobb-Dougls non-conventional model is as follows:

\[
Ln \ GDP = Ln A + \alpha Ln K + \beta Ln L + \gamma Ln RC \quad (4.48)
\]

The result arises from the estimation of the model, through OLS method, shown in Table 4.7. As the table shows, the results seem to be desirable but this regression may be a suprious regression. In order to study the presence of a suprious regression, the unit root test of ADF was done and the result of it has been presented in Table 4.8.

<table>
<thead>
<tr>
<th>Table (4.7) Ordinary Least Squares Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable is Ln GDP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln K</td>
<td>.31274</td>
<td>.058900</td>
<td>5.3097 [.000]</td>
</tr>
<tr>
<td>Ln L</td>
<td>.51799</td>
<td>.030981</td>
<td>16.7196 [.000]</td>
</tr>
<tr>
<td>Ln RC</td>
<td>.064654</td>
<td>.026752</td>
<td>2.41681 [.025]</td>
</tr>
<tr>
<td>Intercept</td>
<td>.0045413</td>
<td>.0016421</td>
<td>2.7656 [.012]</td>
</tr>
<tr>
<td>Shock</td>
<td>.21681</td>
<td>.051842</td>
<td>4.1821 [.000]</td>
</tr>
<tr>
<td>R-squared</td>
<td>.97302</td>
<td>R-bar-squared</td>
<td>.96788</td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>.051706</td>
<td>F-stat. F(4,21)</td>
<td>189.3583 [.000]</td>
</tr>
</tbody>
</table>
Mean of dependent variable 11.9861
S.D. of dependent variable .28852
Residual sum of squares .056144
Equation log-likelihood 42.9008
Akaike Info. Criterion 37.9008
Schwarz Bayesian criterion 34.7555
DW-statistic 1.2287

Diagnostic Tests

<table>
<thead>
<tr>
<th>Test statistics</th>
<th>LM version</th>
<th>F version</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: serial correlation</td>
<td>CHSQ(1)=3.3396 [.068]</td>
<td>F(1,20)=2.9476 [.101]</td>
</tr>
<tr>
<td>B: functional form</td>
<td>CHSQ(1)=.018435 [.892]</td>
<td>F(1,20)=.014191 [.906]</td>
</tr>
<tr>
<td>C: normality</td>
<td>CHSQ(2)=1.4323[.489]</td>
<td>Not applicable</td>
</tr>
<tr>
<td>D: heteroscedasticity</td>
<td>CHSQ(1)=.73089 [.393]</td>
<td>F(1,24)=.69419 [.413]</td>
</tr>
</tbody>
</table>

A: Lagrange multiplier test of residual serial correlation.
B: Ramsey’s RESET test using the square of the fitted values.
C: Based on a test of skewness and kurtosis of residuals.
D: Based on the regression of squared residuals on squared fitted values.
Source: Author calculation by Microfit (4.0). See appendix B16.

Table (4.8)

<table>
<thead>
<tr>
<th>Unit Root Tests for Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>:Based on OLS regression of Ln GDP on</td>
</tr>
<tr>
<td>Intercept</td>
</tr>
<tr>
<td>26 observations used for estimation from 1971 to 1996</td>
</tr>
<tr>
<td>Test Statistic</td>
</tr>
<tr>
<td>DF</td>
</tr>
<tr>
<td>ADF (1)</td>
</tr>
</tbody>
</table>

95% critical value for the Dickey – Fuller statistic = -5.0236
LL = Maximized log-likelihood  AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion  HQC = Hannan – Quinn Criterion
Source: Author calculation by Microfit (4.0). See appendix B16.

The value of the test statistics is -2.8913. As the critical value of ADF is a 95 per cent limits of confidence equal with -5.0236, the unit root test hypothesis (non-
stationarity) of the residual is accepted, therefore, the regression of the table (2.6) is a suprious one.

4.4.2.2 The Estimation of the Model with the Dynamic Autoregressive Distributed Lag Method

The dynamic autoregressive distributed lag model is one of the effective methods for estimate the long-run equipment equations. The ARDL modeling approach has numerous advantages in comparison to standard cointegration methods such as Engle and Granger (1987) and Johansen (1995). First, the ARDL can be applied irrespective of whether the underlying variables are of equal integration (e.g., integrated of order one, or $I(1)$). The model is thus relieved of the burden of pre-testing for unit roots among variables (Pesaran et al. 2001). Second, the ARDL is more robust and performs better for small sample sizes than other cointegration techniques (Pesaran and Shin 1999).

In this method, first, we must estimate equation with OLS method for all possible compounds on the bases of the lagged levels of the equation variables. Second, we select one of the estimated regressions according to the four criterions $R^2$, AIC, SBC and HQC. Then the coefficients related to the long-run and the asymptotic error related to the long-run coefficients is resulted according to the selectd ARDL method. Now-a-days performing the ARDL method is easily possible with the appearance of the softwares such as Eviews and Microfit.

4.4.2.2.1 The Estimation of the Classical Model

---

To estimate the model, according to SBC, among various regressions and maximum three lags, the Microfit selected a regression in which three lags for the labor variable (LnL), and no lag for the gross domestic product (Ln GDP) and physical capital (Ln K) were considered. The results have been shown in Table 4.9 and 4.10.

Table (4.9)
ARDL(0,0,3) selected based on Schwarz-Bayesian Criterion
Dependent variable is LnGDP

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LnK</td>
<td>.51348</td>
<td>.038272</td>
<td>13.4167 [.000]</td>
</tr>
<tr>
<td>LnL</td>
<td>3.5066</td>
<td>.64167</td>
<td>5.4649 [.000]</td>
</tr>
<tr>
<td>LnL(-1)</td>
<td>-.99805</td>
<td>1.0259</td>
<td>-.97287 [.343]</td>
</tr>
<tr>
<td>LnL(-2)</td>
<td>-.082815</td>
<td>1.0238</td>
<td>-.080893 [.936]</td>
</tr>
<tr>
<td>LnL(-3)</td>
<td>-2.0100</td>
<td>.62894</td>
<td>-3.1958 [.005]</td>
</tr>
<tr>
<td>INTERCEPT</td>
<td>.012138</td>
<td>.0024588</td>
<td>4.9365 [.000]</td>
</tr>
<tr>
<td>SHOCK</td>
<td>-.12000</td>
<td>.035520</td>
<td>-3.3783 [.003]</td>
</tr>
<tr>
<td>R-squared</td>
<td>.98600</td>
<td></td>
<td>.98158</td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>.039156</td>
<td>F-stat. F(6,19)</td>
<td>223.0666 [.000]</td>
</tr>
<tr>
<td>Mean of dependent variable</td>
<td>11.9861</td>
<td>S.D. of dependent variable</td>
<td>.28852</td>
</tr>
<tr>
<td>Residual sum of squares</td>
<td>.029131</td>
<td>Equation log-likelihood</td>
<td>41.4304</td>
</tr>
<tr>
<td>Akaike Info. Criterion</td>
<td>44.4304</td>
<td>Schwarz Bayesian criterion</td>
<td>40.0271</td>
</tr>
</tbody>
</table>
DW-statistic  
1.9466

Diagnostic Tests

<table>
<thead>
<tr>
<th>Test statistics</th>
<th>LM version</th>
<th>F version</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: serial correlation</td>
<td>CHSQ(1)=.025327[.874]</td>
<td>F(1,18)=.017551[.896]</td>
</tr>
<tr>
<td>B: functional form</td>
<td>CHSQ(1)=1.1253[.289]</td>
<td>F(1,18)=.81431[.379]</td>
</tr>
<tr>
<td>C: normality</td>
<td>CHSQ(2)=.75342[.686]</td>
<td>Not applicable</td>
</tr>
<tr>
<td>D: heteroscedasticity</td>
<td>CHSQ(1)=.34101[.559]</td>
<td>F(1,24)=.31897[.577]</td>
</tr>
</tbody>
</table>

A: Lagrange multiplier test of residual serial correlation.
B: Ramsey’s RESET test using the square of the fitted values.
C: Based on a test of skewness and kurtosis of residuals.
D: Based on the regression of squared residuals on squared fitted values.

Source: Author calculation by Microfit (4.0). See appendix B17.

**Tabel (4.10)**

**Estimated Long-run Coefficients the ARDL Approach**

ARDL (0,0,3) selected based on Schwarz-Bayesian criterion

Dependent variable is Ln GDP

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LnK</td>
<td>.51348</td>
<td>.038272</td>
<td>13.4167[.000]</td>
</tr>
<tr>
<td>LnL</td>
<td>.41581</td>
<td>.021389</td>
<td>19.4406[.000]</td>
</tr>
<tr>
<td>Intercept</td>
<td>.012138</td>
<td>.0024588</td>
<td>4.9365[.000]</td>
</tr>
<tr>
<td>SHOCK</td>
<td>-.12000</td>
<td>.035520</td>
<td>-3.3783[.003]</td>
</tr>
</tbody>
</table>

Source: Author calculation by Microfit (4.0). See appendix B17.

All of the estimating coefficients are highly significant statistically. The results have represent that if the physical capital increase by one percent, the real gross domestic product will be increased by 0.51 per cent and if the labor increase one percent, the real gross domestic product will be increased by 0.42 per cent.

To study the tendency of the model to the long-run equilibrium, it is needed to get the sum coefficients of dependent variable. If they are less than one, the model tends to the long-run equilibrium. In this model because of that the dependent variable
(LnGDP) do not has lag, then the sum coefficients of dependent variable is equal zero. So, the model tends towards the long-run equilibrium.

4.4.2.2 The Estimation of Cobb-Douglas Production Function in the Conventional and Augmented Form

To estimate the model, according to SBC, among various regressions and maximum three lags, the Microfit selected a regression in which three lags for the non-expert employee (LnNEL), and no lag for the gross domestic product (Ln GDP) and physical capital (Ln K) and expert employee (LnEL) were considered. The results have been shown in Table 4.11 and 4.12.

Table (4.11)
Autoregressive Distributed Lag Estimates
ARDL(0,0,0,3) selected based on Schwarz-Bayesian Criterion
Dependent variable is LnGDP

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lnk</td>
<td>.48515</td>
<td>.035332</td>
<td>13.7312 [.000]</td>
</tr>
<tr>
<td>LnEL</td>
<td>.29697</td>
<td>.084535</td>
<td>3.5129 [.002]</td>
</tr>
<tr>
<td>LnNEL</td>
<td>2.9980</td>
<td>.60522</td>
<td>4.9535 [.000]</td>
</tr>
<tr>
<td>LnNEL(-1)</td>
<td>-1.0627</td>
<td>.94216</td>
<td>-1.1279 [.274]</td>
</tr>
<tr>
<td>LnNEL(-2)</td>
<td>.12818</td>
<td>.94780</td>
<td>.13524 [.894]</td>
</tr>
<tr>
<td>LnNEL(-3)</td>
<td>-1.8460</td>
<td>.57820</td>
<td>-3.1926 [.005]</td>
</tr>
<tr>
<td>INTERCEPT</td>
<td>-.0058478</td>
<td>.0059885</td>
<td>-.97650 [.342]</td>
</tr>
<tr>
<td>SHOCK</td>
<td>-.10254</td>
<td>.031242</td>
<td>-3.2821 [.004]</td>
</tr>
<tr>
<td>R-squared</td>
<td>.98969</td>
<td></td>
<td>.98569</td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>.034520</td>
<td>F-stat. F(7,18)</td>
<td>246.9209 [.000]</td>
</tr>
<tr>
<td>Mean of dependent variable</td>
<td>11.9861</td>
<td>S.D. of dependent variable</td>
<td>.28852</td>
</tr>
<tr>
<td>Residual sum of squares</td>
<td>.021450</td>
<td>Equation log-likelihood</td>
<td>55.4094</td>
</tr>
<tr>
<td>Akaike Info. Criterion</td>
<td>47.4094</td>
<td>Schwarz Bayesian criterion</td>
<td>42.3770</td>
</tr>
<tr>
<td>DW-statistic</td>
<td>2.1428</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Diagnostic Tests

<table>
<thead>
<tr>
<th>Test statistics</th>
<th>LM version</th>
<th>F version</th>
</tr>
</thead>
</table>

126
A: Lagrange multiplier test of residual serial correlation.
B: Ramsey’s RESET test using the square of the fitted values.
C: Based on a test of skewness and kurtosis of residuals.
D: Based on the regression of squared residuals on squared fitted values.
Source: Author calculation by Microfit (4.0). See appendix B18.

*Table (4.12)*

**Estimated Long-run Coefficients the ARDL Approach**

**ARDL (0,0,0,3) selected based on Schwarz-Bayesian criterion**

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LnK</td>
<td>.48515</td>
<td>.035332</td>
<td>13.7312 [.000]</td>
</tr>
<tr>
<td>Ln EL</td>
<td>-.29697</td>
<td>.084535</td>
<td>3.5129 [.002]</td>
</tr>
<tr>
<td>Ln NEL</td>
<td>.21752</td>
<td>.058718</td>
<td>3.7045 [.002]</td>
</tr>
<tr>
<td>INTERCEPT</td>
<td>-.0058478</td>
<td>.0059885</td>
<td>-.97650 [.342]</td>
</tr>
<tr>
<td>SHOCK</td>
<td>-.10254</td>
<td>.031242</td>
<td>-3.2821 [.004]</td>
</tr>
</tbody>
</table>

Source: Author calculation by Microfit (4.0). See appendix B18.

All of the estimating coefficients are highly significant statistically. The results have represent that if the physical capital increase by one percent, the real gross domestic product will be increased by 0.49 per cent and if the educated manpower (human capital) increase by one percent, the real gross domestic product will be increased by 0.30 per cent and if the non-educated manpower increase by one percent, the real gross domestic product will be increased by 0.22 per cent.

Results show that the educated manpower as human capital indicator have more effects on the growth of the real gross domestic product compared with the non-educated manpower.
To study the tendency of the model to the long-run equilibrium, it is needed to get the sum coefficients of dependent variable. If they are less than one, the model tends to the long-run equilibrium. In this model because of that the dependent variable (LnGDP) do not has lag, then the sum coefficients of dependent variable is equal zero. So, the model tends towards the long-run equilibrium.

4.4.2.2.3 The Estimation of Cobb-Douglas Production Function in the Non-Conventional Form

To estimate the model, according to SBC, among various regressions and maximum four lags, the Microfit selected a regression in which three lags for the gross domestic product (Ln GDP) and labor (LnL), and four lag for the physical capital (LnK) and higher education and research expenditure (LnRC) were considered. The results have been shown in Table 4.13 and 4.14.

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln GDP (-1)</td>
<td>-.48983</td>
<td>.17190</td>
<td>-2.8495 [.029]</td>
</tr>
<tr>
<td>Ln GDP (-2)</td>
<td>-.072338</td>
<td>.13456</td>
<td>-.53757 [.610]</td>
</tr>
<tr>
<td>Ln GDP (-3)</td>
<td>.22075</td>
<td>.11597</td>
<td>1.9036 [.106]</td>
</tr>
<tr>
<td>Ln k</td>
<td>.11802</td>
<td>.14536</td>
<td>.81192 [.448]</td>
</tr>
<tr>
<td>Ln K (-1)</td>
<td>.099765</td>
<td>.14977</td>
<td>.66614 [.530]</td>
</tr>
<tr>
<td>Ln K (-2)</td>
<td>.31089</td>
<td>.14448</td>
<td>2.1518 [.075]</td>
</tr>
<tr>
<td>Ln K (-3)</td>
<td>.12180</td>
<td>.14646</td>
<td>.83164 [.437]</td>
</tr>
<tr>
<td>Ln K (-4)</td>
<td>.12334</td>
<td>.10336</td>
<td>1.1933 [.278]</td>
</tr>
<tr>
<td>Ln L</td>
<td>3.0068</td>
<td>.41254</td>
<td>7.2885 [.000]</td>
</tr>
<tr>
<td>Ln L (-1)</td>
<td>.30405</td>
<td>.64422</td>
<td>.47197 [.654]</td>
</tr>
<tr>
<td>Ln L (-2)</td>
<td>-.29922</td>
<td>.63473</td>
<td>-.47142 [.654]</td>
</tr>
</tbody>
</table>

Table (4.13)
Autoregressive Distributed Lag Estimates
ARDL(3,4,3,4) selected based on Schwarz-Bayesian Criterion
Dependent variable is LnGDP
<table>
<thead>
<tr>
<th>Test statistics</th>
<th>LM version</th>
<th>F version</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: serial correlation</td>
<td>CHSQ(1)=3.5800[.058]</td>
<td>F(1,5)=.87659[.392]</td>
</tr>
<tr>
<td>B: functional form</td>
<td>CHSQ(1)=8.2063[.004]</td>
<td>F(1,5)=2.5980[.168]</td>
</tr>
<tr>
<td>C: normality</td>
<td>CHSQ(2)=1.0855[.581]</td>
<td>Not applicable</td>
</tr>
<tr>
<td>D: heteroscedasticity</td>
<td>CHSQ(1)=.35734[.550]</td>
<td>F(1,22)=.33251[.570]</td>
</tr>
</tbody>
</table>

A: Lagrange multiplier test of residual serial correlation.
B: Ramsey’s RESET test using the square of the fitted values.
C: Based on a test of skewness and kurtosis of residuals.
D: Based on the regression of squared residuals on squared fitted values.

Source: Author calculation by Microfit (4.0). See appendix B19.

**Table (4.14)**

Estimated Long-run Coefficients the ARDL Approach

**ARDL (3,4,3,4) selected based on Schwarz-Bayesian criterion**

**Dependent variable is Ln GDP**

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln K</td>
<td>.57686</td>
<td>.057810</td>
<td>9.9786[.000]</td>
</tr>
<tr>
<td>Ln L</td>
<td>.35773</td>
<td>.021649</td>
<td>16.5241[.000]</td>
</tr>
<tr>
<td>Ln RC</td>
<td>.12283</td>
<td>.046932</td>
<td>2.6173[.040]</td>
</tr>
</tbody>
</table>
All of the estimating coefficients are highly significant statistically. The results have represent that if the physical capital increase by one percent, the real gross domestic product will be increased by 0.58 per cent and if the labor increase by one percent, the real gross domestic product will be increased by 0.36 per cent and if the higher education and research expenditure increase by one percent, the real gross domestic product will be increased by 0.12 per cent.

Results show that the higher education and research expenditure have positive effects on the growth of the real gross domestic product.

To study the tendency of the model to the long-run equilibrium, it is needed to get the sum coefficients of dependent variable. If they are less than one, the model tends to the long-run equilibrium. In this model the above sum coefficient is equal to -0.22075 which is less than one. So, the model tends towards the long-run equilibrium.

4.5 Conclusion

The economists from 1960s have always tried to estimate the effect of the human capital on the economic growth in various methods. Most important variables which are taken into consideration as an indicator of the human capital we can mention the employees with the higher education and the current expenditure of the higher education and researches.

In this chapter, researcher had a short study about the innovated methods in econometrics. In order to study the effect of the human capital on the economic growth we have used three models. The first model is the same model of new classic growth and is in Cobb-Douglas form in which the real gross domestic product is considered as the production indicator and the physical capital variables and the
employed manpower is taken as a major effect in production. In the second model, dividing the employed manpower into two groups, the experts employee and the non-expert ones, we have asserted the human capital factor into the model. And in the third model by adding the variable of the current expenditure of higher education and researches, as indicator of the human capital, into the first model we study the effect of the human capital on the economic growth ones more.

In order to select the best estimation method, we, first, used the unit root test and assured the stationarity of the variables. Then after the estimation of the models through Engle-Granger’s two step test and approving the presence of a suprious regression we selected the dynamic Autoregressive Distributed Lag (ARDL) method.

By estimating the three models through the ARDL method and the obtained results, the positive effect of the higher educated manpower (human capital) on the real gross domestic product clarified. Thus, the higher educated manpower (human capital) is positively effective on economic growth of Iran.