Impact of Energy Investment on Economic Growth

By

Muhammad Naveed

Supervised By

Dr. Hafsa Hina

A Dissertation Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Philosophy in Econometrics

Department of Econometrics and Statistics

Pakistan Institute of Development Economics

Islamabad

2014

Dedication

My Loving Parents and for their Patience & Encouragement, who devoutly sacrificed all their assets and time to bring me to this position and they through their love, affection, care and financial support and left no stone unturned to offer me sincere help at all critical occasions of my life

Acknowledgments

In The Name of Allah, Most Gracious, Most Merciful

I would like to start this page with my heartfelt, deepest gratefulness and gratitude presented to Allah Almighty "Praise be to Allah, the Lord of the worlds". His benevolence, affection, generosity, and blessings are even beyond our imaginations and deeds. The completion of this dissertation would have been entirely a dream without the strength and guidance provided by Allah Almighty. Thanks to God for wisdom and perseverance which has been bestowed upon me as we are able to turn impossible in to possible through Him who gives us strength.

I am indebted to all those who were a part of my entire journey during the last two years. First of all, I would like to offer special thanks to my supervisor, Dr. Hafsa Hina, who is no doubt a professional, competent and expert economist along with strong personal traits as being the most generous, affectionate, and patient and loving one. However, his excellent guidance, professional advice and availability throughout my dissertation period have been the most supportive factor in the completion of this dissertation. I really feel lucky and among the blessed ones to get an opportunity to work under his supervision.

With due regard and respect, I would also like to thank my loving teacher Hafiz Abdul Sattar, for his encouragement and best wishes. I also want to thank my younger brothers for their unequivocal support. I owe the deep gratitude to Furqan Maqsood who is amongst my dear colleagues and a blooming and emerging young economist. He was very helpful in all kinds of discussion. I would also like to thank my friends, Hafiz Sajid Imran, Ali Raza Cheema, Muhammad Qamarudin and Shahbaz Raw.

Muhammad Naveed

Abstract

Energy is the device of economic growth, as many production and consumption procedures include energy as an elementary input. It leads to economic growth and development in terms of higher per capita income. It is widely believed that economic growth and energy usage are mutually dependent. The aim of this study is to explore the impact of energy investment on the economic growth. For this purpose energy is introduced as factor input in the growth model (Mankiw *et al.* 1992) along with physical capital, labor and human capital and some other policy variables. The annual time series data are collected from period of 1970 to 2012 for Pakistan. Autoregressive Distributed Lag (ARDL) approach is used to investigate the relationship between economic growth (Gross domestic product per capita) and independent variables (share of investment in energy, share of investment in physical capital, share of investment in human capital and growth rate of labor, technology and depreciation rate, inflation rate, foreign direct investment, external debt and trade openness). The results of this study reveal that energy investment has positive and significant impact on economic growth in the long run. Physical capital and human capital both are found to be insignificant in the long run but having negative impact on economic growth. Trade openness has a positive and significant impact on economic growth both in short run and long run. Growth rate of labour has a negative insignificant impact on economic growth. Trade openness and external debt are found to be negative with significant impact on economic growth. Inflation is found to be negatively associated with economic growth of Pakistan. The study has important policy implication that government should encourage the investment activities in energy sector to meet the rising energy demand which in turn leads to stimulate economic growth. This economic growth then generates the employment opportunities in the country.

Table of Contents

List of Tables

List of Figures

CHAPTER 1

1.1 Introduction

Energy is the key factor of economic development, as many procedures such as production and consumption include energy as an elementary factor. On production side, traditional, economists like Adam Smith have concentrated on land, labor, and capital as major inputs for production and economic growth. These inputs were major components of agrarian economies of 17th and 18th centuries. On the other hand, in 19th century with the development of manufacturing economies, the economists have recognized the position of energy in the production development and declared it as an essential factor of production (Stern 1997a).

On consumption side, in the Keynesian background where consumption and income are significantly associated, in the same way energy consumption in all systems pushes economic production. It leads to economic growth and development in terms of higher per capita income. It is widely believed that economic growth and energy usage are mutually dependent. The broad industrial development, suburbanization and growing population have increased the demand of energy, particularly in the emerging countries.

Economists have been concerned with economic growth for several years. This theme undertakes a significant place in economic system. Economic development has become much considerable to researchers since 1990s together with the development of the modern growth theories.

Growth theory examines the discrepancy in the tolls of economic development between countries, in order to classify the determinants that may affect the economic growth. These determinants have different impacts on economic development depending on economic situations. Determining factors of growth are not similar in all nations, divergent from one country to another, and from one time period to another.

Any variation in investment will create two effects: it will change aggregate demand as well as productive capacity of the economy (Domar 1946). Economic growth is directly associated to the saving rate and inversely connected to the population growth rate (Solow 1956). New extensions of the theory of neo-classical growth together with the theories of endogenous growth have highlighted the character of human capital in economic development (Romer, 1986), (Lucas, 1988) and (Mankiw *et al.1992*).

Most investigations on energy investment have emphasized the part of energy protection investment and the long-run influences of research and development investment for renewed energy equipment. Even within the confines of the prevailing energy structures, the need for energy investment may rise due to augmented demand and ups and downs in the primary and final energy mixtures. In addition, any effort to save energy through more effective manufacture and distribution machinery will add to the energy investment budget.

Conservation investment leads to improve efficiency in energy usage through building insulation, energy efficient technologies and innovative production techniques. It is indirectly related with the energy sector and its special effects are not easily and clearly distinguishable, since it is spread out in the economy through capital regeneration investment. The natural question that arises is: “What is the impact of investment in energy on economic growth?” and its solution is of key significance to policymakers.

In literature, energy investment is found having positive and negative effects on the economic progress. For example, J-Emmanuel *et al.* (1983) theoretically show energy investment leads to reduce the economic growth because investment in energy will direct funds from other productive sectors of economy. Ammad *et al.* (2013) empirically investigated Public energy investment has a positive impact on the production of all sectors except the negative effect in case of production of electricity and gas distribution.

Investment considered key factor in the determination of economic performance of any nation. It generates the employment opportunities and encourages technological developments through embodiment of new skills. It helps to take on new production techniques and increases the productivity of a country by bringing more competition in the economy. Investment spending is considered as unstable factor of aggregate demand because it depends on various elements. That is why it leads to much variation in gross domestic product of a country. Investment has been much affected by internal and external factors in the course of the last few years and is considered a crucial concern.

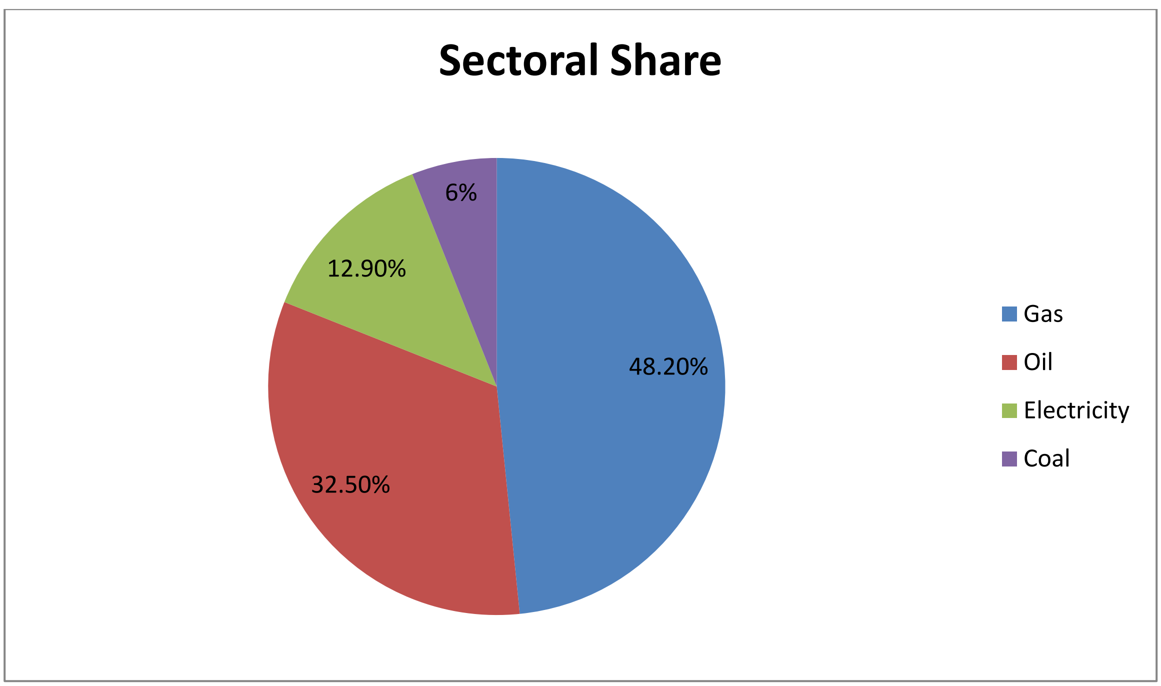
Total investment was recorded 18.79 percent of GDP in 2006-07 which has reduced to 14.22 percent of GDP in 2012-13. Similarly fixed investment was also higher (17.61percent of GDP) in 2007-08 than 12.6 percent of GDP in 2012-13. Public investment percentage of GDP has also decreased from 4.8 percent in 2007-08 to 3.9 percent in 2012-13.

1.2 An Over View of Energy Sector in Pakistan

Energy has significant importance in determining economic situation of a nation and is always used as a key input in industrial progress, commercial development and domestic improvement activities. Energy disturbances and shortages not only reduce economic development and employment opportunities but also badly affect the social structure of the society. Energy crises have been adversely affecting Pakistan since 2007 and became most serious issue in 2012. It negatively affects the economic performance.

Net primary energy supply was 64727 thousand TOEs (tonnes of oil equivalent) in 2012 which was 64522 thousand TOEs in 2011. The average growth rate of net energy supply was 1.8 percent during the previous last six years. The total energy use in 2012-13 was 40026 thousand TOEs in which 29 percent was used in transformation and 10 percent was used in diversion. But if we compare total energy use with the last year was 38842 thousand TOEs, further, the average growth rate of energy use in Pakistan was 2.9 percent during the period of last six years. Sectoral share of energy supply shows that gas and oil have largest share in energy supply of Pakistan. Gas contributes 48.2 percent, Oil contributes 32.5 percent, electricity contributes 12.9 percent and coal contributes approximately 6 percent in total energy supply of Pakistan in 2013 (Economic Survey of Pakistan 2012-13). Figure 1.1 shows the sectoral share of energy supply of Pakistan.

Figure 1.1: Sectoral Share of Energy Supply of Pakistan



Source: Economic Survey of Pakistan

On the demand side, the growth rate of demand of electricity was 4 percent per annum in 1990s which has increased to 7 percent per year annum during the period of 1999-2000 to 2006-2007. Electricity demand has been growing 3 to 4 percent per year up to 2003-04. However, it increased rapidly in succeeding years and reached up to 10 percent during the period of 2007-08. This huge increase in electricity demand happened due to increase in population and expansion in the economy.

During the last five years the economy of Pakistan has grown on average at the rate of 2.9 percent per annum (Economic Survey of Pakistan 2012-13). Energy demand is increasing rapidly due to rise in population and economic development while energy supply could not be increased due to deterioration in the power sector. The average energy supply in Pakistan was 12400 MW in April 2012 while average energy demand was recorded 17400 MW and the shortfall during the period was 5000 MW (Annual Plan 2013-14). This shortfall mainly arises due to the constraints on fuel supply and poor situation of hydroelectric production. According to this scenario of Pakistan, energy demand is larger than its supply. This excess energy demand highlights the need to invest in energy sector to meet the economic needs of energy and it might allow the country to get higher growth level and employment opportunities.

- Total gross fixed capital formation in electricity generation and distribution and gas distribution was 57230 million rupees in 2007-08 which has reduced to 52296 million rupees in 2012-13.
- The gross fixed capital formation in electricity generation and distribution and gas distribution in private sector has been reduced to 2887 million rupees in 2012-13 which was 7951 million rupees in 2007-08.

- In public and general government sectors, it has been increased to 49409 million rupees in 2012-13 which was 49279 million rupees in 2007-08 (Economic Survey of Pakistan 2013-14).

1.3 Contribution to the Study

Although large empirical work has been done to study the effect of energy use on economic growth yet present study is the first one in my knowledge, planned to empirically study the effect of energy investment on economic growth of Pakistan. Earlier studies are being devoted to check the impact of investment on economic growth. This study will contribute by incorporating energy as factor input in the growth model (Mankiw *et al.* 1992) along with physical capital, labor, human capital and other control variables such as inflation, trade openness, external debt and foreign direct investment.

1.4 Objectives of the Study

The study has the following main objective

- To empirically study the impact of energy investment on economic growth in Pakistan.

1.5 Hypothesis

The main consideration of the present research is to find out the effect of energy investment on economic growth in Pakistan. The study will test the following null and alternative hypothesis.

H_0: There is statistically insignificant relationship between energy investment and economic growth of Pakistan.

H_1: There is statistically significant association between energy investment and economic growth in Pakistan.

1.6 Arrangement of the Study

Remainder of the study is ordered as follows: chapter 2 provides the review of literature, chapter 3 gives the theoretical frame work, chapter 4 discusses the methodology and data, chapter 5 gives the empirical results, chapter 6 provides the conclusion and policy recommendations and at the end references are given.

CHAPTER 2

LITERATURE REVIEW

In literature many studies have examined the impact of energy on economic growth. For example, Kraft and Kraft (1978), Aqeel and Butt (2001), Soytas and Sari (2003), Chang and Lee (2005) have analyzed the link between energy use and economic progress. Before discussing literature, we briefly explain the concepts of theoretical growth models. Section 2.1 of this chapter will provide the theoretical frame work of growth models. However, section 2.2 will discuss the empirical literature review.

2.1 Theoretical Growth Models

In this section we will present the literature review relating to the theories of the growth models. This section is further divided in three subsections. Section 2.1.1 will explain exogenous growth models. Section 2.1.2 will discuss the endogenous growth models and section 2.1.3 will describe energy as a factor input.

2.1.1 Exogenous Growth Models

We will first briefly give the review of exogenous growth models. These are Solow (1956) growth model and human capital augmented Solow model.

2.1.1a Neoclassical Solow Growth Model

Solow (1956) in his neoclassical growth model tries to explain the situation where labour and capital can be used in changing proportions. The original neoclassical Solow growth model is an aggregate production function of the form:

$$Y_t = F(A_t, K_t, L_t)$$

Where Y_t is output, A_t is level of technology, K is capital and L is labour. The model assumes that the production function is homogeneous of first degree, Diminishing returns to each input is hold and elasticity of substitution is positive and constant. The fundamental equation of the model suggests that the dynamics of capital growth are related with constant rate of saving and a constant rate of depreciation. Level of technology and Labor are assumed to grow exogenously at exponential rates.

According to this model growth process would ultimately come to stop in the absence of technological progress. As a result the economy finally converges to steady-state level in which growth of both capital per-capita and output per-capita change at exogenous rate of technological progress. Consequently, long run growth of the economy is not affected due to changes in the saving rate and growth rate of population. Long run growth pattern is directly related to saving rate and inversely associated to growth rate of population. Long run growth path is affected by these parameters accordingly whereas slope remains unchanged.

2.1.1b Human-Capital Augmented Solow Growth Model

Extension of Solow growth (the neo-classical growth) model has highlighted the character of human capital in economic growth. Mankiw e*t al.* (1992) introduced human capital as separate input in the neoclassical Solow growth model of production function. In this model, the production technology is referred to as the human-capital augmented Solow model. The production function describes as following

$$Y_t = H_t^{\alpha} K_t^{\beta} (A_t L_t)^{1-\alpha-\beta}$$

Where Y represents output, A represents technology, L shows labor force, K reveals physical capital and H is human capital. The exponents α, β *and* $1-\alpha-\beta$ reflect the elasticities of output with respect to human capital, physical capital and effective labor respectively. This model also assumes that the production function is linearly homogeneous and diminishing return to each input is hold. This makes sure that the economy will converge to a stable equilibrium in the long run.

Besides the Solow model, this model also assumes consumption or investment in physical capital or human capital is made by the output of the economy produced and both human capital and physical capital both deprecate at the same constant rate. Also the methods of investment people make in physical capital as well as human capital both are same.

Like the Solow model, human capital augmented Solow model also reaches steady state where growth of output per effective worker and growth of physical and human capital per effective worker grow at exogenous rate of technological progress. A permanent rise in share of investment in human capital accumulation will lead to shift the steady state level of output upwards to a higher long run growth path but the slope or rate of growth slowly returns to its initial value. One of the important dissimilarity between original Solow model and Mankiw *et al*. 1992 (human-capital augmented Solow) model is concerned with magnitude of the effect of change in the rate of saving on the level of output. Output elasticity with respect to share of investment is more dominant in the augmented neoclassical growth model. This is because with the same rate of investment in human capital, an upward shift of saving rate raises the steady-state level of output which further leads to increase the human capital accumulation as well.

2.1.2 Endogenous Growth Models

The most important disadvantage of the exogenous growth models was that they assume that the long run growth rate is determined exogenously. Complex productivity growth process cannot be explained properly when the growth rate of productivity has been given. To capture this problem Paul Romer (1986) developed a New Growth theory in which he endogenize the growth determinants. In this way the growth rate of productivity will be determined within the model. The economists have since then, introduced two different approaches on how to include human capital in economic growth models. The first group of economists emphasizes human capital accumulation as a device of economic progression and second group highlight the role of human capital in innovation and new technologies.

2.1.2a Growth by Human Capital Accumulation

Lucas (1988) developed an economic model by incorporating human capital in the production function in the same way as technology does in the original Solow model. This model is based on the assumption that the economy is closed and contained of identical agents aiming to maximize life-time utility. Economic agents are concerned with two variables: level of consumption (which determines the accumulation of physical capital) and distribution of time between work and skill acquirement (which influence agent's future productivity). In this growth theory the level of technology is assumed to be constant. Lucas gives the following production technique:

$$Y_t = AK_t^{\beta}\left(u_t \; h_t \; N_t\right)^{1-\beta} h_{at}^{\gamma}$$

Where Y represents output, A shows technology level, K reveals physical capital, N denotes labor, u is the fraction of agent's time spending for work, h is the human capital of representative individual and h_a is the average skill level in the economy. Growth rate of population is assumed to be exogenously given.

Lucas (1988) assumes the linear assumption between the distribution of time to skill acquirement and human capital accumulation. This linearity assumption implies that human capital is not affected with the growth rate of human capital. Consequently regardless of human capital in the economy, any effort causing rise in human capital will produce the same percentage increase. Furthermore, non-diminishing returns to human capital make sure that human capital can grow without bound and hence lead to generating endogenous growth. When the equilibrium value of time distributed to skill acquirement increase, economic growth also increases which is opposed to exogenous growth models.

The existence of the human capital spillovers is not a necessary condition for the steady-state. In the sustained growth, if there is no external effects of human capital, then the output per-capita, physical capital per-capita and human capital per-capita all grow at the same rate (i.e. they follow the balanced growth path). When human capital per worker is increased due to exogenous shock, this will also generate a higher level of investment in physical capital to reestablish the steady-state ratio. But in the case where human capital has a positive external effect, then physical capital per worker grows more rapidly than human capital. In this model human capital accumulation depends on productivity of schooling and the fraction of time devoted to acquirement of skill. This model also points out that the rate of time preference and the coefficient of relative risk aversion are negatively related to the fraction of time devoted to acquirement of skill whereas the productivity of schooling positively affects the fraction of time devoted to acquirement of skill.

2.1.2b Human Capital and Technological Progress in Growth Models

The second type of endogenous growth models emphasizes that technological change (Research and Development) is main stream of long run economic growth patterns as mentioned by the neoclassical Solow growth model. However, rather accepting the assumption of exogenous technological change, these models accept that large portion of innovation occurs due to research and development (R&D) activities carried by economic representative in response to market incentives. Furthermore in this model skilled human capital has a key role in research and development sector.

According to Romer's model (1990) the economy contains of three sectors: the final goods sector, the intermediate goods sector and the research sector. Both the final goods sector and the research sector are competitive in nature. The research sector applies human capital with prevailing stock of technological knowledge to generate different designs of capital goods. These different designs with economy's savings are then used by the intermediate goods sector to produce new capital intermediate goods. The final goods sector combines these new capital intermediate goods with labor and human capital to produce final output. The production function of final goods sector is defined as follows:

$$Y = H_Y^{\alpha} L^{\beta} \sum_{j=1}^{A} x_j^{1-\alpha-\beta}$$

Where Y represents output, H_Y is human capital used in production, L is labor, A is the stock of knowledge and x_j denotes the intermediate capital goods used in the production of final goods. The model assumes an important simplifying assumption that supply of labor and total stock of human capital will remain same over time in the economy. Furthermore it confirms that the numbers of different intermediate capital goods in the economy are determined by the stock of knowledge, which is taken to be a nonrival good in the model.

The existence of non-rival technological knowledge with monopolistic competition in Romer's (1990) model, the price of intermediate goods sector is higher than the marginal cost due to the availability of monopoly rents. This permits the firms in the intermediate goods sector to finance their research and development activities and also pay for patents.

The presence of non-rivalry of ideas shows that production of new knowledge is determined by existing stock of knowledge and human capital allocated to research and development activities. Sustained growth in this model occurred due to dual effect. First, there are an increasing number of products generated with the stock of knowledge. Second are the knowledge spillovers because all researchers have unrestricted right to use the existing ideas. Both of these effects make sure that technological knowledge can grow without bound, and leading to endogenous growth. In the level of steady-state, stock of capital, knowledge and output all develop at the same rate of technological progress. Thus any effort leads to raise the human capital stock will increase the economic growth forever.

2.1.3 Energy as a Factor Input

Natural scientist and ecological economists have emphasized on the role of energy in economic production and growth processes. The efficiency law (second law of thermodynamics) says that minimum quantity of energy is required to carry out physical work. Since all production processes involve work. Therefore, energy must be required for all economic production process consequently energy is always considered as an essential factor of production (Stern, 1997a). Cleveland *et al.* (1984), Murphy and Hall (2011) and Hall *et al.* (2001) believe that energy show important role in determining economic development.

2.2 Empirical Literature Review

Previous studies in literature have empirically examined the impact of energy on economic progress. Following the introduction this section is further divided into two sub-sections

2.2.1 Literature review related to Pakistan

Impact of energy consumption on economic growth has received considerable attention of academic researchers and international organizations and institutions later the starting work of Kraft and Kraft. (1978). Literature review related to the Pakistan is given as follows:

Aqeel and Butt (2001) have observed the connection between energy use and economic growth using time series data annually from 1956 to 1996 in Pakistan. They have applied cointegration methodology and Hsiao type granger causality approach. Their empirical findings reveal one-way causality from economic growth to total energy consumption and petroleum consumption and from electricity consumption to economic growth.

Siddiqui (2004) has empirically investigated the association between energy consumption and economic growth in Pakistan by applying time series data annually from 1970-2003. The study has used the Hsiao's type Granger causality to examine the relationship between energy use and economic growth. Estimated results of the study show that stock of capital, growth rate of exports and growth rate of electricity and petroleum products contributes positively and significantly to economic progress whereas human capital contributes positively and insignificantly to economic growth.

Khalid *et al*. (2008) investigated the impact of energy consumption including oil, gas and electricity on gross domestic product (GDP) growth of agriculture sector of Pakistan. By using time series data annually from 1972 to 2005, the results of Johansen cointegration and Engle-Granger approach show no causality between oil consumption, electricity consumption and GDP growth.

Qazi *et al.* (2008) explored the causal connection between energy consumption and economic growth by utilizing time series data annually covering the period of 1971-2007. The study has used the autoregressive distributive lag cointegration approach introduced by Pesaran *et al.* (2001). The empirical findings reveal unidirectional causality from economic growth to energy consumption in the long run.

Zaheer *et al.* (2011) have examined the connection between energy consumption and economic development by applying time series data at annual frequency from 1980-2009. The study has used the Johansen cointegration and ECM (error correction mechanism) approach. The empirical findings suggest the unidirectional causality from energy use to economic development.

Shahbaz *et al.* (2011) empirically surveyed the causal connection between energy consumption and economic growth by applying data at annual frequency from 1971-2008 in Pakistan. Autoregressive distributed lag cointegration approach introduced by Pesaran *et al.* (1997, 2000, and 2001). The empirical results show the one-way causality from economic growth to energy consumption.

Zaman *et al.* (2011) have empirically studied the causation concerning real gross domestic product (GDP) and sectoral oil consumption of Pakistan using annual frequency data from 1972-2008. They have applied the Johansen and Juselius (1990) cointegration and traditional Engle-Granger approach. Their findings shows that transport, power generation and industry sector oil consumption are positively affecting real GDP, while household, agriculture and government sector oil consumption are negatively contributing in real GDP. The causality analysis shows that the uni-directional causality is running from real GDP, transport sector and industrial sector oil consumption to power sector oil consumption.

Qazi *et al.* (2012) have empirically examined the association between industrial production and energy consumption at disaggregate level by applying annual frequency data from 1972-2010 in Pakistan. They have used the variables like consumer price index, the employment rate, oil, gas, electricity, coal, value added as an industrial output and total energy usage. They have used the Johansen *et al.* (1990, 1992) cointegration methodology and VECM (vector error correction model). Their empirical findings shows that there is a short run bi-directional causality between oil usage and industrial production, however there exist one-way causality form electricity and total energy usage to industrial output in Pakistan economy.

Shahbaz *et al.* (2012) have empirically examined the link between economic growth and energy usage renewable and nonrenewable by using the annual time series data from 1972 to 2011 in Pakistan. They have applied ARDL bound testing and Gregory and Hansen methodology (1990) to test the presence of long run links among the variables. Estimated results of Granger causality show the existence of two-way causality between economic development and renewable energy and nonrenewable energy usage.

Imran *et al.* (2012) have empirically inspected the connection between energy usage and economic growth including the variables like gross domestic product (GDP), electricity, coal, gas, oil, trade openness and inflation using annual data from 1972 to 2012 in Pakistan. The results of autoregressive model and Engle-Granger approach show the existence of one-way causality from electricity, oil and gas usage to GDP growth, from inflation to coal and electricity consumption, trade openness to oil consumption and from GDP growth to trade openness, whereas two-way causality is found in case of coal consumption and GDP growth.

Attiya *et al*. (2013) have empirically studied the long run association between electricity usage and per capita GDP by using the data of time series over the period of 1971-2008. The study has applied the Engle-Granger and vector error correction mechanism (VECM). Empirical results show the existence of unidirectional causality from electricity usage to GDP per capita.

Ammad *et al.* (2013) has analyzed the public sector energy investment on sectoral output, private investment and employment using annual data of time series from1981-2011. The study applied Engle-Granger, vector autoregressive model (VAR) and impulse response function. They found 16 elasticity coefficients for output, 8 for private investment and 8 for employment. The study shows that public sector energy investment has a negative impact on, electricity and gas distribution sector in case of output, finance and insurance sector in case of private investment and a positive impact on agriculture and construction sector in case of employment. The study also reveals that one rupee increase in public sector energy investment in manufacturing, mining and quarrying and transport sector leads to increase output of rupee 0.88, 0.76 and 0.61 in these sectors respectively.

From the above literature we can conclude that there was no work done on the investment in energy in Pakistan. Purpose of my study will be to try to fill this gap.

2.2.2 International Studies:

Yang (2000) has empirically investigated the link between real gross domestic product (GDP) and energy usage at aggregate and disaggregates levels for Taiwan. Annual frequency data is used from 1954-1997 for real gross domestic product, total energy usage, coal, natural gas, and oil and electricity consumption. The results of Granger causality approach shows the existence of two-way causality among total energy use and real GDP, whereas a unidirectional causality from real gross domestic product to oil consumption and natural gas consumption to real gross domestic product.

Soytas and Sari (2003) have analyzed the causation between per capita gross domestic product (GDP) and annual energy usage for G-7 and 9 top emerging economies. They used time series data from 1950-1992 for all countries except 1950-1990 for Argentina, 1960-1992 for Indonesia, and 1953-1991 for Korea and 1965-1994 for Poland. They used Johansen (1988) and Johansen and Juselius (1990) methodology for the detection of cointegration. The results of vector error correction modeling (VECM) show the existence of one-way long run causality from annual energy usage to per capita gross domestic product for Turkey, France, West Germany and Japan, bidirectional causality for Argentina and short run bidirectional causality for Argentina and Turkey. In order to check the validity of the causality beyond the sample period they also applied the variance decompositions (VDs) and the VDs results support the causal relationships found by using VEC model.

Paul and Bhattacharya (2004) have empirically investigated the association between energy and economic growth using the annual data of time series from 1950-1956 in India. They have used national income as gross domestic product, population as labor, commercial energy use as energy usage and gross fixed capital formation as capital. They have applied three methodologies like Engle-Granger error correction, standard Granger causality test and Johansen multivariate cointegration approach. Their findings show the existence of long run one-way causality from growth to energy usage in the Engle-Granger model while the one-way causality runs from energy usage to economic growth in the standard Granger causality model. Furthermore they applied the Johansen multivariate cointegration approach and the results shows a short-run causality runs from energy usage to economic growth and long-run causality runs from economic growth to energy usage.

Galip *et al.* (2004) has explored the connection between energy usage and real gross domestic product using annual data of time series from1950-2000 in Turkey. Augmented Dickey-Fuller (1979) and the Phillips-Perron (1988) unit root tests reveals that the series are integrated of order one i.e. I (1) while Perron (1997) and Zivot and Andrews (1992) shows that both the series are trend stationary with structural break. Hsiao version Granger causality approach show the nonexistence of causality between energy usage and real gross domestic product in turkey if detrended data is used.

Ghali and Sakka (2004) have examined the association between output growth and energy use by applying the neo-classical aggregate production technology. They have used annual data from 1961-1997 in Canada. Johansen (1988, 1991, and 1992) and Johansen and Juselius (1990) cointegration and vector error correction (VEC) approach is used. Their findings reveal the existence of two-way causality between energy use and economic growth. Further the results of variance decomposition of forecast error shows that a shock to energy use would leads to 15% change in future output growth rate.

Ramazan *et al.* (2008) studied the relationship between industrial output, employment and energy consumption by applying monthly data of time series from 2001:1 to 2005:6 in United States. They have applied ARDL (autoregressive distributed lag) methodology introduced by Pesaran *et al.* (1997, 2001) to test the association among the relevant variables. Their empirical findings show that in the long run hydroelectric power, fossil fuel, waste, solar, and wind energy usage are significantly determined by the employment and industrial output, while natural gas and wood energy are not significantly determined by industrial output and employment.

Sasa (2008) has studied the effects of public sector investment on economic growth by utilizing annual panel data from 1997 to 2006 for Croatia. He has used Pooled ordinary least squares (OLS), fixed, between and random estimations of the models. Empirical results show that in the short run 1% increase in public investment, category of infrastructure construction and investment in transport will lead to increase the output by 5.7%, 2.8% and 7% respectively. Furthermore, physical capital in the sector of electricity, gas and water supply has positive (significant) impact on gross domestic product in case of pooled OLS model.

Yuan *et al.* (2008) evaluated the causal relationship between real gross domestic product and energy consumption in China by applying one sector neo-classical aggregate production technique. They used time series data from 1963 to 2005 on total energy consumption, coal consumption, oil consumption, real GDP, total employment and value of fixed assets of all industrial enterprises as a proxy for growth of capital stock. They have used Johansen (1991, 1995), Johansen and Juselius (1990) and VECM techniques. Their findings show that there exist long-run two-way causality between real GDP and energy consumption at both aggregated and disaggregated levels, while short run one-way causality from, real gross domestic product to total energy and from coal and electricity consumption to real GDP.

Dhungel (2008) have examined the link between real GDP per capita and total commercial energy, including coal, oil and electricity consumption in Nepal. By applying the data from 1980-2004, the results of Johansen cointegration and VECM (vector error correction) approach show the existence of one-way causality from total commercial energy, coal and oil consumption to real GDP per capita and from real GDP per capita to electricity consumption per capita.

Bekhet and Othman (2011) have empirically examined the attachment among FDI, total consumption expenditure, electricity consumption, consumer price index, and gross domestic product by utilizing the data of time series from 1971 to 2009 for Malaysia. The results of Engle-Granger cointegration methodology and VECM approach show the existence of long run one-way cointegration from electricity consumption to foreign direct investment, gross domestic product and consumer price index.

Evan *et al.* (2011) have empirically examined the association between per capita total primary energy consumption (EC) and real gross domestic product (GDP) by using annual panel data from 1980-2006 for 17 Asian countries. They have used Pedroni (1999, 2001, and 2004) and Kao (1999) panel cointegration, panel Fully Modified OLS (FMOLS) and panel vector error correction modeling (VECM). Empirical results show the presence of long run causality run from GDP to energy consumption and short run association from energy consumption to real GDP.

Dipa and Yanying (2012) have empirically explored connection between energy usage and economic growth by applying panel data from 1990-2009 for 80 developing countries. They divided the panel of 80 countries into three groups namely: 12 low income, 37 upper middle income and 31 lower middle income nations. They have used panel cointegration proposed by Pedroni (1999, 2004) and panel dynamic OLS introduced by Kao and Chiang (2000). For upper and lower middle income countries their estimated results show long run uni directional causality from energy usage to economic growth and from economic growth to energy usage for low income countries.

Huang *et al.* (2008) has analyzed the association between energy consumption and economic growth by utilizing annual panel data from 1972-2002 for 82 countries. They have applied the GMM-SYS approach to estimate the panel VAR model. When they used the data of 82 countries as a whole their findings suggests show the presence of positive two-way causation between energy consumption and economic growth.

Binh (2011) have empirically checked the connection between energy consumption and economic growth for Vietnam by applying the annual time series data from 1976-2010. He has used the structural cointegration developed by Gregory and Hansen (1996a, b) and Granger causality test. The estimated results show that economic growth cause energy consumption only.

Sahbi and Jaleleddine (2012) have analyzed the relation between energy consumption and economic growth by applying annual panel data from 1971-2008 for 95 countries. They have applied fully modified OLS, dynamic OLS cointegration techniques introduced by Kao (1999) and Pedroni (1997, 1999). The results of panel error correction model (ECM) show that long run uni- directional causality from gross domestic product to energy consumption for low and high income countries and bilateral causality between GDP and energy consumption for lower middle and upper middle income countries.

Abid and Sebri (2011) have explored association between energy usage and economic development in the whole economy as well as transport, industry and residential sector by using the data of time series from 1980 to 2007 in Tunisia. The Johansen (1988) and Johansen and Juselius (1990) methodology is used. The long run findings reveals the existence of two-way causality between energy consumption and economic growth at aggregate level and at disaggregated level there is short run one-way causality from industrial sector value added to energy consumption while, there is no causality found in the long run.

Mahedi (2013) has empirically explored the association among economic growth, investment and electricity consumption for Bangladesh by applying annual data from 1981-2011. Johansen cointegration and Granger causality approach have been applied for analysis. Empirical results reveal that electricity consumption and investment have positive impacts on economic growth both in short run and long run.

Amar *et al.* (2013) has empirically examined the impact of energy consumption on economic growth by applying annual panel data for 22 African nations from 1980-2009. The study has used the fully modified ordinary least squares (FMOLS) and Dynamic ordinary least square (DOLS). The empirical results show that energy consumption, physical capital and labor force are found to have positive impacts on economic growth for all nations.

From above literature related to international studies we can conclude that there was no substantial work done on investment in energy. So, my study will try to find some relationship between investment in energy and economic growth.

2.2.3 Review of Growth Models with Other Control Variables

Literature review of growth models related to control variables such as human capital, inflation rate, trade openness, foreign direct investment and external debt, which have been used in our model, are discussed in the Table 2.1

Table 2.1 Growth Models with Other Control Variables

Author	Objective	Methodology	Data Period	Outcome
Abbas (2000)	Effect of human capital on economic growth	OLS	1970-1994	Secondary enrolment schooling rates affect positively to economic growth
Aamir *et al.* (2005)	Trade openness impact on economic growth	Johansen cointegration	1972-2002	Trade openness contribute negatively to economic growth
Qaisar *et al.* (2008)	Human capital impact on growth	Johansen cointegration	1960-2003	Human capital cause negatively to economic growth.
Shahbaz *et al.* (2008)	Growth and its determinants	ARDL	1991-2007	Financial development and FDI contribute positively to economic growth
Usman (2012)	Impact of trade on economic growth	OLS	1977-2008	Trade openness and FDI affect positively and negatively to economic growth respectively
Afzal *et al.*	School education	ARDL	1971-2009	Physical capital and

(2010)	impact on economic growth.			education have positive impact on real GDP
Rahman *et al.* (2010)	Economic growth and its determinants	FMOLS and ARDL	1971-2006	Stock market development, human capital and FDI all positively effects economic growth.
Husnain *et al.* (2011)	Impact of public spending and foreign direct investment on economic growth	OLS	1975-2008	Public spending and FDI contribute negatively and positively to growth respectively.
Qadri *et al.* (2011)	Human capital effect on economic growth	Johansen cointegration	1978-2007	Human capital positively affect economic growth
Ali *et al.* (2012)	Impact of human capital on economic growth	OLS	1973-2011	Human capital and inflation have positive and negative effects on economic growth respectively.
Khattak and Khan (2012)	Human capital impact on	OLS	1971-2008	Secondary education positively contribute to

	economic growth			economic growth
Reza *et al.* (2012)	Impact of education expenditure on economic growth	OLS	1981-2010	Education expenditure and gross fixed capital formation have positive and negative insignificant effects on economic growth respectively.
Nabila *et al.* (2012)	Human capital and health effect on economic growth	Johansen cointegration	1974-2009	Both human capital and health affect positively to economic growth
Najia *et al.* (2013)	Impact of foreign direct investment on economic growth	OLS	1981-2010	Foreign direct investment, trade, foreign debt and inflation rate have negative effects on economic growth.
Rifaqat *et al.* (2012)	External debt and its accumulation on economic growth.	Johansen cointegration and Engel – Granger	1970-2010	External debt negatively affect economic growth
Lin (2002)	Effect of education	Engel-Granger	1965-2000	Education has positive

	on economic growth			impact on economic growth.
Balamurali *et al. (2004)*	Impact of foreign direct investment on economic growth	Johansen cointegration and Engel-Granger	1977-2003	Foreign direct investment has positive impact on economic growth
Blin *et al.* (2009)	Impact of foreign direct investment on economic growth	ARDL	1975-2000	Foreign direct investment and human capital have positive effects on economic growth.
Risikat (2010)	Impact of human capital on economic growth	Johansen cointegration	1977-2006	Human capital has positive effects on economic growth

CHAPTER 3

THEORETICAL FRAMEWORK

In this chapter section 3.1 present the theoretical framework of economic model by incorporating energy in the growth model by Mankiw *et al.* (1992) and section 3.2 is related to the econometric model.

3.1 Theoretical Framework of Model

New Classical Growth model by Solow (1956) generally considers the capital and labor as intermediate inputs in determining economic growth. Mankiw *et al.* (1992) have introduced the human capital in Solow growth. That is

$$Y(t) = H(t)^{\alpha} K(t)^{\beta} (A(t) L(t))^{1-\alpha-\beta} \tag{3.1}$$

Where Y represents output, A represents technology, L shows labor force, K reveals physical capital and H is human capital. The exponents α, β *and* $1-\alpha-\beta$ reflect the share of human capital, physical capital and effective labor in output respectively.

Energy is always a crucial factor of production (Stern, 1997b). Cleveland *et al.* (1984), Hall *et al.* (2001) and Murphy and Hall (2011) consider that energy shows significant role in determining economic growth. To find the relationship between economic growth and energy we include the energy as a factor input in MRW growth model

$$Y(t) = (A(t), K(t), L(t), H(t), E(t)) = K(t)^{\alpha}\ H(t)^{\beta}\ E(t)^{\gamma} (A(t)L(t))^{1-\alpha-\beta-\gamma} \tag{3.2}$$

Dividing Equation (3.2) by $A(t)\,L(t)$

$$\frac{Y(t)}{A(t)L(t)} = \frac{K(t)^{\alpha}\ H(t)^{\beta}\ E(t)^{\gamma}\,(A(t)L(t))^{1-\alpha-\beta-\gamma}}{A(t)L(t)} = \frac{K(t)^{\alpha}\ H(t)^{\beta}\ E(t)^{\gamma}}{(A(t)L(t))^{\alpha+\beta+\gamma}}$$

$$\frac{Y(t)}{A(t)L(t)} = \frac{K(t)^{\alpha}\ H(t)^{\beta}\ E(t)^{\gamma}}{(A(t)L(t))^{\alpha}(A(t)L(t))^{\beta}(A(t)L(t))^{\gamma}} = \left(\frac{K(t)}{A(t)L(t)}\right)^{\alpha}\left(\frac{H(t)}{A(t)L(t)}\right)^{\beta}\left(\frac{E(t)}{A(t)L(t)}\right)^{\gamma}$$

$$y(t) = k(t)^{\alpha}\ h(t)^{\beta}\ e(t)^{\gamma} \qquad (3.3)$$

Where $y(t) = \frac{Y(t)}{A(t)L(t)}$, $k(t) = \frac{K(t)}{A(t)L(t)}$, $h(t) = \frac{H(t)}{A(t)L(t)}$, $e(t) = \frac{E(t)}{A(t)L(t)}$

Now we take

$$k(t) = \frac{K(t)}{A(t)L(t)}$$

Taking the derivative of the above equation with respect to time

$$\frac{dk(t)}{dt} = \frac{\dot{K}(t)}{A(t)L(t)} - \frac{K(t)}{(A(t)L(t))^2}\left(\dot{A}(t)\,L(t) + A(t)\,\dot{L}(t)\right) \qquad (3.4)$$

Where $\dot{K}(t)$ and $\dot{A}(t)$ represents the derivatives of physical capital and level of technology with respect to time respectively. If we denote investment in physical capital by s_K then net investment in physical capital will be

$$\dot{K}(t) = \frac{dK(t)}{dt} = s_k Y(t) - \delta\,K(t) \qquad (3.5)$$

Using equation (4) in equation (3) yield

$$\frac{dk(t)}{dt} = \frac{s_k Y(t) - \delta\,K(t)}{A(t)L(t)} - \frac{K(t)}{(A(t)L(t))}\left(\frac{\dot{A}(t)}{A(t)} + \frac{\dot{L}(t)}{L(t)}\right)$$

$$\frac{dk(t)}{dt} = \frac{s_k Y(t)}{A(t)L(t)} - \frac{\delta K(t)}{A(t)L(t)} - \frac{K(t)}{(A(t)L(t))}\left(\frac{\dot{A}(t)}{A(t)} + \frac{\dot{L}(t)}{L(t)}\right)$$

$$\frac{dk(t)}{dt} = s_k y(t) - \delta k(t) - k(t)(g+n) = s_k y(t) - (n+g+\delta)k(t) \qquad (3.6)$$

Where $y(t) = \frac{Y(t)}{A(t)L(t)}$, $\quad k(t) = \frac{K(t)}{A(t)L(t)}$, $\quad n = \frac{\dot{L}(t)}{L(t)}$, $\quad g = \frac{\dot{A}(t)}{A(t)}$

$$\frac{dk(t)}{dt} = s_k y(t) - (n+g+\delta)k(t) \qquad (3.7)$$

Steady state (equilibrium) occur at the point where $\frac{dk(t)}{dt} = 0$

Now equation (3.7) becomes as

$$s_k y(t) = (n+g+\delta)k(t)$$

$$s_k\, k(t)^{\alpha}\, h(t)^{\beta}\, e(t)^{\gamma} = (n+g+\delta)k(t)$$

$$\frac{s_k}{n+g+\delta} = \frac{k(t)}{k(t)^{\alpha}\, h(t)^{\beta}\, e(t)^{\gamma}} = \frac{k(t)^{1-\alpha}}{h(t)^{\beta}\, e(t)^{\gamma}}$$

$$k(t)^{1-\alpha} = \frac{s_k\, h(t)^{\beta}\, e(t)^{\gamma}}{n+g+\delta}$$

$$k(t) = \left(\frac{s_k\, h(t)^{\beta}\, e(t)^{\gamma}}{n+g+\delta}\right)^{1/1-\alpha} \qquad (3.8)$$

Now we take

$$h(t) = \frac{H(t)}{A(t)L(t)}$$

Taking the derivative of the above equation with respect to time

$$\frac{dh(t)}{dt} = \frac{\dot{H}(t)}{A(t)L(t)} - \frac{H(t)}{(A(t)L(t))^2}\left(\dot{A}(t)\,L(t) + A(t)\,\dot{L}(t)\right) \tag{3.9}$$

Where $\dot{H}(t)$ and $\dot{A}(t)$ represents the derivatives of human capital and level of technology with respect to time respectively. If we denote investment in human capital by s_h then net investment in human capital will be

$$\dot{H}(t) = \frac{dH(t)}{dt} = s_h Y(t) - \delta\, H(t) \tag{3.10}$$

Using equation (3.10) in equation (3.9) we get

$$\frac{dh(t)}{dt} = \frac{s_h Y(t) - \delta\, H(t)}{A(t)L(t)} - \frac{H(t)}{(A(t)L(t))}\left(\frac{\dot{A}(t)}{A(t)} + \frac{\dot{L}(t)}{L(t)}\right)$$

$$\frac{dh(t)}{dt} = \frac{s_h Y(t)}{A(t)L(t)} - \frac{\delta\, H(t)}{A(t)L(t)} - \frac{H(t)}{(A(t)L(t))}\left(\frac{\dot{A}(t)}{A(t)} + \frac{\dot{L}(t)}{L(t)}\right)$$

$$\frac{dh(t)}{dt} = s_h y(t) - \delta\, h(t) - h(t)(g+n) = s_h y(t) - (n+g+\delta)h(t) \tag{3.11}$$

$$\frac{dh(t)}{dt} = s_h y(t) - (n+g+\delta)h(t) \tag{3.12}$$

Steady state (Equilibrium) occur at the point where $\frac{dh(t)}{dt} = 0$

Now equation (3.12) becomes as

$$s_h y(t) = (n+g+\delta)h(t)$$

$$s_h\, k(t)^{\alpha}\, h(t)^{\beta}\, e(t)^{\gamma} = (n+g+\delta)h(t)$$

$$\frac{s_h}{n+g+\delta} = \frac{h(t)}{k(t)^{\alpha}\, h(t)^{\beta}\, e(t)^{\gamma}} = \frac{h(t)^{1-\beta}}{k(t)^{\alpha}\, e(t)^{\gamma}}$$

$$h(t)^{1-\beta} = \frac{s_h\, k(t)^{\alpha}\, e(t)^{\gamma}}{n+g+\delta}$$

$$h(t) = \left(\frac{s_h\, k(t)^{\alpha}\, e(t)^{\gamma}}{n+g+\delta} \right)^{1/1-\beta} \tag{3.13}$$

Now we take

$$e(t) = \frac{E(t)}{A(t)L(t)}$$

Taking the derivative of the above equation with respect to time

$$\frac{de(t)}{dt} = \frac{\dot{E}(t)}{A(t)L(t)} - \frac{E(t)}{(A(t)L(t))^2}\left(\dot{A}(t)\, L(t) + A(t)\, \dot{L}(t)\right) \tag{3.14}$$

Where $\dot{E}(t)$ and $\dot{A}(t)$ represents the derivatives of energy and level of technology with respect to time respectively. If we denote investment in energy sector by s_e then net invest in energy sector will be

$$\dot{E}(t) = \frac{dE(t)}{dt} = s_e Y(t) - \delta\, E(t) \tag{3.15}$$

Using equation (3.15) in equation (3.14) we get

$$\frac{de(t)}{dt} = \frac{s_e Y(t) - \delta\, E(t)}{A(t)L(t)} - \frac{E(t)}{(A(t)L(t))}\left(\frac{\dot{A}(t)}{A(t)} + \frac{\dot{L}(t)}{L(t)} \right)$$

$$\frac{de(t)}{dt} = \frac{s_e Y(t)}{A(t)L(t)} - \frac{\delta\, E(t)}{A(t)L(t)} - \frac{E(t)}{(A(t)L(t))}\left(\frac{\dot{A}(t)}{A(t)} + \frac{\dot{L}(t)}{L(t)} \right)$$

$$\frac{de(t)}{dt} = s_e y(t) - \delta\, e(t) - e(t)\left(g+n\right) = s_e y(t) - \left(n+g+\delta\right)e(t) \tag{3.16}$$

$$\frac{de(t)}{dt} = s_e y(t) - (n + g + \delta)e(t) \tag{3.17}$$

Steady state (equilibrium) occur at the point where $\frac{de(t)}{dt} = 0$

Now equation (3.17) becomes as

$$s_e y(t) = (n + g + \delta)e(t) \Rightarrow \; s_e \, k(t)^{\alpha} \, h(t)^{\beta} \, e(t)^{\gamma} = (n + g + \delta)e(t)$$

$$\frac{s_e}{n + g + \delta} = \frac{e(t)}{k(t)^{\alpha} \, h(t)^{\beta} \, e(t)^{\gamma}} = \frac{e(t)^{1-\gamma}}{k(t)^{\alpha} \, h(t)^{\beta}}$$

$$e(t)^{1-\gamma} = \frac{s_e \, k(t)^{\alpha} \, h(t)^{\beta}}{n + g + \delta}$$

$$e(t) = \left(\frac{s_e \, k(t)^{\alpha} \, h(t)^{\beta}}{n + g + \delta} \right)^{1/1-\gamma} \tag{3.18}$$

Now we solve equation (3.8), (3.13) and (3.18) simultaneously

Using equation (3.8) in (3.13), we get

$$h(t) = \left(\frac{s_h \left(\frac{s_k \, h(t)^{\beta} \, e(t)^{\gamma}}{n + g + \delta} \right)^{\alpha/1-\alpha} e(t)^{\gamma}}{n + g + \delta} \right)^{1/1-\beta}$$

$$h(t) = \left(\frac{s_h \, s_k^{\alpha/1-\alpha} \;\; h(t)^{\alpha\beta/1-\alpha} \;\; e(t)^{\alpha\gamma/1-\alpha} \;\; e(t)^{\gamma}}{(n + g + \delta)^{1/1-\alpha}} \right)^{1/1-\beta}$$

$$h(t) = \left(\frac{s_h \, s_k^{\alpha/1-\alpha} \;\; e(t)^{\alpha\gamma/1-\alpha} \;\; e(t)^{\gamma}}{(n + g + \delta)^{1/1-\alpha}} \right)^{1/1-\beta} \; h(t)^{\alpha\beta/(1-\alpha)(1-\beta)}$$

$$\frac{h(t)}{h(t)^{\alpha\beta/(1-\alpha)(1-\beta)}} = \left(\frac{s_h \, s_k^{\alpha/1-\alpha} \;\; e(t)^{\alpha\gamma/1-\alpha} \;\; e(t)^{\gamma}}{(n + g + \delta)^{1/1-\alpha}} \right)^{1/1-\beta}$$

$$h(t)^{1-\alpha-\beta/(1-\alpha)(1-\beta)} = \left(\frac{s_h\, s_k^{\alpha/1-\alpha} \;\; e(t)^{\alpha\gamma/1-\alpha} \;\; e(t)^{\gamma}}{(n+g+\delta)^{1/1-\alpha}} \right)^{1/1-\beta}$$

$$h(t) = \left(\frac{s_h\, s_k^{\alpha/1-\alpha} \;\; e(t)^{\alpha\gamma/1-\alpha} \;\; e(t)^{\gamma}}{(n+g+\delta)^{1/1-\alpha}} \right)^{1-\alpha/1-\alpha-\beta}$$

$$h(t) = \left(\frac{s_h^{1-\alpha}\, s_k^{\alpha} \;\; e(t)^{\gamma}}{n+g+\delta} \right)^{1/1-\alpha-\beta} \tag{3.19}$$

Using equation (3.8) in (3.18)

$$e(t) = \left(\frac{s_e \left(\frac{s_k\, h(t)^{\beta}\, e(t)^{\gamma}}{n+g+\delta} \right)^{\alpha/1-\alpha} h(t)^{\beta}}{n+g+\delta} \right)^{1/1-\gamma}$$

$$e(t) = \left(\frac{s_e\, s_k^{\alpha/1-\alpha}\; h(t)^{\beta/1-\alpha}}{(n+g+\delta)^{1/1-\alpha}} \right)^{1/1-\gamma} e(t)^{\alpha\gamma/(1-\alpha)(1-\gamma)}$$

$$\frac{e(t)}{e(t)^{\alpha\gamma/(1-\alpha)(1-\gamma)}} = \left(\frac{s_e\, s_k^{\alpha/1-\alpha}\; h(t)^{\beta/1-\alpha}}{(n+g+\delta)^{1/1-\alpha}} \right)^{1/1-\gamma}$$

$$e(t)^{1-\alpha-\gamma/(1-\alpha)(1-\gamma)} = \left(\frac{s_e\, s_k^{\alpha/1-\alpha}\; h(t)^{\beta/1-\alpha}}{(n+g+\delta)^{1/1-\alpha}} \right)^{1/1-\gamma}$$

$$e(t) = \left(\frac{s_e\, s_k^{\alpha/1-\alpha}\; h(t)^{\beta/1-\alpha}}{(n+g+\delta)^{1/1-\alpha}} \right)^{1-\alpha/1-\alpha-\gamma}$$

$$e(t) = \left(\frac{s_e^{1-\alpha}\;\; s_k^{\alpha}\;\; h(t)^{\beta}}{n+g+\delta} \right)^{1/1-\alpha-\gamma} \tag{3.20}$$

Using equation (3.20) in equation (3.19)

$$h(t)=\left(\frac{s_h^{1-\alpha}\ s_k^{\alpha}\ \left(\frac{s_e^{1-\alpha}\ s_k^{\alpha}\ h(t)^{\beta}}{n+g+\delta}\right)^{\gamma/1-\alpha-\gamma}}{n+g+\delta}\right)^{1/1-\alpha-\beta}$$

$$h(t)=\left(\frac{s_h^{1-\alpha}\ s_k^{\alpha}\ \ s_e^{(1-\alpha)\gamma/1-\alpha-\gamma}\ \ s_k^{\alpha\gamma/1-\alpha-\gamma}}{(n+g+\delta)^{\frac{1-\alpha}{1-\alpha-\gamma}}}\right)^{1/1-\alpha-\beta}\qquad h(t)^{\beta\gamma/(1-\alpha-\gamma)(1-\alpha-\beta)}$$

$$\frac{h(t)}{h(t)^{\beta\gamma/(1-\alpha-\gamma)(1-\alpha-\beta)}}=\left(\frac{s_h^{1-\alpha}\ s_k^{\alpha}\ \ s_e^{(1-\alpha)\gamma/1-\alpha-\gamma}\ \ s_k^{\alpha\gamma/1-\alpha-\gamma}}{(n+g+\delta)^{\frac{1-\alpha}{1-\alpha-\gamma}}}\right)^{1/1-\alpha-\beta}$$

$$h(t)^{\frac{(1-\alpha)(1-\alpha-\beta-\gamma)}{(1-\alpha-\gamma)(1-\alpha-\beta)}}=\left(\frac{s_h^{1-\alpha}\ s_k^{\alpha}\ \ s_e^{(1-\alpha)\gamma/1-\alpha-\gamma}\ \ s_k^{\alpha\gamma/1-\alpha-\gamma}}{(n+g+\delta)^{\frac{1-\alpha}{1-\alpha-\gamma}}}\right)^{1/1-\alpha-\beta}$$

$$h(t)=\left(\frac{s_h^{1-\alpha}\ s_k^{\alpha}\ \ s_e^{(1-\alpha)\gamma/1-\alpha-\gamma}\ \ s_k^{\alpha\gamma/1-\alpha-\gamma}}{(n+g+\delta)^{\frac{1-\alpha}{1-\alpha-\gamma}}}\right)^{\frac{(1-\alpha-\gamma)}{(1-\alpha)(1-\alpha-\beta-\gamma)}}$$

$$h(t)=\left(\frac{s_h^{1-\alpha-\gamma}\ s_k^{\alpha}\ \ s_e^{\gamma}}{n+g+\delta}\right)^{1/1-\alpha-\beta-\gamma} \tag{3.21}$$

Using equation (3.19) in equation (3.20)

$$e(t)=\left(\frac{s_e^{1-\alpha}\ s_k^{\alpha}\ \left(\frac{s_h^{1-\alpha}\ s_k^{\alpha}\ e(t)^{\gamma}}{n+g+\delta}\right)^{\beta/1-\alpha-\beta}}{n+g+\delta}\right)^{1/1-\alpha-\gamma}$$

$$e(t)=\left(\frac{s_e^{1-\alpha}\ \ s_k^{\alpha}\ \ s_h^{(1-\alpha)\beta/1-\alpha-\beta}\ s_k^{\alpha\beta/1-\alpha-\beta}\ \ e(t)^{\gamma\beta/1-\alpha-\beta}}{(n+g+\delta)^{1-\alpha/1-\alpha-\beta}}\right)^{1/1-\alpha-\gamma}$$

$$e(t)=\left(\frac{s_e^{1-\alpha}\ \ s_k^{\alpha}\ \ s_h^{(1-\alpha)\beta/1-\alpha-\beta}\ s_k^{\alpha\beta/1-\alpha-\beta}}{(n+g+\delta)^{1-\alpha/1-\alpha-\beta}}\right)^{1/1-\alpha-\gamma}\quad e(t)^{\beta\gamma/(1-\alpha-\beta)(1-\alpha-\gamma)}$$

$$\frac{e(t)}{e(t)^{\beta\gamma/(1-\alpha-\beta)(1-\alpha-\gamma)}}=\left(\frac{s_e^{1-\alpha}\ \ s_k^{\alpha}\ \ s_h^{(1-\alpha)\beta/1-\alpha-\beta}\ s_k^{\alpha\beta/1-\alpha-\beta}}{(n+g+\delta)^{1-\alpha/1-\alpha-\beta}}\right)^{1/1-\alpha-\gamma}$$

$$e(t)^{\frac{(1-\alpha)(1-\alpha-\beta-\gamma)}{(1-\alpha-\beta)(1-\alpha-\gamma)}}=\left(\frac{s_e^{1-\alpha}\ \ s_k^{\alpha}\ \ s_h^{(1-\alpha)\beta/1-\alpha-\beta}\ s_k^{\alpha\beta/1-\alpha-\beta}}{(n+g+\delta)^{1-\alpha/1-\alpha-\beta}}\right)^{1/1-\alpha-\gamma}$$

$$e(t)=\left(\frac{s_e^{1-\alpha}\ \ s_k^{\alpha}\ \ s_h^{(1-\alpha)\beta/1-\alpha-\beta}\ s_k^{\alpha\beta/1-\alpha-\beta}}{(n+g+\delta)^{1-\alpha/1-\alpha-\beta}}\right)^{\frac{1-\alpha-\beta}{(1-\alpha)(1-\alpha-\beta-\gamma)}}$$

$$e(t)=\left(\frac{s_e^{1-\alpha-\beta}\ \ s_k^{\alpha}\ \ s_h^{\beta}}{n+g+\delta}\right)^{\frac{1}{1-\alpha-\beta-\gamma}} \qquad (3.22)$$

Using equation (3.21) and (3.22) in equation (3.8)

$$k(t)=\left(\frac{s_k\left(\frac{s_h^{1-\alpha-\gamma}\ s_k^{\alpha}\ s_e^{\gamma}}{n+g+\delta}\right)^{\frac{\beta}{1-\alpha-\beta-\gamma}}\ \left(\frac{s_e^{1-\alpha-\beta}\ s_k^{\alpha}\ s_h^{\beta}}{n+g+\delta}\right)^{\frac{\gamma}{1-\alpha-\beta-\gamma}}}{n+g+\delta}\right)^{1/1-\alpha}$$

$$k(t)=\left(\frac{s_k\left(\frac{s_h^{1-\alpha-\gamma}\ s_k^{\alpha}\ s_e^{\gamma}}{n+g+\delta}\right)^{\frac{\beta}{1-\alpha-\beta-\gamma}}\ \left(\frac{s_e^{1-\alpha-\beta}\ s_k^{\alpha}\ s_h^{\beta}}{n+g+\delta}\right)^{\frac{\gamma}{1-\alpha-\beta-\gamma}}}{n+g+\delta}\right)^{1/1-\alpha}$$

$$k(t)=\left(\frac{s_h^{\beta(1-\alpha-\gamma)/1-\alpha-\beta-\gamma}\; s_k^{\alpha\beta/1-\alpha-\beta-\gamma}\; s_e^{\beta\gamma/1-\alpha-\beta-\gamma}\; s_e^{\gamma(1-\alpha-\beta)/1-\alpha-\beta-\gamma}\; s_k^{\alpha\gamma/1-\alpha-\beta-\gamma}\; s_h^{\beta\gamma/1-\alpha-\beta-\lambda}}{(n+g+\delta)^{1/1-\alpha}}\right)^{1/1-\alpha}$$

After simplification

$$k(t)=\left(\frac{s_k^{1-\beta-\gamma}\; s_h^{\beta}\; s_e^{\gamma}}{n+g+\delta}\right)^{\frac{1}{1-\alpha-\beta-\gamma}} \tag{3.23}$$

Using equation (3.23), (3.22) and (3.21) in equation (3.3)

$$y(t)=\left(\frac{s_k^{\;1-\beta-\gamma}\; s_h^{\;\beta}\; s_e^{\;\gamma}}{n+g+\delta}\right)^{\alpha/1-\alpha-\beta-\gamma}\quad\left(\frac{s_h^{\;1-\alpha-\gamma}\; s_k^{\;\alpha}\; s_e^{\;\gamma}}{n+g+\delta}\right)^{\beta/1-\alpha-\beta-\gamma}\left(\frac{s_e^{\;1-\alpha-\beta}\; s_k^{\;\alpha}\; s_h^{\;\beta}}{n+g+\delta}\right)^{\gamma/1-\alpha-\beta-\gamma}$$

Simplifying the above equation we get

$$y(t)=\left(s_k^{\;\alpha}\; s_h^{\;\beta}\; s_e^{\;\gamma}\right)^{\frac{1}{1-\alpha-\beta-\gamma}}(n+g+\delta)^{-\left(\frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}\right)}$$

$$\frac{Y(t)}{A(t)\,L(t)}=\left(s_k^{\;\alpha}\; s_h^{\;\beta}\; s_e^{\;\gamma}\right)^{\frac{1}{1-\alpha-\beta-\gamma}}\;(n+g+\delta)^{-\left(\frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}\right)}$$

$$\frac{Y(t)}{L(t)}=A(t)\left(s_k^{\;\alpha}\; s_h^{\;\beta}\; s_e^{\;\gamma}\right)^{\frac{1}{1-\alpha-\beta-\gamma}}(n+g+\delta)^{-\left(\frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}\right)}$$

$$\frac{Y(t)}{L(t)}=A(t)\;\left(s_k^{\;\alpha}\; s_h^{\;\beta}\; s_e^{\;\gamma}\right)^{\frac{1}{1-\alpha-\beta-\gamma}}(n+g+\delta)^{-\left(\frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}\right)}$$

Taking “ln” on both sides of the above equation we get

$$\begin{aligned}\ln\left(\frac{Y(t)}{L(t)}\right)&=\ln A(t)+\frac{\alpha}{1-\alpha-\beta-\gamma}\ln s_k+\frac{\beta}{1-\alpha-\beta-\gamma}\ln s_h\\&\quad+\frac{\gamma}{1-\alpha-\beta-\gamma}\ln s_e-\frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}\ln(n+g+\delta)\end{aligned} \tag{3.24}$$

$$\ln\left(\frac{Y(t)}{L(t)}\right)=\beta_0+\beta_1\ln s_k+\beta_2\ln s_h+\beta_3\ln s_e+\beta_4\ln(n+g+\delta) \tag{3.25}$$

Where

$$\beta_0 = \ln A(t),\ \ \beta_1 = \frac{\alpha}{1-\alpha-\beta-\gamma},\ \ \beta_2 = \frac{\beta}{1-\alpha-\beta-\gamma},\ \ \beta_3 = \frac{\gamma}{1-\alpha-\beta-\gamma},\ \ \beta_4 = -\frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}$$

In literature of economic growth various variables such as inflation (INF), trade openness (TOP), foreign direct investment (FDI) and external debt (ED) have been included to complete the picture of economic growth. Equation (3.25) is further generalized by incorporating these variables. The model then becomes as:

$$\ln\left(\frac{Y(t)}{L(t)}\right) = \beta_0 + \beta_1 \ln s_k + \beta_2 \ln s_h + \beta_3 \ln s_e + \beta_4 \ln(n+g+\delta) + \beta_5 \ln INF + \beta_6 \ln FDI + \beta_7 \ln TOP + \beta_8 \ln ED \tag{3.26}$$

3.2 Econometric Model:

The econometric representation of growth model under equation (3.26) can be presented as

$$\ln\left(\frac{Y(t)}{L(t)}\right) = \beta_0 + \beta_1 \ln s_k + \beta_2 \ln s_h + \beta_3 \ln s_e + \beta_4 \ln(n+g+\delta) + \beta_5 \ln INF + \beta_6 \ln FDI + \beta_7 \ln TOP + \beta_8 \ln ED + \varepsilon_t \tag{3.27}$$

Here $Y(t)/L(t)$ shows the gross domestic product per capita, s_k, s_h *and* s_e represents share of investment in physical capital, human capital and energy sector, n shows annual growth rate of labor, g indicates growth rate of technology, δ depicts depreciation rate, and INF, TOP, FDI and ED represents respectively inflation, trade openness, foreign direct investment and external debt. β_0 indicate the intercept and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ *and* β_8 shows the regression coefficients that we want to estimate and the error term ε_t is independently and identically distributed that is $IID(0, \sigma_{\varepsilon}^{2})$. Theoretically it is expected that share of investment in energy, share of investment in physical capital and share of investment in human capital, trade openness have positive impacts while growth rate of labor force and depreciation rate, inflation, foreign direct investment and external debt have negative impact on economic growth.

CHAPTER 4

METHODOLOGICAL FRAMEWORK AND DESCRIPTION OF VARIABLES

This chapter will provide the methodological framework, description of variables and data sources. Section 4.1 describes the cointegration methodology. Section 4.2 discusses the various diagnostic tests. However, section 4.3 is related to the description of variables.

4.1 Cointegration

The purpose of this study is to examine the cointegration relationship between energy investment and economic growth along other control variables. Autoregressive distributed lag (ARDL) approach will be applied to check the long run relationship. This technique assumes that one set of variables are level stationary i.e. I(0) and other are stationary at first difference i.e. I(1). However, the fundamental assumptions of the ARDL approach are violated if the integration order of any variable is larger than 1 (Ouattara, 2004). For this purpose, in this research, we start by testing for the integration order of the included variables, before to estimation of the ARDL model.

4.1.1 Unit Root Test

In time series data there is a possibility of spurious results. Therefore, it is necessary to address the problem of non-stationary to avoid these spurious results. Stationary properties of the variables are examined by the augmented Dickey-Fuller (ADF) test (1979). The augmented DF test is the modified form of the standard Dickey-Fuller (DF) test. The ADF test augmented the Dickey-Fuller equation by including the lagged difference term of the dependent variable as independent variables so as to remove the problem of auto-correlation. The ADF test has been applied with or without intercept and/ or a time trend to determine the non-stationary of variables. The ADF test is expressed in the following model

$$\Delta y_t = \alpha + \beta t + \rho y_{t-1} + \sum_{i=1}^{p} \Delta y_{t-i} + \mu_t$$

(4.1)

Where y_t shows time series, α represents constant term, t is the time trend, Δ is the first difference operator, β *and* ρ are the parameters to be estimated, p represents the optimal lag length and μ_t is the white noise error term. The null hypothesis $H_0 : \rho = 0$ (series is non-stationary) is tested against the alternative hypothesis $H_0 : \rho < 0$ (series is stationary) based on τ-statistic. Since test statistic does not based on the student's t-distribution. Therefore, critical values provided by Dickey and Fuller (1979) and Mackinnon (1996) are used for analysis.

4.2.2 ARDL Cointegration Approach

The main purpose of the study is to check how share of investment in energy affects the per capita growth rate in short and long run. To obtain the objectives of the study, we will estimate our model by utilizing the *ARDL* (autoregressive distributed lag) methodology proposed by Pesaran and Shin (1999) and further proposed by Pesaran *et al*. (2001). This methodology is preferred to the Engle-Granger (1987) two-step methodology and Johansen (1988) and Johansen and Juselius (1990) approach to co-integration, and have many advantages. By using ARDL approach the long and short run impacts of variables could be found out at the same time. With the ARDL model, co-integration analysis can be done without identifying of whether the underlying independent variables are purely I(0), purely I(1) or a mixture of both, while the other approaches such as the Johansen as well as Engle-Granger methodology are concerned with the long run association among I(1) variables. In this approach the long run relationship to be assessed by OLS method once the lag order of the variables is known.

This methodology makes progress upon the other approaches since it is superior at controlling small samples and dynamic causes of bias. Pesaran *et al*. (2001), Pesaran and Shin (1999), and Haug (2002) show that the short-run parameters of the OLS estimators in the unrestricted error correction model (UECM) are consistent and the long-run parameters are super consistent in small samples. This approach also controls for endogeneity problem. As we have been using eight explanatory variables and data period is from 1970-2012. In this situation ARDL approach is an appropriate technique because it captures the small sample bias.

4.2.2a ARDL Model Specification

To estimate the growth model with energy and other control variables such as inflation, foreign direct investment, trade openness and external debt, the unrestricted error correction model under ARDL methodology given as follows:

$$\begin{aligned}
\Delta \ln\left(\frac{Y(t)}{L(t)}\right) &= \alpha_0 + \theta_Y \ln\left(\frac{Y}{L}\right)_{t-1} + \theta_k \ln s_{kt-1} + \theta_h \ln s_{ht-1} + \theta_e \ln s_{et-1} + \theta_{n+g+\delta} \ln(n+g+\delta)_{t-1} \\
&+ \theta_{INF} \ln INF_{t-1} + \theta_{TOP} \ln TOP_{t-1} + \theta_{FDI} \ln FDI_{t-1} + \theta_{ED} \ln ED_{t-1} + \sum_{i=1}^{r} \phi_{1i} \Delta \ln\left(\frac{Y}{L}\right)_{t-i} \\
&+ \sum_{j=0}^{s} \phi_{2j} \Delta \ln s_{kt-j} + \sum_{k=0}^{t} \phi_{3k} \Delta \ln s_{ht-k} + \sum_{l=0}^{u} \phi_{4l} \Delta \ln s_{et-l} + \sum_{m=0}^{v} \phi_{5m} \Delta \ln(n+g+\delta)_{t-m} \\
&+ \sum_{n=0}^{w} \phi_{6n} \Delta \ln INF_{t-n} + \sum_{o=0}^{x} \phi_{7o} \Delta \ln TOP_{t-o} + \sum_{p=0}^{y} \phi_{8p} \Delta \ln FDI_{t-p} + \sum_{q=0}^{z} \phi_{9q} \Delta \ln ED_{t-q} + \varepsilon_t
\end{aligned} \qquad \textbf{(4.1)}$$

Where, $\left(\frac{Y(t)}{L(t)}\right)$, s_k , s_h , s_e INF, TOP, FDI and ED are respectively gross domestic product per capita, share of investment in physical capital, share of investment in human capital, share of investment in energy, inflation rate, trade openness, foreign direct investment and external debt. θ_Y, θ_k, θ_h, θ_e, $\theta_{n+g+\delta}$, θ_{INF}, $\theta_{TOP}, \theta_{FDI}$ *and* θ_{ED} are long-run coefficients, α_0 is the drift term, ε_t is white noise error term and $r, s, t, u, v, w, x, y, z$ are optimal lag length.

The AIC (Akaike Information Criterion) or *SBC* (Schwarz Bayesian Criterion) will be followed to choose the orders of the lags in ARDL model. ARDL technique will be applied in following three steps.

4.2.2b Bound Testing Approach

In ARDL bound testing approach, the first step is to find the values of the parameters of equation (4.1) by OLS (ordinary least square) method. A long run association among the gross domestic product per capita and other independent variables exists if lagged level coefficients are jointly significant. The null hypothesis of the absence of cointegration relationship represented by $H_0 : \theta_Y = \theta_k = \theta_h = \theta_e = \theta_{n+g+\delta} = \theta_{\text{INF}} = \theta_{\text{TOP}} = \theta_{FDI} = \theta_{ED} = 0$, if it is rejected against the alternative hypothesis of long run relationship represented by $H_a : \theta_Y \neq \theta_k \neq \theta_h \neq \theta_e \neq \theta_{n+g+\delta} \neq \theta_{\text{INF}} \neq \theta_{\text{TOP}} \neq \theta_{FDI} \neq \theta_{ED} \neq 0$, then it can be concluded that a long run connection present among the gross domestic product per capita and share of investment in energy with other control variables. The existence of long run relationship is tested by using F-statistic and compared with the critical values proposed by Pesaran *et al.* (2001). These critical values are available for different number of explanatory variables and different combinations of deterministic part that is whether the model include drift or trend term.

Two types of asymptotic critical values have been provided by Pesaran *et al*. (2001) to test for co-integration. The lower critical bound (LCB) and upper critical bound (UCB) are applied to check either the variables included in the model are co-integrated for long run association or not. We apply LCB to test the long run association among the variables when all the variables are level stationary i.e. I (0) and we use UCB when all the variables are stationary at first difference i.e. I (1). If the calculated value of F-statistic is larger than the UCB that is $F > UCB$ the null hypothesis of no cointegration relationship can be rejected irrespective of the orders of integration of the variables and hence we can conclude that the long run relationship exists between gross domestic product per capita and explanatory variables.

Conversely, if the observed value of F-test is lower than LCB that is $F < LCB$ then we fail to reject the hypothesis of no co-integration and hence conclude that the long run relationship does not exist among gross domestic product per capita and explanatory variables.

Lastly, if the calculated value of the F-test falls between LCB and UCB that is, $LCB < F < UCB$ the result is questionable and the integration order of the essential variables has to be studied more deeply.

After checking the presence cointegration among the relevant variables, the second step of the investigation is to find out the estimated coefficients of the long run relation. In this regard we will estimate the following equation

$$\ln\left(\frac{Y}{L}\right)_{t-1} = \pi_1 \ln s_{kt-1} + \pi_2 \ln s_{ht-1} + \pi_3 \ln s_{et-1} + \pi_4 \ln(n+g+\delta)_{t-1} + \pi_5 \ln INF_{t-1} + \pi_6 \ln TOP_{t-1} + \pi_7 \ln FDI_{t-1} + \pi_8 \ln ED_{t-1} + v_t \quad (4.2)$$

Where

$$\pi_1 = \frac{\theta_k}{\theta_Y},\ \pi_2 = \frac{\theta_h}{\theta_Y},\ \pi_3 = \frac{\theta_e}{\theta_Y},\ \pi_4 = \frac{\theta_{n+g+\delta}}{\theta_Y},\ \pi_5 = \frac{\theta_{INF}}{\theta_Y},\ \pi_6 = \frac{\theta_{TOP}}{\theta_Y},\ \pi_7 = \frac{\theta_{FDI}}{\theta_Y},\ \pi_8 = \frac{\theta_{ED}}{\theta_Y}$$

In last stage, we find the short-run dynamic coefficients by estimating an error correction model related with the long-run estimators. The equation for this purpose is represented as follows:

$$\Delta \ln\left(\frac{Y(t)}{L(t)}\right) = \alpha_0 + \sum_{i=1}^{r} \phi_{1i} \Delta \ln\left(\frac{Y}{L}\right)_{t-i} + \sum_{j=0}^{s} \phi_{2j} \Delta \ln s_{kt-j} + \sum_{k=0}^{t} \phi_{3k} \Delta \ln s_{ht-k} + \sum_{l=0}^{u} \phi_{4l} \Delta \ln s_{et-l}$$
$$+ \sum_{m=0}^{v} \phi_{5m} \Delta \ln(n+g+\delta)_{t-m} + \sum_{n=0}^{w} \phi_{6n} \Delta \ln INF_{t-n} + \sum_{o=0}^{x} \phi_{7o} \Delta \ln TOP_{t-o} + \sum_{p=0}^{y} \phi_{8p} \Delta \ln FDI_{t-p}$$
$$+ \sum_{q=0}^{z} \phi_{9q} \Delta \ln ED_{t-q} + \varphi ECM_{t-1} + u_t \tag{4.3}$$

Where ECM shows error correction term and is represented as follows:

$$ECM = \Delta \ln\left(\frac{Y(t)}{L(t)}\right) - \alpha_0 - \sum_{i=0}^{r} \phi_{1i} \Delta \ln\left(\frac{Y}{L}\right)_{t-i} - \sum_{j=0}^{s} \phi_{2j} \Delta \ln s_{kt-j} - \sum_{k=0}^{t} \phi_{3k} \Delta \ln s_{ht-k}$$
$$- \sum_{l=0}^{u} \phi_{4l} \Delta \ln s_{et-l} - \sum_{m=0}^{v} \phi_{5m} \Delta \ln(n+g+\delta)_{t-m} - \sum_{n=0}^{w} \phi_{6n} \Delta \ln INF_{t-n} - \sum_{o=0}^{x} \phi_{7o} \Delta \ln TOP_{t-o}$$
$$- \sum_{p=0}^{y} \phi_{8p} \Delta \ln FDI_{t-p} - \sum_{q=0}^{z} \phi_{9q} \Delta \ln ED_{t-q} \tag{4.4}$$

And φ shows the speed of adjustment coefficient and its absolute value indicates how quickly the equilibrium is reached in the short run model. The expected sign of this coefficient should be negative and highly significant. The negative sign with high significance level ensure whenever the shock occur, the dependent variable convergent to its long run equilibrium value.

4.2 Diagnostic Tests

As serial correlation, heteroskedasticity and non-normality all violate the important assumption that errors follow the normal distribution with mean equal to zero and constant variance i.e. $N(0,\sigma^2 I)$. For this purposes the diagnostic tests are also applied. The Jarque-Bera (JB) test is applied to test the normality assumption. First this test finds the skewness and kurtosis measures of the OLS residuals. Under this statistic the null hypothesis is that the errors follow the normal distribution. JB test statistic has the chi-square distribution with 2 degree of freedom.

In time series, the successive values of the dependent variable or error terms are likely to exhibit inter-correlate. This problem in econometrics is named as serial correlation or autocorrelation. The presence of serial correlation in the data set leads to inconsistent standard errors which in turn affect statistical inference. Breusch Godfrey LM test is used to detect autocorrelation. This test follows the chi-square distribution.

The error variance σ^2 at time t is likely to found correlate with the squared error term in period (t-1). This problem is known as autoregressive conditional heteroskedasticity (ARCH). Ignoring ARCH affects may lead inefficiency in estimated results. So, ARCH test is used to detect the problem of heteroskedasticity.

In order to determine the structural stability of the parameters of the model, the CUSUMSQ test (cumulative sum of squares of residuals) is applied. CUSUMSQ test depends on and plots the cumulative sum of square of the recursive residuals along with the 5% straight critical lines. The parameters are found to be instable if the cumulative sum square of the recursive residuals cross or goes outside the two critical lines.

4.3 Description of Variables

This section will describe the variables and give source from where these variables are taken. Following variables are included in the study

4.3.1 Gross Domestic Product per Capita (Y/L)

A number of economists measure economic output of a nation through its gross domestic product (GDP). We have used gross domestic product per capita measured in constant local currency as proxy of economic growth. The data on this variable is taken from World Development Indicator.

4.3.2 Share of Investment in Physical Capital (S_k)

Gross fixed capital formation in current market prices is used as a proxy of physical capital stock. We divide the physical capital stock series by gross domestic product at constant factor cost of 1999-20000 and obtained the investment in physical capital (ratio of GDP). We use ratio of physical capital stock to GDP as a share of investment in physical capital. The share of investment in physical capital is without any measurement unit because physical capital stock and GDP both are measured in millions of rupees. As the investment in electricity generation, distribution and gas distribution is included in gross fixed capital formation so we have used gross fixed capital formation after subtracting the investment in electricity generation, distribution and gas distribution from gross fixed capital formation. The data on this variable is taken from several issues of Pakistan economic survey.

4.3.3 Annual Growth Rate of Labor Force, Depreciation Rate and Growth Rate of Technology

The total labor force, including employed and unemployed people having age 15 years or older who can provide the labor services in the production of goods and services, is measured as labor input (L). The data on labor force is taken from various issues of Pakistan economic survey. The measurement unit of labour force is in millions of people. Annual growth rate of labor force is used as growth rate of labor force (n). Technology growth rate g plus depreciation rate δ is assumed to be 0.05 (Mankiw *et al.* 1992). It is expected that $n + g + \delta$ will affect negatively to economic growth.

4.3.4 Share of Investment in Human Capital (S_h)

Human capital is referred to as skills and knowledge embodied in labor force. Human capital (H) is used as a proxy of the total enrolment in secondary education. We have used human capital to labor force ratio as a share of investment in human capital. This proxy is also used by Mankiw *et al.* (1992). The data on enrolment in secondary education is taken from various issues of Pakistan economic survey. The share of investment in human capital is unit less because this variable is constructed after converting labor force in thousands as secondary education. It is expected this variable have positive effect on economic growth.

4.3.5 Share of Investment in Energy (S_e)

The gross fixed capital formation in electricity generation, distribution and gas distribution in current market prices is used as investment in energy (E). Our study will use the ratio of investment in energy to GDP as a share of investment in energy. The annual time series data for this variable is taken from various issues of Pakistan economic surveys. Share of investment in energy is without any measurement unit because both GDP and investment in energy are measured in millions of rupees. Share of investment in energy is expected to have positive sign.

4.3.6 Inflation (INF)

There is an important connection between inflation and economic growth. Kowalski (2000) found the negative relationship between inflation and economic growth. He argued that inflation determines the economic stability of a nation. High level of inflation indicates serious economic problem for the country. CPI annual percent is used as a proxy for inflation. This proxy is also used by Ali *et al.* (2012). The data on this variable is taken from World Development Indicator. We expect a negative relationship of this variable with dependent variable.

4.3.7 Trade Openness (TOP)

We have also included trade openness in our model to capture the effect of outer demand or openness on economic growth of domestic economy. Literature reveals positive impact of trade openness on economic growth by increasing domestic output. A ratio of imports plus exports to GDP is used as a proxy of trade openness. This proxy is also used by Shahbaz *et al.* (2008), Husnain *et al.* (2011) and Balamurali e*t al. (2004).* The data on this variable is derived from various issues of Pakistan economic survey. We expect trade openness will positively affect economic growth as it has in previous literature. Expected sign for trade openness is positive.

4.3.8 Foreign Direct Investment (FDI)

Foreign direct investment (FDI) is mostly considered an important determinant of economic growth in the developing nations like Pakistan. It causes to change the economic growth by motivating domestic investment, improving infrastructure, bringing technological improvements and by stimulating human capital in the host countries. According to Kowalski (2000) foreign direct investment positively affects economic growth. FDI contribute positively to economic growth for those countries having higher level of human capital and negatively for those countries having low level of human capital (*E.B et al 1998).* Mixed results of FDI with economic growth are found in previous literature. FDI is associated negatively to economic growth (Kogid *et al*. 2010), Najia *et al*. (2013) .In our study foreign direct investment percentage of GDP is used as a proxy of FDI. This proxy is also used by Blin *et al.* (2009) and Husnain *et al.* (2011). The data on this variable is taken from various issues of Pakistan economic survey.

4.3.9 External Debt (ED)

Total debt is one of determinant of economic growth (Kowalski 2000). Total debt is negatively associated with economic growth, (Kowalski 2000) and Najia *et al.* (2013). The external debt stock percentage of gross national income is used as a proxy of external debt (ED). The expected sign of this variable is negative. The data on this variable is derived from WDI.

Time series data at annual frequency is used for the analysis covering the period of 1970 to 2012.

4.4 Construction of variables

$$\frac{Y}{L} = Gross\ domestic\ product\ per\ capita$$

$$S_h = \frac{\text{Total enrolment in secondary education}}{Labour\ force}$$

$$S_k = \frac{\text{Gross fixed capital formation - gross fixed capital formation in energy}}{Gross\ domestic\ product}$$

$$S_e = \frac{\text{Gross fixed capital formation in energy}}{Gross\ domestic\ product}$$

$$n + g + \delta = Anual\ growth\ rate\ of\ labour\ force + growth\ rate\ of\ techno\log y + depriciation\ rate$$

$$TOP = \frac{Exports + \text{Im}\,ports}{Gross\ domestic\ product}$$

$$INF = \text{CPI annual percent}$$

$$FDI = \text{foreign direct investment } percentage \text{ of gross domestic product}$$

$$ED = \text{External Debt Stocks percentage of Gross National Income}$$

CHAPTER 5

EMPERICAL RESULTS

This chapter provides and analyzes the empirical results of the econometric model using the econometric methodology explained in chapter 4. Section 5.1 covers the unit root to identify the stationary property of the variables. Section 5.2 provides the Bounds testing approach to check the cointegration between the variables employed in the model. 5.3 section discuses short run dynamics of energy-growth model by applying error correction mechanism. Diagnostic tests and CUSUMQ test are presented in section 5.4.

5.1 Unit Root Test

Stationary of all variables, such as gross domestic product per capita, share of investment in physical capital, share of investment in human capital, share of investment in energy, inflation rate, trade openness, foreign direct investment and external debt, are identified to confirm that the variables are not integrated of order greater than one. As the bounds test is applicable only for the variables that are either *I (1)* or *I (0)*, and the computed critical values of upper and lower bounds given by Pesaran *et al. (2001*) are not valid for the variables stationary at second difference i.e. *I (2).* Therefore, it is necessary to ensure that none of the variable is stationary at second difference or more before applying the ARDL approach.

The Augmented Dickey-Fuller (ADF) test is applied to all the variables to test the null hypothesis of non-stationary. Table 5.1 reports the results of ADF unit root test for all the variables. As can be seen that gross domestic product per capita (Y/L), share of investment in human capital (S_h), share of investment in energy (S_e), inflation rate (INF) and foreign direct investment are integrated of order 1 while, growth rate of labor force plus depreciation rate plus growth rate of technology $(n+g+\delta)$, trade openness (TOP), share of investment in physical capital (S_k) and external debt (ED) are integrated of order zero.

The different order of integration of the variables suggests that ARDL co-integration approach provided by Pesaran *et al. (2001)* is an appropriate methodology for estimation. Therefore, the presence of long run cointegration among the variables is identified by using ARDL approach.

Table 5.1: ADF Unit Root Test

Variables	Intercept	Trend	Level	Intercept	Trend	First Difference	Conclusion at level	Conclusion at first difference
$\ln(Y/L)$	Yes	No	-1.49(0)	Yes	No	-6.031***	I(1)	I(0)
$\ln S_e$	Yes	Yes	-3.04(0)	Yes	No	-8.38***	I(1)	I(0)
$\ln S_h$	Yes	No	-1.26(0)	Yes	No	-6.63***	I(1)	I(0)
$\ln(n+g+\delta)$	Yes	No	-8.08(0)***	Yes	No	…	I(0)	…
$\ln S_k$	Yes	No	-3.66(1)***	Yes	No	…	I(0)	…
$\ln INF$	Yes	No	-2.97(0)**	Yes	No	-6.51***	I(1)	I(0)
$\ln TOP$	Yes	No	-4.6(0)***	Yes	No	…	I(0)	…
$\ln ED$	Yes	No	- 5.043(0)***	Yes	No	…	I(0)	…
$\ln FDI$	Yes	No	-2.042(0)	Yes	No	-5.82***	I(1)	I(0)

Note: ***,** and * implies significance at 1%, 5% and 10%, respectively. Numbers of lag are shown in parenthesis.

5.2 Bound Testing Approach

To find the long run association between the variables of growth model, in ARDL model, it is necessary to determine the optimal lag length of the variables at first difference. For this purpose Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (SBC) is followed. Table 5.2 reports the results for optimal lag length. AIC exhibits smallest value corresponding to lag 2 and SBC has minimum value at lag one. However, we prefer to choose lag length according to AIC as other criterion LR, FPE and HQ also provides minimum value corresponding to lag 2.

Table 5.2: Appropriate Lag Length Selection Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	2.690059	NA	1.10e-11	0.307802	0.683952	0.444775
1	280.2665	419.7498	8.24e-16	-9.281294	-5.519794*	-7.911563
2	399.8826	128.3685*	2.28e-16*	-11.16500*	-4.018155	-8.562516*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Growth model with energy and other control variables (share of investment in physical capital, share of investment in human capital, inflation rate, trade openness, foreign direct investment and external debt) is a general model. It incorporates the Solow growth model, MRW growth model and growth model with energy only. Therefore, it is interesting to check the presence of cointegration in each growth model separately by taking per capita GDP as dependent variable.

The ARDL cointegration equation is estimated using Ordinary Least Squares (OLS) approach for growth models. The hypothesis of the absence of cointegration relationship among the variables of the growth model is tested by using F-statistic. After computing the F-statistic the observed value of F-test is compared with the two types (upper and lower bounds) of critical values given by Pesaran *et al*. (2001).

Table 5.3: Bound Test Results

Cointegration	F-statistics	I (0)	I (1)	
Solow Growth Model				
$F_{\ln y}(\ln y/\ln s_k, \ln(n+\delta+g))$	2.29	3.10	3.87	No
MRW Growth Model				
$F_{\ln y}(\ln y/\ln s_k, \ln s_h, \ln(n+\delta+g))$	3.805	2.79	3.67	Yes
Growth Model with Energy				
$F_{\ln y}(\ln y/\ln s_k, \ln s_h, \ln s_e, \ln(n+\delta+g))$	3.12	2.56	3.49	Inconclusive
Growth Model with Energy and Other Control Variables				
$F_{\ln y}(\ln y/\ln s_k, \ln s_h, \ln s_e, \ln INF, \ln TOP, \ln FDI, \ln ED, \ln(n+\delta+g))$	6.068	2.27	3.28	Yes

Note: critical values are given only at 5% significance level.

5.2.1 Bound Test on Solow Growth Model

The calculated value of F-statistic in the Solow growth model for the joint null hypothesis of no cointegration is found to be 2.29 and is less than the lower bound of critical values at 95 percent (Table 5.3). The smaller value of the F-test than the lower critical bound fails to reject the joint hypothesis of no long run relationship and confirms that the long run relationship do not exists in the Solow growth model.

5.2.2 Bound Test on MRW Growth Model

The calculated value of F-statistic in the MRW growth model for the joint null hypothesis of no cointegration is found to be 3.805 and is larger than the upper critical bound value at 95 percent (Table 5.3). The larger value of the F-statistic than the upper critical bound value support to rejects the joint null hypothesis of no long run relationship and confirms that the long run connection exists in the MRW growth model.

5.2.3 Bound Test on Growth Model with Energy

The calculated value of F-statistic in the growth model with energy for the joint null hypothesis of no cointegration is found to be 3.12 which lie between upper bound and lower bound of critical value at 95 percent (Table 5.3). This suggests that we cannot draw conclusion about cointegration in the growth model with energy.

5.2.4 Bound Test on Growth Model with Energy and Other Control Variables

The calculated value of F-statistic in the growth model with energy and other control variables for the joint null hypothesis of no cointegration is found to be 6.068 and is larger than the upper side critical value at 95 percent (Table 5.3). The larger value of F-statistic than the upper side critical value supports to reject the joint null hypothesis of no long run relationship and confirms the existence of long run association between economic growth (Y/L) and share of energy investment (S_e), along other control variables.

Bound test found the existence of long run association in MRW growth model and general growth model with energy. In the next section the long run results of respective models are presented.

5.2.5 Long Run Empirical Results of MRW Growth Model

The long run empirical results of MRW growth model are shown in Table 5.4

Table 5.4: Long Run Results of MRW Growth Model

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	0.3823	0.3335	1.1462	0.2608
$\ln(n+g+\delta)$	-0.0445	0.0344	-1.295	0.205
$\ln S_h$	-0.0256	0.0136	-1.8831*	0.0694
$\ln S_k$	0.0935	0.0487	1.92*	0.0643

Note: *, ** and *** implies significance at 10%, 5% and 1% respectively.

The coefficient of growth rate of labour force $(n+g+\delta)$ contributes negatively but insignificantly to economic growth in case of Pakistan. More technically an increase in growth rate of labour force by 1% leads to reduce economic growth by approximately 0.0445%, keeping all other variables constant.

The estimated coefficient of long run relationship of human capital has negative and statistically significant effect on economic growth at 10% level only. More precisely 1% increase in human capital leads to reduce economic growth by approximately .0256%, keeping all other variables included in the model are constant. Our results are also consistent with *Dulleck* (2008), Qaisar *et al. (2008).* But our results are opposite to Mankiw *et al*. (1992).

Physical capital has a key significance for the determinant of economic growth. In our study the coefficient of share of physical capital (S_k) proxied by the ratio of gross fixed capital formation to the GDP is found to be positive and significant at 10% significance level. More technically economic growth increased by approximately 0.0935% due to a 1%

increase in physical capital by keeping the other things same. Our estimated results are consistent with previous literature like Mankiw *et al*. (1992).

5.2.6 Long Run Empirical Results of Growth Model with Energy and Other Control Variables

The estimated results of the long run association among economic growth and share of energy investment with other control variables are given in table 5.5

Table 5.5: Long Results of Growth Model with Energy and Other Control Variables

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	3.4773	0.6555	5.304	0.0000
$\ln(n+g+\delta)$	-0.0259	0.0179	-1.4396	0.1634
$\ln INF$	-0.0485	0.0107	-4.5287***	0.0002
$\ln S_e$	0.0353	0.0131	2.6943***	0.0129
$\ln S_h$	-0.00077	0.0156	-0.0493	0.9611
$\ln S_k$	-0.0559	0.0417	-1.3416	0.1928
$\ln TOP$	0.3179	0.0976	3.2579***	0.0035
$\ln FDI$	-0.0075	0.0040	-1.8525*	0.0768
$\ln ED$	-0.1344	0.0375	-3.5847***	0.0016

Note: *, ** and *** implies significance at 10%, 5% and 1% respectively

The estimated coefficient of energy investment has an expected positive sign and highly significant impact on economic growth. More precisely we can say that a 1 percent change (increase/decrease) in energy investment leads to change (increase/decrease) economic growth by approximately 0.0353 percent, other things keeping the same. Energy investment contributes positively to output (Ammad *et al.* 2013). In literature, our results support the study of Ammad *et al.* (2013).

Physical capital has a key significance for the determinant of economic growth. In our study the coefficient of share of physical capital (S_k) proxied by the ratio of gross fixed capital formation to the GDP is found to be surprisingly negative and statistically insignificant. The possible reason may be the subtraction of gross fixed capital formation in energy sector from gross fixed capital formation as a whole, due to which physical capital contributing negatively to economic growth of Pakistan.

Growth rate of labor force $(n+g+\delta)$ has found to be negative insignificant impact on economic growth. Its estimated coefficient is -0.0259. The possible reason of the negative sign might be that Pakistan is a labor rich nation but has unskilled labor which is unlikely to increase the output in the country. Furthermore, agriculture is a dominant sector in Pakistan and it involves 45 percent of the total employed labor force (Pakistan economic survey 2012-13). But there exists disguised unemployment in this sector. Therefore, labor is contributing negatively to economic growth. Our results are confirmed by Mankiw *et al.* (1992) and Rafaqat *et al.* (2012).

The estimated coefficients of the long run relationship show that trade openness (ratio of exports plus imports to GDP) has an expected positive sign and highly significant impact on GDP per capita proxied by economic growth. More technically a 1 percent change (increase/decrease) in trade openness leads to approximately 0.3179 percent change (increase/ decrease) in economic growth, keeping other things constant. Thus more openness leads to higher economic growth. Trade openness leads to make possible specialization which in turn increases productivity of workers. As a result the output of the economy will rise. Trade openness also increases markets for new products and leads to generate the benefits arising from competition and economies of scale. Our results are confirmed by the study of Usman (2012).

Considering the impact of inflation (INF), it has negative sign with higher level of significant. The estimated coefficient shows that higher inflation reduces economic growth. In technical meaning a 1% increase in inflation reduces economic growth by approximately 0.0485 percent, keeping all other things same. In literature our results are consistent with Kowalski (2000), Najia *et al.* (2013) and Ali *et al.* (2012).

The estimated coefficients of the long run relationship show that human capital has negative sign but statistically insignificant indicating no significant impact of human capital on economic growth. The reason might be that the high drop-out ratios because of which all students that get admission in school do not complete their education. The other important reason might be that in Pakistan the poverty level is very high and most of the parents put their children to work rather than sending them in schools. Our results are consistent with Dulleck (2008). The model includes the human capital to account for domestic advancement, which in developing countries are found to be limited. As a result, human capital may not be found significant and also have negative effect on economic growth (Nelson *et al.* 1966).

The estimated coefficient of FDI is contributing negatively and significantly to economic growth only at 10% level of significance. The coefficient of FDI (0.0075) indicates that 1% increase in FDI reduces economic growth by approximately 0.0075 percent, other things have been held constant. The possible reason of the negative sign of

FDI may be the energy crises, underdeveloped infrastructure and unskilled labor force. Our results are associated with Najia e*t al*. (2013) and Usman (2012).

Looking at the coefficient of external debt, it found to be negative and has highly significant impact on economic growth. This coefficient reveal that 1% increase in external debt reduce the economic growth by approximately 0.1344 percent, other things remaining the same. The possible reason of negative sign of external debt might be that most of the resources are transferred in the debt payments rather than on investment purposes. As a result lesser amount of funds will be used for services such as schools, construction of new roads, new business opportunities and hospitals. Another possible reason might be that more external debt payments force the government to increase taxes to finance the high debt payments. That increase in taxes leads to increase interest rate which in turn discouraged the investment projects. The reduction in investment leads to reduce economic growth. Therefore, external debt is negatively associated to economic growth. In literature our results are confirmed by the study of Rafaqat *et al*. (2012) and Najia *et al*. (2013).

5.3 Short Run Dynamics of Growth Models

This section will provide the short run dynamic of growth models. Table 5.6 discusses the short run results of MRW growth model. Whereas, short run results of growth model with energy and other control variables are given in Table 5.7.

Table 5.6: Short Run Results of MRW Growth Model

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	-0.0672	0.0318	-2.1139	0.04
Δ(ln(Y/L(-1))	-0.2363	0.1877	-1.26	0.217
Δ(ln(n +g +δ))	-0.0397	0.0147	-2.71***	0.010
Δ(ln(n +g +δ(-	-0.0075	0.0131	-0.57	0.5695
2))	0.1085	0.0612	1.77*	0.0857
Δ(lnS_k)	-0.0996	0.06496	-1.53	0.1349
Δ (lnS_k(-1))	-0.0398	0.0144	-2.769***	0.0091
ECM(-1)				
R-squared	0.2489	F-statistic	1.823	
Adjusted R-squared	0.1124	Prob.(F-statistic)	0.1248	

Note: *, ** and *** implies significance at 10%, 5% and 1% respectively

Short run dynamic results are obtained from the error correction (ECM) approach. The coefficient of the ECM_{t-1} term shows the speed of adjustment and indicates how quickly the equilibrium is reached. The expected sign of the coefficient of the ECM_{t-1} term should be negative and highly significant. The high significance coefficient of ECM_{t-1} term confirms the presence of cointegration between the variables (Banerjee *et al*. 1998). In our analysis the speed of adjustment coefficient is found to be -0.0398 which is highly significant at 5% level of significance. The negative sign of the coefficient of the ECM_{t-1} term clearly indicates that if the equilibrium deviates from its long run path, it will converge back to its equilibrium position with 0.0398 speeds of adjustment. In other words, it shows that previous period discrepancy in equilibrium is corrected with an adjustment speed of 3.98 percent per year.

Table 5.7: Short Run Results of Growth Model with Energy and Other Control Variables

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	3.4772	0.4030	8.6275	0.0000
Δ(ln(Y/L(-1))	-0.6027	0.0.1205	-5.0018*	0.0000
Δ(ln(TOP)	0.1347	0.0363	3.7080*	0.0008
Δ(ln(TOP(-1))	-0.2353	0.0422	-5.5733*	0.0000
Δ(ln(INF(-1))	0.0449	0.0079	5.67*	0.0000
Δ(ln(ED)	-0.2197	0.0307	-7.1656*	0.0000
Δ(ln(ED(-1))	0.0268	0.0051	5.2797*	0.0000
Δ(ln(ED(-2))	0.0132	0.0038	3.4686*	0.0016
ECM(-1)	-0.2110	0.0246	-8.5798*	0.0000
R-squared	0.7534	F-statistic	11.8362	
Adjusted R-squared	0.6897	Prob.(F-statistic)	0.0000	

Note: *, ** and *** implies significance at 10%, 5% and 1% respectively

After confirming the cointegration relationship between economic growth (Y/L) and share of energy investment (S_e) with other control variables, we now examine the short run dynamics of ADRL model. The estimated results of short run dynamics are reported in Table 5.7. These results are obtained from the error correction (ECM) approach. The high significance ECM term in our analysis confirms the existence of cointegration relationship between economic growth (Y/L) and share of energy investment (S_e) with other control variables. The speed of adjustment coefficient is found to be -0.2110 which is highly significant at 5% level of significance (Table 5.7). It shows that previous period discrepancy in equilibrium is corrected with an adjustment speed of 21.10 percent per year.

The sped of convergence is smaller in MRW growth model than the growth model with energy and other control variables. The reason of low speed of convergence in MRW growth model may be that the growth model with energy includes energy investment while MRW growth model does not include this investment. That is why speed of convergence is low in MRW growth model.

5.4 Diagnostic and Stability Tests

To determine the correctness of the models, the diagnostic tests and stability tests are also carried out. This section will provide diagnostic tests such as normality, serial correlation, heteroskedasticity and Ramsey test. Table 5.8 reports the diagnostic tests of MRW growth model and Table 5.9 will provide diagnostic tests of growth model with energy and other control variables. Whereas, stability tests are shown in Figure 5.1 and Figure 5.2 for MRW growth model and growth model with energy and other control variables respectively.

Table 5.8: Diagnostic Tests of MRW Growth Model

Test	Test Statistic	Prob.	Critical value
Normality Test(Jarque Bera)	0.4376	0.8035	$\chi^2_{0.05(2)} = 5.99$
Serial Correlation LM Test	1.6495	0.1990	$\chi^2_{0.05(1)} = 3.84$
ARCH Test	0.0454	0.8313	$\chi^2_{0.05(1)} = 3.84$
Ramsey Reset Test	0.000809	0.9775	$\chi^2_{0.05(1)} = 3.84$

Table 5.9: Diagnostic Tests on Growth Model with Energy and Other Control Variables

Test	**Test Statistic**	**Prob.**	**Critical value**
Normality Test	2.8311	0.2428	$\chi^2_{0.05(2)} = 5.99$
Serial Correlation LM Test	0.6291	0.4277	$\chi^2_{0.05(1)} = 3.84$
ARCH Test	0.2421	0.6227	$\chi^2_{0.05(1)} = 3.84$
Ramsey Reset Test	0.0180	0.8939	$\chi^2_{0.05(1)} = 3.84$

The results of certain diagnostic tests show that model does not suffer from the problem of heteroskedasticity, serial correlation, non-normality and instability of the parameters of the both the models. While Figure 5.1(CUSUMSQ for MRW growth model) and Figure 5.2(CUSUMSQ growth model with energy and other control variables) show that cumulative sum of square residuals (CUSUMSQ) does not cross the 5% critical straight line, consequently this shows that there is no significant structural instability in the parameters of both the models.

Figure 5.1: Cumulative Sum of Square Residuals of MRW Growth Model (CUSUMSQ)

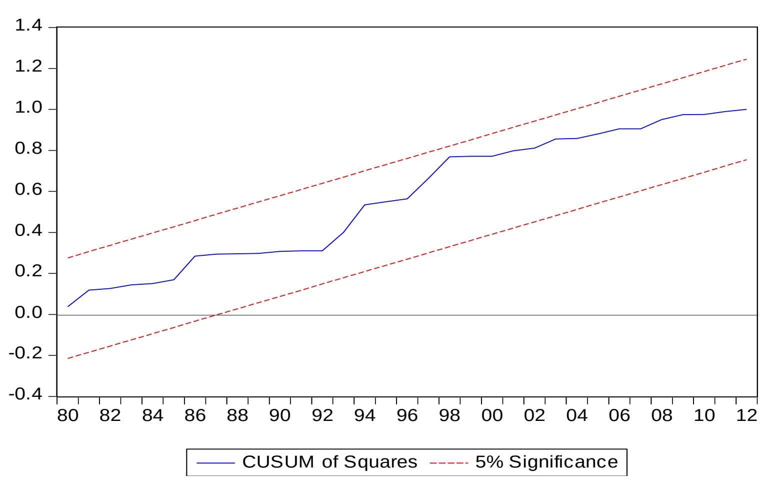
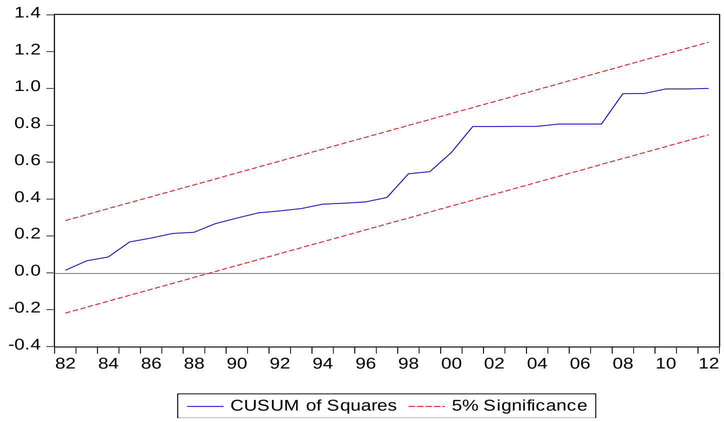


Figure 5.2: Cumulative Sum of Square Residuals of Growth Model with Energy and Other Control Variables (CUSUMSQ)



CHAPTER 6

CONCLUSION AND POLICY RECOMMENDATIONS

The impact of energy consumption on economic growth has been analyzed extensively in previous literature. The previous literature on the effect of energy investment on economic growth is relatively scarce. Not even a single study is found in the literature that systematically investigates the effect of energy investment on economic growth. The present study is one in my knowledge that fills the existing gap by thoroughly studying the effect of energy investment on economic growth of Pakistan. To thoroughly explore the effect of energy investment on economic growth of Pakistan, we incorporate energy as factor input in the growth model (Mankiw *et al.* 1992) along with physical capital, labor and human capital.

Present study uses annual time series data on gross domestic product per capita in constant local currency, Physical capital proxied by gross fixed capital formation to ratio of GDP, Energy investment proxied by gross fixed capital formation in energy to ratio of GDP, human capital proxied by secondary education to ratio of labor force, growth rate of labor force, annual inflation rate based on CPI, trade openness proxied by imports plus exports to ratio of GDP, foreign direct investment as a percentage of GDP and external debt stock percentage of GNI for the period of 1970-2012 to investigate the short and long run association between energy investment and economic growth.

An autoregressive distributed lag (ARDL) approach is applied to study the long run association between economic growth and energy investment. Short run dynamics of Pakistan's economic growth are examined through error correction mechanism. The most important result of this study is that energy investment has a positive significant effect on economic growth in the long run. More technically, this result reveals that energy investment is associated with appreciation of economic growth in the long run.

The long run coefficient of growth rate of labor force $(n+g+\delta)$ is affecting negatively and insignificant to economic growth in case of Pakistan. Indeed, this result suggest that growth rate of labor force is associated with the depreciation of Pakistan's growth in long run.

Looking at results, physical and human capital both are found to be insignificant in the long run but having negative impact on economic growth. These results suggest that both physical and human capital leads to reduce economic growth.

Inflation, one of the determinants of macroeconomic instability, is found to be negative and significant in the long run whereas positive significant effect on economic growth in the short run. These results reveal that inflation is related with the reduction of economic growth in the long run and it is associated with the appreciation of growth in the short run but after one period lag.

The estimated coefficients of the long run relationship show that trade openness have positive sign and highly significant effect on economic growth both in short and long run. These results show that trade lead to increase economic growth both in short and long run. Foreign direct investment has a negative significant effect on economic growth in the long run. This result reveals that FDI is associated with the reduction of economic growth. Whereas, external debt (ED) has a negative significant effect on economic growth both in short and long run. These results show ED is associated with the depreciation of economic growth both in short and long run.

The short run dynamics of the research are analyzed through the error correction modeling (ECM) approach. The high significance level of ECM_{t-1} term in our analysis confirms that there exists long run association between economic growth and energy investment with other control variables. The negative sign of the coefficient of the ECM_{t-1} term with high level of significance clearly indicates that if the equilibrium deviates from its long run path, it will converge back to its long run equilibrium position after some adjustment.

Policy Implication

The study has an important policy implication that government should encourage the investment activities in energy sector to meet the rising energy demand which in turn leads to stimulate economic growth. This economic growth then generates the employment opportunities in the country.

REFERENCES:

Abbas, Q., & Mujahid-Mukhtar, E. (2000). "The Role of Human Capital in Economic Growth:

A Comparative Study of Pakistan and India". The Pakistan Development Review, 451-473.

Abbasa, Q., & Foreman-Peck, J. (2008). "Human Capital and Economic Growth: Pakistan, 1960-2003".The Lahore Journal of Economics: PP. 1-27

Abid, M., & Sebri, M. (2011). "Energy Consumption-Economic Growth Nexus: Does The Level of Aggregation Matter"?. International Journal of Energy Economics and Policy, 2(2), 55-62.

Adawo, M. A. (2011). "Has Education (Human Capital) Contributed To The Economic Growth Of Nigeria"?. Journal of Economics and International Finance,3(1), 46-58.

Adhikari, D., & Chen, Y. (2012). "Energy Consumption and Economic Growth: A Panel Cointegration Analysis for Developing Countries". Review of Economics & Finance, 3(2), 68-80.

Afzal, M., Farooq, M. S., Ahmad, H. K., Begum, I., & Quddus, M. A. (2010). "Relationship Between School Education and Economic Growth in Pakistan: ARDL Bounds Testing Approach to Cointegration". Pakistan Economic and Social Review, 39-60.

Ali, S., Chaudhry, I. S., & Farooq, F. (2012). "Human Capital Formation and Economic Growth in Pakistan". Pakistan Journal of Social Sciences (PJSS),32(1), 229-240.

Altinay, G., & Karagol, E. (2004). "Structural Break, Unit Root, and the Causality Between Energy Consumption and GDP in Turkey". Energy Economics, 26(6), 985-994.

Ammad, S., & Ahmed, Q. M. "Dynamic Effects of Energy Sector Public Investment on Sectoral Economic Growth: Experience from Pakistan Economy".

Aqeel, A., & Butt, M. S. (2001). "The Relationship Between Energy Consumption and Economic Growth in Pakistan". Asia-Pacific Development Journal, 8(2), 101-110.

Ashraf, Z., Javid, A. Y., & Javid, M. (2013). "Electricity Consumption and Economic Growth: Evidence from Pakistan". Economics and Business Letters, 2(1).

Azhar, U. (2012). "Effects of Trade Liberalization on Economic Growth of Pakistan". Journal of Applied and Emerging Sciences, 3(1), PP72-78.

Balamurali, N., & Bogahawatte, C. (2004). "Foreign Direct Investment and Economic Growth in Sri Lanka". Sri Lankan Journal of Agricultural Economics, *6*(1), 37-50.

Banerjee, A., Dolado, J., & Mestre, R. (1998). "Error-Correction Mechanism Tests for Cointegration in a Single-Equation Framework". Journal of Time Series Analysis,*19*(3), 267-283.

Bedi-uz-Zaman, M. F., & Ullah, S. "Sectoral Oil Consumption and Economic Growth in Pakistan: An ECM approach". American Journal of Science and Industrial Research PP 149-156.

Bekhet, H. A., & bt Othman, N. S. (2011). "Causality Analysis Among Electricity Consumption, Consumer Expenditure, Gross Domestic Product (GDP) and Foreign Direct Investment (FDI): Case Study of Malaysia". Journal of Economics and International Finance, 3(4), 228-235.

Binh, P. T. (2011). "Energy Consumption and Economic Growth in Vietnam: Threshold Cointegration and Causality Analysis". International Journal of Energy Economics and Policy, 1(1), 1-17.

Blin, M., & Ouattara, B. (2009). "Foreign Direct Investment and Economic Growth in Mauritius: Evidence From Bounds Test Cointegration". Economie internationale, (1), 47-61.

Chaudhry, I. S., Safdar, N., & Farooq, F. (2012). "Energy Consumption and Economic Growth: Empirical Evidence from Pakistan". Pakistan Journal of Social Sciences (PJSS), 32(2), 371-382.

Dauda, R. O. S. (2010). "Role of Human Capital in Economic Development: An Empirical Study of Nigerian Case". In Manuscript, Oxford Business and Economics Conference Program.

Dhungel, K. R. (2008). "A Causal Relationship Between Energy Consumption and Economic Growth in Nepal". Asia-Pacific Development Journal, 15(1), 137.

Drezgić, S. (2008). "The Effects of Public Sector Investments on Economic Growth of Croatia". Dubrovnik. Young Economists Seminar to 14th Dubrovnik Economic Conference.

Faisal Sultan Qadri, F., & Abdul Waheed, W. (2011). "Human Capital and Economic Growth: Time Series Evidence From Pakistan". Pakistan Business Review

Farhani, S., & Ben Rejeb, J. (2012). "Link Between Economic Growth and Energy Consumption in Over 90 Countries". Interdisciplinary Journal of Contemporary Research in Business (IJCRB), 3(11), 282-297.

Ghali, K. H., & El-Sakka, M. I. (2004). "Energy Use and Output Growth in Canada: A Multivariate Cointegration Analysis". Energy Economics, 26(2), 225-238.

Ghani, E., & Din, M. U. (2006). "The Impact of Public Investment on Economic Growth in Pakistan". The Pakistan Development Review, 87-98.

Huang, B. N., Hwang, M. J., & Yang, C. W. (2008). "Causal Relationship Between Energy Consumption and GDP Growth Revisited: A Dynamic Panel Data Approach". Ecological economics, 67(1), 41-54.

Hye, Q. M. A., & Riaz, S. (2008). "Causality Between Energy Consumption and Economic Growth: The Case of Pakistan". The Lahore Journal of Economics,13(2), 45-58.

Kakar, Z. K., Khilji, B. A., & Khan, M. J. (2011). "Financial Development and Energy Consumption: Empirical Evidence From Pakistan". International Journal of Trade, Economics and Finance, 2(6), 469-471.

Khattak, N. U. R. (2012). "The Contribution of Education to Economic Growth: Evidence from Pakistan". International Journal of Business and Social Science Vol. 3 No. 4

Lau, E., Chye, X. H., & Choong, C. K. (2011). "Energy-Growth Causality: Asian Countries Revisited". International Journal of Energy Economics and Policy, 1(4), 140-149.

Lin, T. C. (2002). "Education, Technical Progress, and Economic Growth: The Case of Taiwan". Economics of Education Review, 22(2), 213-220.

Mankiw, N. G., Romer, D.and Weil, D. N. (1992). "A Contribution to the Empirics of Economic Growth". The Quarterly Journal of Economics, 107(2), 407-437.

Masuduzzaman, M. (2012). "Electricity Consumption and Economic Growth in Bangladesh: Co-integration and Causality Analysis". Global Journal of Management and Business Research, 12(11).

Mushtaq, K., Abbas, F., & Ghafoor, A. (2007). "Energy Use for Economic Growth: Cointegration and Causality Analysis from the Agriculture Sector of Pakistan". The Pakistan Development Review, 1065-1073.

Nabila A., Asma A., & Hafeez ur Rehman, H. (2012). "Human Capital and Economic Growth in Pakistan: A Cointegration and Causality Analysis". International Journal of Economics and Finance, 4(4), p135.

Najia, S., Masnoon, M., & Rafique, N. (2013). "Impact of Foreign Direct Investment on Economic Growth of Pakistan". Advances in Management & Applied Economics, 3(1), 35-45

Paul, S., & Bhattacharya, R. N. (2004). "Causality Between Energy Consumption and Economic Growth in India: A Note on Conflicting Results". Energy Economics,26(6), 977-983.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). "Bounds Testing Approaches to the Analysis of Level Relationships". Journal of Applied Econometrics, 16(3), 289-326.

Qazi, A. Q., Ahmed, K., & Mudassar, M. (2012). "Disaggregate Energy Consumption and Industrial Output in Pakistan: An Empirical Analysis" (No. 2012-29). *Economics Discussion Papers.*

Rahman, M. M., & Salahuddin, M. (2009, September). "The Determinants of Economic Growth in Pakistan: Does Stock Market Development Play a Major Role"?. In Proceedings of the 38th Australian Conference of Economists PP 1-22. Economic Society of Australia

Reza, A., & Valeecha, S. "Impact of Education on Economic Growth of Pakistan-Econometric Analysis". IOSR Journal of Business and Management (IOSR-JBM) ISSN: 2278-487X. Volume 5, Issue 4 (Nov. - Dec. 2012), PP 20-27.

Robert E. Lucas, Jr. (1988). "On The Mechanics of Economic Development" Journal of Monetary Economics 22 3-42. North-Holland

Samouilidis, J. E. and Mitropoulos, C. S., (1983). "Energy Investment and Economic Growth" Energy Economics 237-246

.

Sari, R., Ewing, B. T., & Soytas, U. (2008). "The Relationship Between Disaggregate Energy Consumption and Industrial Production in the United States: An ARDL Approach". Energy Economics, 30(5), 2302-2313.

Shahbaz, M., & Feridun, M. (2012). "Electricity Consumption and Economic Growth Empirical Evidence from Pakistan". Quality & Quantity, 46(5), 1583-1599.

Shahbaz, M., Ahmad, K., & Chaudhary, A. R. (2008). "Economic Growth and its Determinants in Pakistan". The Pakistan Development Review, 471-486.

Shahbaz, M., Zeshan, M., & Afza, T. (2012). "Is Energy Consumption Effective to Spur Economic Growth in Pakistan"? New Evidence from Bounds Test to Level Relationships and Granger Causality Tests. Economic Modelling, 29(6), 2310-2319.

Siddiqui, A. H., & Iqbal, J. (2005). "Impact of Trade Openness on Output Growth for Pakistan: An Empirical Investigation". Market Forces Vol.1 No. 1.

Siddiqui, R. (2004). "Energy and Economic Growth in Pakistan" The Pakistan Development Review, 175-200.

Solow, R. M. (1956). "A Contribution to the Theory of Economic Growth". The Quarterly Journal of Economics, 65-94.

Soytas, U., & Sari, R. (2003). "Energy Consumption and GDP: Causality Relationship in G-7 Countries and Emerging Markets". Energy economics, 25(1), 33-37.

Ul Husnain, M. I., Khan, M., Akram, N., & Haider, A. (2011). "Public Spending, Foreign Direct Investment and Economic Growth". International Research Journal of Finance and Economics, (61).

Yang, H. Y. (2000). "A Note on the Causal Relationship Between Energy and GDP in Taiwan". Energy Economics, 22(3), 309-317.

Yuan, J. H., Kang, J. G., Zhao, C. H., & Hu, Z. G. (2008). "Energy Consumption and Economic Growth: Evidence from China at Both Aggregated and Disaggregated levels". Energy Economics, 30(6), 3077-3094.