Impact of Energy Consumption on Economic Growth and Environment: Disaggregated Analysis for Asian Developing Economies

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Dedication

This thesis is dedicated to my parents and grandmother, for their love, patience and for providing me with an excellent education

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Abbreviations and Acronyms

ARDL=Autoregressive distributed lag

C=capital

CO_2= Carbon dioxide

CO_2E=Carbon dioxide emissions

ECM =Error correction models

EIA =Energy information administration

EK=Environmental Kuznets

FD= Financial development

FDI =Foreign direct investment

FMOLS =Fully modified ordinary least square estimator

GDP=Gross domestic product

GDPS= Gross domestic product square

IEA= International energy agency

IPCC= Intergovernmental panel on climate change

L=Labor

RGDP=Real gross domestic product

TFPG =Total factor productivity growth

TO,T=Trade openness

VECM= Vector error correction model

Abstract

This study uses more recently developed panel cointegration (Pedroni, 1999) techniques to evaluate the link between disaggregate energy consumption (coal, petroleum, electricity, renewable energy consumption), economic growth and environment (by incorporating, trade openness and financial development as control variables) in a sample of 8 Asian Developing countries. Cointegration tests verify long run link (relationship) among all variables. To find long run elasticity's fully modified OLS is used, which confirms that all forms of disaggregate energy consumption explain optimistic, significant and positive impact on economic growth. Results also show that all forms of disaggregate energy use illustrate significant, positive impact on CO_2 emissions (except coal consumption) and also validate existence of EK curve (Environmental, Kuznets curve). For short run dynamics and panel causality analysis VECM (vector error correction, model) is applied, which shows short run dynamics and long run adjustment. Important policy implication is that government needs to promote renewable energy sector because its increase economic growth and its impact on environment degradation is low as compare to other sectors. Investment in renewable energy sector is beneficial for private and public sector. For this purpose cost and benefit analysis, of various forms of energy sector needs to be adopted.

Keywords: Panel cointegration, disaggregate energy consumption, economic growth, fully modified OLS, Environmental Kuznets curve.

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CHAPTER 1

Introduction

1.1 Background

The affiliation between economic growth, consumption of energy (disaggregate forms) and environment (CO_2 emissions) attract economists, policy makers, researchers, and analyst now a day. As said by Erbaykal (2008), the petroleum emergency in 1970s shows that energy should be treated as a production factor. Previous studies (Sadorsky, 2012; Apergis and Payne, 2009) paying attention on aggregate level of energy consumption. For the time being coil, petroleum, electricity, renewable energy consumption has become important component in Asian developing countries energy use. The significance of these components of energy consumption can be recognized by the huge amount of money spent to import these components and how an increase in petroleum price and LPG shortage affect the smooth operation of many businesses in the country (Kwakwa, 2011).

The link between economic growth and consumption of energy is mostly intentional area in *"Energy Policy and Energy Economics"* (Payne, 2010; Ozturk, 2010). The affiliation between Economic growth, energy use (disaggregate forms) and environment (CO_2 emissions) are very important for policy making. The relationship between these variables is very critical, but need to evaluate it for developing new valuable energy and environmental policies. If causal link found between energy use (disaggregate forms) to output, then any shrinking in consumption of energy for energy conservative policies to reduce CO_2 emissions will reduce output.

Sadorsky (2012) uses panel Cointegration technique to explore the affiliation between outputs, consumption of energy, and trade (for a panel, 7 South American countries). Results of panel cointegration show long run association between all variables (output, energy, capital, labor and imports or exports).

Literature on energy field has possible four hypotheses for evaluate the link between consumption of energy and economic growth. First one **Growth** hypothesis explains, that energy plays a major role to determine growth and complement with labor and capital. According to growth hypothesis any conservation policy to reduce consumption of energy for environment protection will affect economic growth; it means by increasing consumption of energy will boost real GDP (gross, domestic product). But if increase in consumption of energy reduces real GDP then conservation policies will not affect growth. Second **Conservation** hypothesis confirmed, if energy consumption rise in response to increase in real GDP. Third **Neutrality** hypothesis exists if no causal association between consumption of energy and real GDP. Forth **in Feedback** hypothesis, bidirectional causal connection exists between consumption of energy and real GDP.

Literature supports that in addition to traditional variable, other variables (called, control variables) effect growth. This study includes financial development and trade openness as Hecksher Ohlin (H-O) theory support that trade openness increase growth. These variables also have effect on CO_2E (carbon dioxide emissions). According to EK (environmental Kuznets) curve at earlier stage the impact of economic growth is higher on CO_2E but after a point its impact decreases. This effect can be examined by including nonlinear GDP. Theoretically and empirically both evidence found that consumption of energy effect growth and vice versa. However growth (standard, growth theories) models do not treat consumption of energy as input factor.

In current scenario consumption of energy has great importance for economy because energy is a backbone and wheel for growth. On other scenario if economic growth of a country grows that means per capita income grows, end result is that demand for energy like oil, gas and electricity will also grow. According to Global Energy Survey 2007, the expected demand for energy is increased minimum 50 % by 2030 and 70 % for developing countries. Causality analysis is very important for policy making issues like energy conservation policy. When consumption of energy is treating as an input factor then conservation policy is very important for policy making.

The reasons of use disaggregate energy consumption are that, first aggregate energy consumption data does not show which country is dominant against many sources of energy use. Second aggregate consumption of energy does not capture which type of energy resource has higher effect on growth as Yang (2000). Third the gain of disaggregate energy consumption is that we may also comparison causality analysis against different sources of energy spending (Sari et al, 2008).

Renewable energy supply may play a key role for fulfillment of future energy demand. Now various kinds of new technologies can complete the space between energy order and supply by improving supply of renewable energy consumption (Economic Report of the President USA 2006).

How to maintain stable economic growth and how to reduce CO_2E are two main concern questions of environmental protection and energy policy in whole world. Kyoto

(1977) describes the industrial nations which have ratified the treaty to reduce greenhouse gases emissions. Kyoto (1977) concludes that carbon dioxide emissions approximately 5.2% below than their 1990 level. Proponents also stress upon that this is an important issue of every country of the world.

According to proponents industrial nations produce approximately 40% of human generated carbon dioxide emissions in whole world in previous years. But on the other hand, due to shortage of energy income will fall. Proponents say that reducing CO_2E by falling consumption of energy is an unrealistic goal because by doing this income will fall (rise unemployment) and through this channel economic growth will also be affected.

In literature many writers describe that due to shortage of energy will raise unemployment and income will fall (Masih, 1998; Ghali et al, 2004; Oh and Lee, 2004; Beaudreau, 2005; and Stern, 1993 & 2000), also determine energy as main factor. The link between growth and energy (consumption) avail much interest of researchers due to its effect on sustainable development and awareness of greenhouse gases emissions. In previous studies problem of omitted variable biased occurred (Yu and Hwang, 1984; Akarca and Long, 1980; Jin, 1992). More recent studies include capital and labor by multivariate approach such as Stern (1993, 2000).

In developing countries, it is found that trade with energy has a remarkable rate of growth (Giles and Williams, 2000; Cuadros et al, 2004; and Ozturk, 2010). Literature also displays that development in financial sector also effects economic growth (Shahbaz and Lean, 2012). By extended Cob Douglas Production function we can examine long run affiliation between economic growth, financial development, energy consumption, capital and international trade.

Growth is main objective of all countries; climate change and global warming also alert us about dangers and thus idea of sustainable development become popular in current scenario. In literature, a lot number of studies support the survival of *"*EK curve hypothesis which states there is an inverted U shaped inverse relationship between economic growth and environmental degradation*"* such as (Dinda and Coondoo, 2006; Coondoo and Dinda, 2008; Grossman and Krueger, 1991; Shafik, 1992; Akbostanci et al, 2009).

Now a day economic development is a global issue in whole world. Many countries encourage foreign investors for investment to promote economic growth. But environmental degradation problem is also hidden behind this. Global climate change and air pollution problems caused by greenhouses gas emissions have turn into main international issue. Carbon dioxide emissions are primary greenhouse gas accountable for global warming. Kyoto (1977) describes the industrial nations which have ratified the treaty to reduce greenhouse gases emissions. Kyoto (1977) concludes that carbon dioxide emissions approximately 5.2% below than their 1990 level.

Energy in any form like electricity, petrol, renewable, and coal all are wheel for economic growth. Demand for energy increases as country grows. International Energy Agency (2006) reports that primary demand for energy is expected to rise 50% from time period 2004 to 2030. According to this report 20 trillion dollar (US dollar 2006) required for fulfillment of this demand. This report suggests to investing in renewable energy sector. According to International Energy Agency (2006, page 214) sector of power generation is fasting growing sector for both carbon dioxide emissions and energy demand. Sustainable development can be achieved if we promote power generation sector (IEA, 2006).

According to Solow (1956, 1957) growth framework, growth of labor force (managerial skills) and technological advances determine total output of the nation. Hence factors of production determine total factor productivity such as Kendrick (1961), Denison (1985), Easterly and Levine (2001), Jones (1997), Upadhyay and Miller (2000). Consumption of energy and total factor productivity is new field of research. The link between these two is firstly introduced by Schurr (1983) and Jorgenson (1984). Disaggregate energy consumption related work has been done by few researchers such as Chien and Hu (2007), Kymn and Hisnanick (1992), Turner and Hunley (2011).

The report of IPCC (intergovernmental panel, on climate change, 2007) clearly highlights that global warming is main environmental issue like increasing carbon dioxide emissions. Carbon dioxide emissions increases due to energy consumption, to solve this problem reduce consumption of energy but this process will reduce economic growth. If EK curve hypothesis exist then growth becomes a solution for reducing carbon dioxide emissions (Rothman, 1998; de Bruyn, 1998). Different countries adopt different options for fight against global warming (Soytas and Sari, 2006).

1.2 Objective of the Study

The chief objective of study is to evaluate (examine) the impact of disaggregates energy consumption (coil, petroleum, electricity, renewable sector) on growth in developing Asian Economies. More specifically objectives are:

- To check (examine) the impact of disaggregated energy consumption including control variables (financial development and trade openness) on economic growth.
- To check (examine) the impact of disaggregated energy consumption including control variables (financial development, trade openness) on environment (CO_2 emissions).

1.3 Significance of the Study

Economic growth, financial development, consumption of energy, and trade openness all have a trend to progress together across every point in time as all the countries of the world continue to develop in every region of humanity. This study is going to be first of its kind, it will contribute to existing literature by explaining the impact of disaggregate energy consumption (coil, petroleum, electricity, renewable sector), also include control variables (trade openness and financial development) on economic growth and environment (CO_2 emissions). Previous literature on energy mostly consider total consumption of energy, this study will consider disaggregate energy consumption in case of Asian developing countries.

1.4 Motivation of study

As economy is at the forefront of any state's policy and the era of post modernism is fast pacing, the topic *"*Impact of energy consumption on economic growth and environment: disaggregated analysis for Asian developing economies*"* motivated me a lot. One of the scholars has rightly put the crystal clear importance of the Asian countries in the following manner: *"twenty first century is going to be Asia centered economically"* this quote motivated me to check the impact of disaggregate energy consumption by including other variables (financial development and trade openness) on economic growth and environment in Asian developing economies.

1.5 Contribution to the literature

Although large empirical work is being devoted to check the association of total energy use (consumption) on economic growth but present study is first one (in my knowledge), intended to measure the "impact of disaggregate energy consumption on economic growth by incorporating financial development and trade openness in Asian developing economies (Panel study). Previous studies separately examine the impact of energy consumption on growth and growth impact on environment (CO_2 emissions). This study will consider both, the impact of disaggregate energy consumption on growth, and then growth and energy consumption impact on environment (CO_2 emissions)"

1.6 Organization of the study

After introduction section, the rest of study is planned as follows, Second section provides literature review, Theoretical framework is discussed in Third section, Forth section lays down the methodology and data, Fifth section presents empirical results and discussion, Sixth section concludes the study and derives some policy implications.

CHAPTER 2

Literature Review

A large body of research is undertaken to examine (evaluate) the association between energy use, growth and environment. This chapter reviews the most relevant literature in these two areas; Chapter is further separated in three sections. Section (2.1) describes Literature Review, Energy use (consumption) on Growth and section (2.2) describes Literature Review about Energy use (Consumption) on Environment. Section (2.3) describes summary of literature review.

2.1 Literature Review on Effect of Energy Consumption on Growth

The relationship between energy consumption and economic growth is extensively researched. Salim et al. (2008) examine the short run and as well as long run causal affiliation between consumption of energy and output in six NON OECD (Pakistan, Thailand, Bangladesh, China, India and Malaysia) developing countries. Annual data set is used from 1980-2005. For short run analysis VECM (vector error correction, model) and for long run Cointegration models are used. The empirical results show bidirectional causal link between and income in Malaysia, Unidirectional causal association runs from output to consumption of energy in Thailand and China, consumption of energy to output in Pakistan and India, Bangladesh investigated as energy Neutral Economy.

Ziramba (2009) studied the relationship between disaggregate energy consumption and industrial productivity (output) in South Africa by using Cointegration technique.

Annual data set is used from 1980-2005. The study also finds the causal relationship between various forms of disaggregate energy consumption and industrial production (output). The findings show that industrial production (output) and employment are found long run variables (forcing variables) for consumption of electricity. By applying, Toda and Yamamoto (Cointegration technique), find bidirectional causal affiliation between industrial production (output) and consumption of oil. Neutrality hypothesis is accepted for other forms of consumption of energy. The results also show causal affiliation between employment and consumption of electricity, consumption of coal to employment.

Sari et al. (2008) investigate the association between disaggregate energy consumption and industrial output (production), and employment in United States by using ARDL (autoregressive, distributed lag) technique. The monthly data set are used from 2001:1-2005:6. For analysis of level relationship Bounds testing approaches are used. The results of the study show that real output (production) and employment are long run variables (forcing variables) and key determinants of fossil fuel, solar, waste, and conventional hydroelectric power, and wind energy consumption. But employment and real output are not significance determinants of natural gas and wood energy consumption.

Lee and Chang (2008) examine co movement and causal affiliation (relationship) between real GDP and energy consumption, including capital stock and labor by applying unit root (developed, panel unit root tests), panel based ECM (error correction models) and panel cointegration. 16 Asian countries data set are taken from time period 1971-2002. The empirical results describe long run association between energy consumption and real GDP with positive sign (when heterogeneous, country effect considering). The empirical results also discover that unidirectional Granger causal association found from growth to energy consumption in long run but not in the short run.

Shrif et al. (2012) check the affiliation between growth to energy consumption growth to energy consumption in Pakistan from the time period 1972-2012. The empirical results explain that the electricity consumption is significantly have an impact on growth as compare to others energy sources, while oil consumption affect growth negatively due to higher imports volume. Trade openness has a positive impact on growth. This study also suggests that gas or coal should be used for energy use for the purpose of reducing import burden.

Shahbaz et al. (2013) examines the link between energy consumption and economic growth by including international trade, financial development, and capital in China from the time period 1971-2011. The ARDL bound testing procedure approach is apply to evaluate long run link between these variables. The empirical findings states that long run affiliation exists between these variables. The findings also describe that exports, energy consumption, financial development; capital, imports and international trade have positive impact on economic growth. This study also suggests using alternative energy sources.

Apergis and Payne (2009) investigate the affiliation between energy consumption and economic growth in six nations (Central American) from 1980-2004. For investigate causal association panel Cointegration and ECM is applied. Consistent with findings of heterogeneous panel Cointegration test by Pedroni (1999), Cointegration exists between real GDP, energy consumption, labor force, and capital with significant coefficients (+ signs).

Granger causality test results show that in short and long run causal link found between energy (consumption) to economic growth.

Narayan and Smyth (2009) check the causal affiliation between electricity consumption, exports and GDP for Middle Eastern countries panel. Statistically significant link found between variables for the panel as a whole. The study also suggests that these nations must focus on electricity infrastructure (communications) and promote exports especially non-oil exports.

Mahadevan and Adjaye (2007) reinvestigate GDP growth and energy (consumption) nexus by using panel ECM. The panel data set is used for 20 net importers and exporters nations from time period 1971-2002 (time period). The findings show, bidirectional causal affiliation between growth and energy (consumption) in short and long run for developed nations (countries), while energy (consumption) promote growth in short run only for developing nations (countries). The earlier result is same for energy importers also but later is only for those developed countries that exist in this category. The results of causality analysis and elasticity's responsiveness are also compared by using both pooled and unspooled estimation technique.

Tugcu (2013) investigates the link between disaggregate energy consumption (nuclear, fossil, renewable) and TFPG (total factor productivity growth) in Turkey from time period 1970-2011. ARDL, bounds test procedure Cointegration technique and Dolado and Lutkepohl's Granger causality technique is applied. The results of the study show that disaggregate energy (consumption) are co integrated to total factor productivity growth and bidirectional causal link found between these variables. The findings of the study also show that only the share of renewable energy consumption affects total factor productivity with a positive sign.

Lee (2005) reinvestigates the causality relationship and co movement between GDP and energy uses. Panel data set are used for 18 developing countries from time period 1975-2001. Panel Cointegration and panel ECM are applied. Empirical results shows, that long run Cointegration association exists between these variables. The long run affiliation is finding by using FM, OLS (fully modified, ordinary least square estimator). Causality runs from energy consumption to GDP both in long and short run but not vice versa.

Apergis and Payne (2010) investigate the affiliation between economic growth and energy consumption in nine South American nations (countries) from 1980 to 2005 (panel data). Panel Cointegration and ECM is used for look into causal connection between variables. The findings of panel Cointegration (Pedroni's, heterogeneous) test confirm a long run equilibrium association between real GDP, energy consumption, labor force and capital with statistically significant positive signs. Causal link found from energy to growth both in short long run, also support the Growth hypothesis.

Sadorsky (2011) evaluates the impact of financial development on energy (consumption). 9 Central and Eastern European frontier economies are taken from 1996 to 2006. This study use different proxies for financial development including 4 banking sector and 3 stock market variables, and use dynamic panel demand model. The findings show statistically significant (+ sign) between financial development and energy (consumption) for 3 banking sector and 1 for stock market variable.

Shahbaz and Lean (2012) examine the affiliation between financial development, energy consumption, economic growth, industrialization and urbanization in Tunisia from time period 1971-2008. This study use ARDL, bounds procedure Cointegration method. The findings justify long run connection between all variables.

Sadorsky (2012) look into the link between trade, output and energy (consumption) in 7 countries (South American) from 1980-2007. Panel Cointegration findings show long run affiliation between capital, output, labor, energy and trade (exports or imports). The result also justifies that causal connection found between trade (exports or imports) and energy (consumption) in long run.

2.2 Literature Review on the Impact of Energy Consumption on Environment

Many studies have been written to evaluate the impact of energy consumption on Environment. Pao and Tsai (2011) look into the impact of FDI (foreign direct investment) and growth on environment condition using panel Cointegration technique from the time period between 1980 and 2007. In long run equilibrium, CO_2 emissions come into view energy consumption elastic and FDI inelastic. Unidirectional causal link found from output to FDI and energy (consumption) to emissions. Bidirectional causal affiliation found between emissions and FDI, output and energy (consumption), output and emissions.

Jalil and Feridun (2011) examine the impact of financial development, growth and energy (consumption) on environment in china from the time period 1953 to 2006. The ARDL, bound testing procedure approach is applying to evaluate long run link between these variables. According to findings negative relationship found between financial development and environmental pollution, energy (consumption) and trade openness are chief determinant of emissions in long run. Findings also verify the existence of EK Curve in china.

Mehrara (2007) examines the causal affiliation between per capita energy (consumption) and per capita GDP using panel data for 11 oil exporting countries from 1971-2002. Panel Cointegration test verify long run affiliation between variables. Unidirectional causal link verify from growth to energy (consumption). The study also suggests that these countries should adopt low domestic oil prices for the purpose of high exports, because any energy conservation policy like that any reduction in energy (consumption) will not harm growth.

Sharma (2011) study the determinants of CO_2E for 69 countries (global panel), and high, low and middle income (sub panels) group countries from 1985 to 2005. The results of the study show that total primary energy consumption and GDP per capita (for, global panel), are chief determinants of CO_2E, while trade openness, urbanization and electric power consumption negatively affect CO_2E. While all variables are found positively affect CO_2E (for, sub panels) except urbanization.

Soytas and sari (2009) check long run affiliation between energy consumption, economic growth and emissions in Turkey. The annual data set are used from 1960 to 2000. One shocking and surprising result is that granger causality runs from CO_2E to energy consumption. No causal affiliation found between emissions and income; it shows that Turkish government can shrink emissions without effecting growth.

Ozturk and Salahuddin (2012) check long run affiliation between energy (consumption), CO_2E and growth in India. The annual data set are used from 1971 to 2007. One central result is that causal link found from energy (consumption) to growth, growth to energy (consumption), energy (consumption) to emissions. The short term adjustment of ECM confirms that deviations will remove in long run, while emissions and energy (consumption) will converge to equilibrium. It shows that if Indian government wants to reduce CO_2E then they will forgo growth.

Suri and chapman (1998) check the existence of EK curve with time series and pooled cross country econometrically. The study also investigate that commercial energy consumption is a big cause of environment pollution.

Soytas et.al (2007) checks the impact EC and income on CO_2E from time period 1960 to 2004 in United States. This study sees the presence of EK curve shape by including energy (consumption) in the model. According to findings of granger causality analysis energy (consumption) granger cause carbon emissions while income of united stated does not granger cause carbon emissions. This study concludes that growth in income of United States is not a way to reduce carbon emissions.

Hossain (2011) explore the dynamic affiliation between emissions, economic growth, energy use, urbanization and trade openness. The panel data set are use from the time period 1971 to 2007 for newly industrial countries. The findings of Cointegration (Johansen fisher) test prove that Cointegration exists between variables. Causality analysis describe that no causal link in long run between variables while in short run unidirectional causal association found between variables. The results of elasticity's in long run describe that energy (consumption) coefficient on CO_2E is higher than short run which shows that as time pass CO_2E rise more due to energy use.

Munir and Khan (2012) study the impact of energy use (fossil fuel) on CO_2E from time period 1980 to 2010 in case of Pakistan. For long run analysis Johansen (Cointegration, test) and for short run analysis VECM is applied. The results of the study confirm that inverted u shaped EK curve exists in Pakistan. The results also show that trade and industry value added have positive sign on CO_2E while development in financial sector has negative sign. Investment, income, population and export have positive sign when energy (consumption) is treated as dependent variable while import has negative sign.

Apergis and Payne (2010) check causal connection between CO_2E, real GDP and energy (consumption) from 1992 to 2004 for eleven commonwealth countries. To check the stationarity of data panel based unit root tests are applied. Pedroni, Cointegration test is applied for check whether Cointegration exist between variables or not. For long run elasticity's FM, OLS is applied and for causality analysis VECM is applied. Findings verify that Cointegration exist between variables. The results also shows that energy (consumption) impact carbon dioxide emissions positively while inverted U shaped Kuznets curve also exist. Bidirectional causality found between emissions and energy (consumption), while unidirectional causal connection found from energy (consumption) to emissions and real output to emissions.

Hilton and Levinson (1998) check the connection between national income and automotive lead emissions from the time period 1972 to 1992 for 48 countries. The results support the existence of inverted u shaped EK curve when lead emissions treated as environmental pollution. According to this study automotive lead emission is divided between two categories, first consumption of gasoline known as pollution activity and second is for each gallon of gasoline known as pollution intensity. The interesting conclusion is that decreasing part of inverted u shaped environment Kuznets due to reducing pollution intensity not due to pollution activity.

Roca and Alcantara (2001) theoretically and diagrammatically describe the link between CO_2E, energy intensity and EK curve from the time period 1972 to 1997 for the case of Spain. In this study indexes are created for energy intensity and CO_2E. There is no evidence that supporting the hypothesis of existence EK curve in Spain.

Kaufmann et al. (1998) explore the impact of income on SO_2 (sulfur dioxide) and index of economic activity (economic activity/ area) on SO_2. The data set are panel from time period 1974 to 1989 for 23 countries. FE (Fixed effect) and RE (random effect) models are used for regression analysis. The results of the study states that inverted U shaped EK curve exist both cases for income as well as spatial intensity of economic activity. SO_2 (sulfur dioxide) reduced more in the case of economic activity index than income which provide new dimension for policy analyst.

Jalil and Mahmud (2009) investigate long run link between energy (consumption), foreign trade, income and emissions from 1975 to 2005 for china. Main objective is that to ensure the existence of EK curve. ARDL, technique results support the existence of Kuznets curve when cubic term is added in the model. According to this study energy (consumption) and income are chief determinants of carbon dioxide emissions. Granger causality runs from economic growth to emissions.

Farhani and Rejeb (2012) investigate the relationship between CO_2E, GDP and energy (consumption) from 1973 to 2008 for fifteen Mena countries. Pedroni, Kao and Johansen Cointegration tests are applied for check whether Cointegration exist between variables or not. For long run elasticity's FM, OLS, Dynamic OLS and simple OLS are applied and for causality analysis VECM is applied. The findings verify that Cointegration exist between variables.

Liu (2005) investigate the impact of CO_2E including control variables on GDP and impact of GDP and energy (consumption) on CO_2E. Panel data set are used from 1975 to 1990 for 24 OECD countries. Both models are jointly determined. Three stage least square

(3SLS) estimation technique is used for estimate both models jointly. The surprising result of the study is that gross domestic product has negative sign on emissions when energy (consumption) is added in model.

Stern et al. (1996) first describes the appropriate definition of EK curve hypothesis and then investigates the reasons behind this. This study reviews five previous studies theoretically and empirically. This study describes a number of estimation problems econometrically and theoretically in previews studies, and explains that world income is skewed rather than normal distributed. The population total projections are depends on 1990 to 2025. To conclude, this study clearly evaluates the problems in previous studies and tries to overcome on it.

Stern and common (2001) tries to check the existence of EK curve hypothesis for sulfur dioxide for world global panel, OECD countries and non OECD countries. The data are used from 1850 to 1990. The findings show that EK curve hypothesis exists for high income group and SO_2 is monotonic function of income in case of global panel. For first differenced global panel and high income countries SO_2 also monotonic function of income. The main conclusion of this study is that emissions reduction is due to time dependence rather than income dependence.

Apergis and Payne (2009) check the causal connection between energy (consumption), output and CO_2E. Panel data set are used from time period 1971 to 2004 for six countries (Central American). Panel unit root tests, Cointegration test (Pedroni), VECM and FM, OLS techniques are used for short and long run analysis. Findings prove the existence of EK curve hypothesis.

Dinda (2004) reviews previous studies on EK curve hypothesis by theoretically explaining reasons behind it. This study also discusses problems, empirical results, background, conceptual framework, concluding remarks and implications that previous studies had been done.

2.3 Summary and Conclusion

All the review describes the relation with aggregate energy (consumption), only few studies describe disaggregate energy (consumption) using time series approach. It would be interesting to investigate the relationship in disaggregated form by using panel data. In literature, there is no single studies that depict the impact of disaggregate energy (consumption) on environment, so it would be motivating to look at the connection between disaggregate energy (consumption) and environment.

CHAPTER 3

Theoretical Framework

This chapter is divided into three parts. Section 3.1 describes conceptual framework, 3.2 model specification whereas Section 3.3 hypotheses.

3.1.1 Conceptual Framework for Energy and Growth

In literature, "classical macroeconomic growth theories primarily focused on labor and capital and did not consider the role of energy resources which are having the significant role for economic growth and production" (Stern and Cleveland, 2004). Energy economists states, "energy is an important factor as well as play a major role in production process; it can be used directly as a final product" (Stern, 1997). "Production of output is determined by energy service, capital stock and labor" (Pokrovski, 2003). "Energy input generates work that moves or transforms matter and physical capital and combines various energy inputs into an aggregate" (Thompson, 2006). "Economic activities consider energy as a required input in the productive process and as the economy is driven by increasing energy demands, we believe that excluding energy use from the production function would clearly be a sign of a lack of judgment" (Lee, 2008).

Theoretically exports as an engine of growth by three ways. First by directly, "an increase in demand of foreigners for domestic exportable products can promote output and overall growth of the economy that will increase income and employment in exportable sector" (Awokuse, 2008). Second, "exports affect growth indirectly by many channels such as: efficient allocation of resources, exploitation of economies of scale, greater capacity utilization and stimulation of technological improvement due to foreign market competition" (Helpman and Krugman, 1985). Third, "by increasing exports foreign exchange reserves can be received that will be helpful for increasing the intermediate imports that in turn raises capital formation and growth (Balassa, 1978; Esfahani, 1991)".

The effect of imports on economic growth may be different from exports (Awokuse, 2008). "For developing economies, Imports provide important factor of production that needed for exports sector. Transfer of technology from developed to underdeveloped Nations could promote economic growth. Endogenous growth models also show that imports can be a channel of long run economic growth because it provides foreign technology and knowledge to domestic firms" (Grossman and Helpman, 1991 ; Coe and Helpman, 1995).

There are two channels through which, financial development can lead to economic growth (Fung, 2009). "The first channel is factor productivity through which financial development may lead to economic growth. In this channel, financial innovations and technologies lesson informational asymmetries and this leads to better monitoring and selection of investment projects" (Townsend, 1979; King and Levine, 1993; Baier et al, 2004). "Financial liberalization increases risk diversification which should lower the cost of equity and investment will increase, thus through this channel ultimately final results increased economic growth" (Bekaert and Harvey, 2000; Bekaert et al 2001, 2002, 2005). "The second channel is called factor accumulation, which states spread of organized financial systems over self-finance". "Organized financial systems increase efficiency as previously unproductive resources are put to better use" (Gurley and shaw, 1955; Bell and Rousseau, 2001).

3.1.2 Conceptual Framework for Energy and Environment

"Energy plays a major role in residential, industrial needs, transportation, and electricity needs. The burning of fossil fuel is necessary in every region as it is used for the production of goods and services. While it is also true that burning of fossil fuel emits a high amount of CO2 and pollutes our environment, it has been empirically and theoretically shown that an increase in energy consumption results in greater economic activity. Higher economic growth will have a positive effect. Boost in energy consumption results in higher GDP because, in addition to the undeviating effect of energy consumed for commercial use which stimulates higher rates of economic growth, higher energy consumption results in an increase in energy production. Through this channel, an increase in pollution emissions is expected due to fast economic growth and ensuing greater fossil fuel consumption" (Hooi and Smyth, 2010).

Trade openness is expected to have a positive effect on CO_2 emissions. "Hecksher Ohlin trade theory also supports positive effect on CO_2 emissions. H-O trade theory states that, under free trade, emergent countries would focus on production of goods in which they have a comparative advantage, such as labor and natural resources". Thus, the movement of goods and services produced in one country for either consumption or further processing is occurred as the result of trade. More "consumption of goods and further processing of goods, which takes place due to greater trade openness, is a source of pollution. Hence, the H-O theory actually perceives that pollution is stimulated from further processing and manufacturing of goods, which results from greater trade openness".

Financial development, can affect CO_2 emissions in many ways (Frankel and Romer, 1999; Dasgupta et al, 2001; Sadorsky, 2010; and zhang, 2011). First, "stock market development helps all listed companies to achieve lower cost of finance capital, increase finance channels, and diversify risk, so as to invest in new projects and buy new installations. Through this channel energy consumption and carbon emissions will increase". Second, "financial development also attracts FDI through this channel boost economic growth and increase carbon emissions". Third, "financial development making cheaper and easier for consumers to borrow money to buy houses, air conditioners, refrigerators, washing machines and automobiles and it will emit more carbon dioxide" (Zhang, 2011). However, "financial development may increase energy efficiency and enterprises' performance and then reduce energy consumption and carbon emissions" (Tamazian et al, 2009; Claessens and Feijen, 2007).

3.2 Model Specifications

3.2.1 Model Specification for Effect of Energy on Growth

CDPF (Cobb Douglas production function) is extensively used to symbolize the connection between inputs and output. It was initially planned by (Knut Wicksell, 1851 & 1926), and tested against statistical confirmation (Cobb and Douglas, 1928). These two (Cobb and Douglas, 1928) published a paper in which they check American economy growth in a model from 1899 to 1922. They represent a simplified outlook of economy in which "production output is determined by the amount of labor involved and the amount of capital invested". While there are many other factors affecting economic performance, their model proved to be remarkably accurate. The following function is used.

$$P(K,L) = bK^{\alpha}L^{\beta}$$

• P = total production

• L = labor input

• K = capital input

• b = factor efficiency

• α And ß = output elasticity's of capital and labor respectively.

While "Neo-classical production model the traditional neo-classical growth model, treating energy inputs as intermediate factors but labor and capital as basic factors". By contrast, "biophysical and ecological view, energy economists consider that energy is a required input and an increasing demand in the production process, and that it plays a crucial role in output determination" (Ghali and Sakka, 2004; Stern, 2000). Numerous studies have attempted to highlight the importance of energy in the production process (Ghali and Sakka, 2004; Oh and Lee, 2004; Soytas, 2003 and Sari, 2007; Stern, 1993and 2000; Tsani, 2010; Warr and Ayres, 2010; Rufael and Menyah, 2010; Yuan et al, 2008).

$$Y = f(K, L, E)$$

GDP depends on capital, labor and energy respectively.

While (Perry Sadorsky, 2012) uses following model.

$$Y = f(K, L, E, O, \varepsilon) = K_{it}^{\alpha}\ L_{it}^{\beta}\ E_{it}^{\gamma}\ O_{it}^{\psi}\ e^{\varepsilon_{it}}$$

GDP depends on capital, labor, energy and trade respectively.

While (Shahbaz et al, 2012) uses following

$$\ln G_t = \beta_1 + \beta_K \ln K_t + \beta_L \ln L_t + \beta_E \ln E_t + \beta_F \ln F_t + \beta_{TR} \ln TR_t + \mu_t$$

GDP determine by capital, labor, energy, financial development and trade respectively.

This study used Cobb Douglas production function to check the relationship between disaggregates energy consumption and economic growth. There are many reasons for using Cobb Douglas production function. First, "Neo-classical marginal productivity theory describes that marginal productivity of labor is positive, because second derivative is firstly positive but after achieving maximum point it will be negative. Therefore, the graph of total output with regard to labor input describes an S-shaped curve. The second reason is that any production function that is used in the form of quantitative economics is basically near to reality. The third reason is that Cobb Douglas production function is mathematically tractable, simple and well-designed to first order conditions for derive factor demand or cost function. Finally, the Cobb–Douglas function can be used for any observed data" (see Shaikh, 1974 and Michl, 1999).

3.2.2 Model specification for Impact of Energy consumption on Environment

Jalil and Feridun(2011) use following model

$$\ln CO2_{it} = \nu_i + \alpha \ln E_{it} + \beta \ln Y_{it} + \gamma \ln Y_{it}^2 + \theta \ln F_{it} + \psi \ln T_{it} + \varepsilon_{it}$$

This study also used this model, but energy is in disaggregated form in this case.

3.3 Hypotheses Development

The following hypothesis are formulated based on the empirical literature given in chapter two theoretical framework

(i) H_1^A : There is Positive relationship between disaggregate energy consumption (coal, petroleum, electricity, renewable energy consumption) and economic growth by remaining all other variables are constant.

(ii) H_1^B: There is Positive relationship between disaggregate energy consumption (coal, petroleum, electricity, renewable energy consumption) and CO_2 emissions by remaining all other variables are constant.

(iii) H_1^C : There is Positive relationship between economic growth and CO_2 emissions by remaining all other variables are constant.

CHAPTER 4

Methodology and Data

Section 4.1 describes methodological framework, 4.2 data, 4.3 variable constructions and 4.4 estimations.

4.1 Methodological Framework

4.1.1 Empirical Specification of Growth model with Energy Consumption

The methodological framework, data and data sources are presented in this chapter. By extended the Cob Douglas production function this study will use following empirical specification of the model as suggested by (Sadorsky, 2012).

$$Y = f(K, L, E, F, T, \varepsilon) = K_{it}^{\alpha} \; L_{it}^{\beta} \, E_{it}^{\gamma} \; F_{it}^{\theta} \, T_{it}^{\psi} e^{\varepsilon_{it}}$$

GDP is a function of capital, labor, energy, financial development and trade openness respectively.

Taking natural log on both sides the model becomes:

$$\ln Y_{it} = \nu_i + \alpha \ln K_{it} + \beta \ln L_{it} + \gamma \ln E_{it} + \theta \ln F_{it} + \psi \ln T_{it} + \varepsilon_{it} \text{.....(1)}$$

Where, Y = Gross Domestic Product (G.D.P)

K= Capital

L = Labor

E = Disaggregate Energy Consumption (coal, petroleum, electricity, renewable energy consumption) will include separately in above equation.

F = Financial Development

T = Trade Openness

According to equation (1) E is defined total energy consumption, electricity consumption, petroleum consumption, renewable energy consumption and coal consumption in model 1, 2,3,4,5 respectively.

4.1.2 Empirical Specification of Environment model with Energy Consumption

The environment is captured by CO_2 emissions. To check the impact of non-linear growth and EC (energy consumption) on environment following empirical specification of the model is used following (Jalil and Feridun, 2011).

$$\ln CO2_{it} = \nu_i + \alpha \ln E_{it} + \beta \ln Y_{it} + \gamma \ln Y_{it}^2 + \theta \ln F_{it} + \psi \ln T_{it} + \varepsilon_{it} ....(2)$$

Where CO_2 = Carbon Dioxide Emissions, and all other variables are same as used by the above model.

According to equation (2) E is defined total energy consumption, electricity consumption, petroleum consumption, renewable energy consumption and coal consumption in model 1, 2,3,4,5 respectively.

4.2 Data

The annual data is taken from WDI (world development indicators) and EIA (energy information administration) for 8 Asian developing countries (Bangladesh, Pakistan, Indonesia, China, Philippines, India, Sri Lanka, and Thailand). The data period is taken from 1990 to 2010.

4.3 Construction of Variables

Coal consumption = (Thousand, Short Tons)

Petroleum consumption = (Thousand Barrels, Per Day)

Electricity consumption = (Billion, Kilowatt / hours)

Renewable Electricity consumption = (Billion, Kilowatt / hours)

Total Energy consumption = (kt, of oil equivalent)

Real GDP is calculated by (GDP, constant 2005 US$). Total labor force is used for labor. Capital is calculated by (Gross fixed capital formation, constant 2005 US$). (Domestic credit to private sector, % of GDP) is used for financial development variable. Trade openness variable is constructed by (Imports + Exports /GDP). (Total Carbon Dioxide Emissions from the Consumption of Energy, Million Metric Tons) is used for CO_2 emissions.

4.4 Estimation Techniques

Panel Cointegration (Pedroni, Kao) tests are applied to verify the long run affiliation between economic growth, disaggregated energy consumption, and environment. FM, OLS is applied to find long run elasticity. For short run VECM is apply. For this analysis first step is to verify the stationarity of data and panel based unit root tests are applied for this purpose. The detailed discussion of these models is given below:

4.4.1 Panel Unit Root Tests

DF (Dickey Fuller) and ADF (Augmented Dickey fuller) tests are extended for panel data analysis, to check whether the data are stationary or not. Mostly unit root (panel based) tests are extension of ADF (Augmented Dickey fuller) test because mostly test include it as a regression component.

The Levin and Lin (LL) Test

Levin and Lin was developed panel unit root test in 1992. On early stage Levin and Lin were presented the test in a working paper in 1992 and completely published in 2002 with chu (co-author). The test is still known as LL test due to work of Levin and Lin. This test is extension of DF (Dickey Fuller) test.

Model is given below:

$$\Delta Y_{i,t} = \alpha_i + \rho Y_{i,t-1} + \sum_{k=1}^{n} \phi_k \Delta Y_{i,t-k} + \delta_i t + \theta_t + \mu_{it}$$

α_i θ_t elaborate that two ways fixed effect allows by the model. Time effects (Unit specific) and fixed effects (Unit specific) both are included.

Two hypotheses null and alternative are given below:

$$H_O : \rho = 0$$

$$H_a : \rho < 0$$

The main assumption of LL test is that individual processes and cross sectionals independent. According to this assumption under null hypothesis p will follow standard normal distribution.

IPS (The Im, Pesaran and Shin) Test

This test is extension of LL test by introduce heterogeneity (on the coefficient of the $Y_{i,t-1}$ variable) and proposed as a fundamental testing method one based (on the average, of the individual unit root test statistics). Test is presented in 1997. It gives separate estimations for each i section and allows separate specifications of parametric values, the lag lengths and the residual variance.

The model of this test is given below:

$$\Delta Y_{i,t} = \alpha_i + \rho_i Y_{i,t-1} + \sum_{k=1}^{n} \phi_{ik} \Delta Y_{i,t-k} + \delta_i t + \mu_{it}$$

And both null and alternative hypothesis are given below:

$H_O : \rho = 0$ (For all i)

$H_a : \rho < 0$ (For, at least one i)

Null hypothesis= series are non-stationary

Alternative hypothesis= at least (one fraction) from series is stationary.

The Im, Pesaran and Shin (1997) formulated model under restrictive assumption that for all cross sections T should be same. Balanced panel is required to compute $\bar{t}$ test statistics. The statistics $\bar{t}$ is the average of individual ADF (t, statistics).

$$\bar{t} = \frac{1}{N}\sum_{i=1}^{N} t_{\rho i}$$

The Im, Pesaran and Shin (1997) also show that under detailed assumptions, $t_{\rho i}$ will converge to t_{iT} statistics which assumes iid with finite variance and mean. They also computed the values for variance and mean. After that they constructed IPS statistics for panel unit root testing.

$$t_{IPS} = \frac{\sqrt{N}\left(\bar{t} - 1/N\sum_{i=1}^{N} E[t_{iT} / \rho_i = 0]\right)}{\sqrt{\operatorname{var}[t_{iT} / \rho_i = 0]}}$$

This statistics follows standard normal distribution.

The Maddala and Wu (MW) Test

Maddala and Wu (1999) discuss some drawbacks of previous tests and proposed a model that can also be estimate unbalanced panels. They do not agree with average ADF statistics, they say that it's not effective way. The basis assumption of MW test is that, a heterogeneous alternative is preferable. Assuming that, If N unit root tests are there:

Then MW is given below:

$$\pi = -2\sum_{i=1}^{N} \ln \pi_i$$

Breitung Unit Root test

There is slight difference between LLC and Breitung test. The difference lies in two ways.Only auto regression portion is removed when constructing standardize proxies. That is:

$$\tilde{e}_{it} = \Delta\tilde{Y}_{it} = \frac{\Delta Y_{it} - \sum_{j=1}^{P_i} \beta_{ij}\Delta Y_{i,t-j}}{\sigma_i}$$

$$\tilde{v}_{i,t-1} = \tilde{Y}_{it-1} = (Y_{it-1} - \sum_{j=1}^{P_i} \beta_{ij}\Delta Y_{i,t-j})/\sigma_i$$

Running the following regression :

$$e^{*}{}_{it} = \rho v^{*}_{i,t-1} + \mu_{it}$$

Where

$$e^{*}{}_{it} = \sqrt{\frac{T-t}{T-t+1}}\left(\tilde{e}_{it}.\frac{\tilde{e}_{it}+\cdots+\tilde{e}_{it+T}}{T-t}\right) \; and$$

$$v_{i,t-1}^{*} = \tilde{v}_{i,t-1} - C_{it}$$

Fisher ADF Test

Consider the following regression model.

$$\Delta Y_{it} = \rho Y_{it-1} + \sum_{i=2}^{P} \theta_i \Delta Y_{t-i+2} + \varepsilon_{it}$$

Null and Alternative Hypothesis:

H_0: $\rho = 0$ (Series is non-stationary)

H_A: $\rho < 0$(Series is stationary)

We use ADF (For the presence, of unit root) test as:

$$t_{\hat{r}} = \frac{\hat{\rho} - 1}{SE(\hat{\rho})}$$

This $t_{\hat{r}}$ does not follow standard student t-value but the critical values are calculated by DF and depend on whether there is an intercept, trend, or intercept and trend.

Fisher PP Test

Fisher-PP (Fisher- Phillips and Parron) proposed non parametric transformation of the t-stat from original DF regression such that under the unit roots null. The transformed statistic (Z-statistic) has DF distribution. To test regression for PP we specify the following model:

$$\Delta Y_t = \beta' D_t + \pi Y_{t-1} + u_t$$

Whereu_t is I(0) may be heteroscedastic. Serial correlation correction, and hetroskedasticity (in the error term u_t) are settlement of PP test.

Null and Alternative Hypothesis

$H_0: \pi = 0$ (Series is non-stationary)

$H_A: \pi < 0$(Series is stationary)

We use ADF test (For the presence of unit root) as:

$$t_{\hat{r}} = \frac{\hat{\pi} - 1}{SE(\hat{\pi})}$$

4.4.2 Cointegration Tests

The Kao Test

Kao was presented his Cointegration test in 1999. This test is Augmented Dickey fuller and Dickey fuller type test, its model is given below

$$Y_{it} = \alpha_i + \beta X_{it} + \hat{u}_{it}$$

According to this equation residual based Cointegration test could be apply.

$$\hat{u}_{it} = e\hat{u}_{it-1} + v_{it}$$

$\hat{u}_{it}$ = estimated residuals from 1st equation. OLS estimate for ρ is given below

$$\hat{\rho} = \frac{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{u}_{it}\hat{u}_{it-1}}{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{u}_{it}^{2}}$$

$$t_{\rho} = \frac{(\hat{\rho}-1)\sqrt{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{u}_{it}^{2}}}{1/(NT)\sum_{i=1}^{N}\sum_{t=2}^{T}(\hat{u}_{it}-\hat{\rho}\hat{u}_{it-1})^{2}}$$

The above equation is t statistic.

Four different kinds of Dickey Fuller tests are proposed by Kao which are given below

$$DF_{\rho} = \frac{\sqrt{N}T(\hat{\rho}-1)+3\sqrt{N}}{\sqrt{10.2}}$$

$$DF_{t} = \sqrt{1.25}t_{\rho} + \sqrt{1.875N}$$

$$DF_{\rho}^{*} = \frac{\sqrt{N}T(\hat{\rho}-1) + 3\sqrt{N}\hat{\sigma}_{v}^{2} / \hat{\sigma}_{0v}^{2}}{\sqrt{3 + 36\hat{\sigma}_{v}^{4} /(5\hat{\sigma}_{0v}^{4})}}$$

$$DF_{t}^{*} = \frac{t_{\rho} + \sqrt{6N}\hat{\sigma}_{v} /(2\hat{\sigma}_{0v})}{\sqrt{\hat{\sigma}_{0v}^{2} /(2\hat{\sigma}_{v}^{2}) + 3\hat{\sigma}_{v}^{2} /(10\hat{\sigma}_{0v}^{2})}}$$

In first two types the association between errors and regressors is strongly exogenous, whereas in last two types the relationship between errors and regressors is endogenous.

Kao (1999) also proposed Augmented Dickey Fuller test, given below regression can be run under it

$$\mathbf{u}_{i,t} = \rho \mathbf{u}_{i,t-1} + \sum_{j=1}^{n} \phi_{j} \Delta \mathbf{u}_{i,t-j} + v_{it}$$

The null hypothesis is that no Cointegration same as Dickey Fuller test and Augmented Dickey Fuller statistic calculated as

$$ADF = \frac{t_{ADF} + \sqrt{6N}\hat{\sigma}_{v} /(2\hat{\sigma}_{0v})}{\sqrt{\hat{\sigma}_{0v}^{2} /(2\hat{\sigma}_{v}^{2}) + 3\hat{\sigma}_{v}^{2} /(10\hat{\sigma}_{0v}^{2})}}$$

All statistics follow standard normal distribution.

The Pedroni Tests

Pedroni (1997, 1999 and 2000) proposed a number of types tests for cointegration that allow considerable heterogeneity in panel data models. Pedroni tests are better than previous panel Cointegration tests because they allow multiple regressors (for heterogeneity, in errors across cross sectional units and for cointegration vector to vary across different sections of the panel).

Pedroni panel regression model is given below:

$$Y_{i,t} = \alpha_i + \delta_t + \sum_{m=1}^{M} \beta_{mi} X_{mi,t} + \mathrm{u}_{i,t}$$

Pedroni proposed seven different kinds of cointegration statistics to capture the between and within effects in his panel. Pedroni tests are classified in two categories. Four tests are incorporated in first category (based on pooling, along the within dimension). These four tests are much similar as previous cointegration tests; these tests have the following test statistics.

(The panel, v-statistic)

$$T^2 N^{3/2} Z_{\hat{v}NT} = \frac{T^2 N^{3/2}}{\left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{u}_{it}^{2}\right)}$$

(The panel, ρ statistic)

$$T\sqrt{N}Z_{\hat{\rho}NT} = \frac{T\sqrt{N}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}(\hat{u}_{it-1}^{2}\Delta\hat{u}_{it}^{2} - \hat{\lambda}_{i}\right)}{\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{u}_{it}^{2}\right)}$$

{The panel, t-statistic (non-parametric)}

$$Z_{tNT} = \sqrt{\tilde{\sigma}_{NT}^{2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{u}_{it-1}^{2}}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\left(\hat{u}_{it-1}^{2}\Delta\hat{u}_{it}^{2} - \hat{\lambda}_{i}\right)\right)$$

{The panel, t-statistic (parametric)}

$$Z_{tNT} = \sqrt{\tilde{\sigma}_{NT}^{*2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{u}_{it-1}^{*2}}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\left(\hat{u}_{it-1}^{*2}\Delta\hat{u}_{it}^{*2} - \hat{\lambda}_{i}\right)\right)$$

Three tests are incorporate in 2nd category, pooling between dimensions. Test statistics of these three tests are given below

{The group, ρ statistic (parametric)}

$$T\sqrt{N}\tilde{Z}_{\tilde{\rho}NT} = T\sqrt{N}\,\frac{\sum_{t=1}^{T}\left(\hat{u}_{it-1}^{2}\Delta\hat{u}_{it}^{2} - \hat{\lambda}_{i}\right)}{\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{u}_{it-1}^{2}\right)}$$

{The group, t-statistic (non parametric)}

$$\sqrt{N}\tilde{Z}_{tNT-1} = \sqrt{N}\sum_{i=1}^{N}\left(\sqrt{\tilde{\sigma}_{i}^{2}\sum_{t=1}^{T}\hat{u}_{it-1}^{2}}\right)\sum_{t=1}^{T}\left(\hat{u}_{it-1}^{2}\Delta\hat{u}_{it}^{2} - \hat{\lambda}_{i}\right)$$

{The group, t-statistic (parametric)}

$$\sqrt{N}\tilde{Z}^{*}{}_{tNT-1} = \sqrt{N}\sum_{i=1}^{N}\left(\sqrt{\tilde{s}_{i}^{*2}\sum_{t=1}^{T}\hat{u}_{it-1}^{*2}}\right)\sum_{t=1}^{T}\left(\hat{u}_{it-1}^{*2}\Delta\hat{u}_{it}^{*2}\right)$$

4.4.3 Fully Modified OLS

This study uses more developed panel estimation technique known as FMOLS. “Fully modified OLS is testing hypothesis and estimating for co integrating vectors in dynamic panels through a way in which also consistent with the degree of cross sectional heterogeneity that has been also permitted in more recent panel Cointegration and panel unit root studies. One advantage of fully modified OLS is that working with this type of panel co integrated approach allows researchers to selectively pool long run information, also allows short run dynamics and fixed effects to be heterogeneous among different members of the panel. One another advantage of fully modified OLS technique is that it produces asymptotically unbiased estimators and nuisance parameter free standard normal distribution” (Pedroni, 1999).

4.4.4 Panel Causality

Cointegration tests confirm that causal relation exist between two variables but does not tell us direction of relationship. For find direction of relationship two steps Granger Causality test is apply. The procedure of this test is that, first estimate equation and finds residuals and incorporates residuals as independent variable, then following dynamic vector error correction model is apply.

$$\Delta Y_{it} = \alpha_{1j} + \sum_{k=1}^{q} \theta_{11ik} \Delta Y_{it-k} + \sum_{k=1}^{q} \theta_{12ik} \Delta E_{it-k} + \sum_{k=1}^{q} \theta_{13ik} \Delta K_{it-k}$$
$$+ \sum_{k=1}^{q} \theta_{14ik} \Delta L_{it-k} + \sum_{k=1}^{q} \theta_{15ik} \Delta FD_{it-k} + \sum_{k=1}^{q} \theta_{16ik} \Delta TO_{it-k} + \lambda_{1i} \varepsilon_{it-1} + \mu_{1it}$$

$$\Delta E_{it} = \alpha_{2j} + \sum_{k=1}^{q} \theta_{21ik} \Delta Y_{it-k} + \sum_{k=1}^{q} \theta_{22ik} \Delta E_{it-k} + \sum_{k=1}^{q} \theta_{23ik} \Delta K_{it-k}$$
$$+ \sum_{k=1}^{q} \theta_{24ik} \Delta L_{it-k} + \sum_{k=1}^{q} \theta_{25ik} \Delta FD_{it-k} + \sum_{k=1}^{q} \theta_{26ik} \Delta TO_{it-k} + \lambda_{2i} \varepsilon_{it-1} + \mu_{2it}$$

$$\Delta CO2_{it} = \gamma_{1j} + \sum_{k=1}^{q} \theta_{11ik} \Delta CO2_{it-k} + \sum_{k=1}^{q} \theta_{12ik} \Delta E_{it-k} + \sum_{k=1}^{q} \theta_{13ik} \Delta Y_{it-k}$$
$$+ \sum_{k=1}^{q} \theta_{14ik} \Delta Y^{2}{}_{it-k} + \sum_{k=1}^{q} \theta_{15ik} \Delta FD_{it-k} + \sum_{k=1}^{q} \theta_{16ik} \Delta TO_{it-k} + \lambda_{1i} \varepsilon_{it-1} + \mu_{1it}$$

$$\Delta CO2_{it} = \gamma_{2j} + \sum_{k=1}^{q} \theta_{21ik} \Delta CO2_{it-k} + \sum_{k=1}^{q} \theta_{22ik} \Delta E_{it-k} + \sum_{k=1}^{q} \theta_{23ik} \Delta Y_{it-k}$$
$$+ \sum_{k=1}^{q} \theta_{24ik} \Delta Y^{2}{}_{it-k} + \sum_{k=1}^{q} \theta_{25ik} \Delta FD_{it-k} + \sum_{k=1}^{q} \theta_{26ik} \Delta TO_{it-k} + \lambda_{2i} \varepsilon_{it-1} + \mu_{2it}$$

CHAPTER 5

Empirical Results and Discussion

The empirical outcomes and their explanations are express in this part. The outcome unit root tests, Cointegration tests, FMOLS and VECM are given in section 5.1, 5.2, 5.3 and 5.4 respectively.

5.1 Panel Unit Root Tests

Five dissimilar types of unit root tests (panel) are applied. First two tests *"*The Levin and Lin (LL) test and Breitung t-stat test are assumed common unit root process, across cross sections. In these two tests null hypothesis is that data are non-stationary or have a unit root and alternative hypothesis is that data are stationary or have a no unit root. While the other three tests such as Im Pesaran and Shin W-stat test, ADF - Fisher Chi-square test and PP - Fisher Chi-square test are assumes individual unit root process, across cross sections*"*. According to table 1, findings express that all variables are non-stationary (or have, a unit root) at level and stationary at first difference.

Table 1 Panel Unit Root Tests

A LGDP	Level Statistics	Probability	Fist Difference Statistics	Probability
The Levin and Lin (LL) test	-0.277	0.391	-4.607	0.000
Breitung t-stat test	1.148	0.874	-3.913	0.000
Im, Pesaran and Shin, W-stat test	-1.226	0.110	-3.201	0.000
ADF - Fisher Chi-square test	21.914	0.146	35.760	0.003
PP - Fisher Chi-square test	8.495	0.932	47.040	0.000
B $LGDP^2$				
The Levin and Lin (LL) test	-0.211	0.416	-4.629	0.000
Breitung t-stat test	1.357	0.912	-3.871	0.000
Im, Pesaran and Shin, W-stat test	-0.968	0.166	-3.174	0.000
ADF - Fisher Chi-square test	20.684	0.191	35.531	0.003
PP - Fisher Chi-square test	7.571	0.960	46.617	0.000
C Labor				
The Levin and Lin (LL) test	5.484	1.000	-3.627	0.000
Breitung t-stat test	0.046	0.518	0.497	0.690
Im, Pesaran and Shin, W-stat test	1.571	0.942	-3.252	0.000
ADF - Fisher Chi-square test	21.232	0.169	43.266	0.000
PP - Fisher Chi-square test	7.612	0.959	54.762	0.000

D Capital				
The Levin and Lin (LL) test	-0.481	0.315	-5.263	0.000
Breitung t-stat test	-0.288	0.386	-3.542	0.000
Im, Pesaran and Shin, W-stat test	-1.437	0.075	-3.932	0.000
ADF - Fisher Chi-square test	21.841	0.148	42.175	0.000
PP - Fisher Chi-square test	12.477	0.710	46.381	0.000
E Openness				
The Levin and Lin (LL) test	-0.148	0.441	-10.427	0.000
Breitung t-stat test	1.286	0.900	-3.936	0.000
Im, Pesaran and Shin, W-stat test	0.463	0.678	-8.936	0.000
ADF - Fisher Chi-square test	16.214	0.438	88.435	0.000
PP - Fisher Chi-square test	15.092	0.517	96.241	0.000
F Carbon Emission				
The Levin and Lin (LL) test	0.160	0.563	-4.713	0.000
Breitung t-stat test	-1.344	0.089	-1.386	0.082
Im, Pesaran and Shin, W-stat test	-0.605	0.272	-5.637	0.000
ADF - Fisher Chi-square test	25.889	0.055	59.384	0.000
PP - Fisher Chi-square test	14.022	0.597	89.247	0.000

G Total Energy				
The Levin and Lin (LL) test	-1.518	0.064	-5.513	0.000
Breitung t-stat test	0.191	0.575	-3.608	0.000
Im, Pesaran and Shin, W-stat test	-0.610	0.270	-6.218	0.000
ADF - Fisher Chi-square test	23.445	0.102	63.682	0.000
PP - Fisher Chi-square test	12.479	0.710	91.777	0.000
H Petrol				
The Levin and Lin (LL) test	-0.464	0.321	-3.544	0.000
Breitung t-stat test	-1.454	0.073	-2.150	0.015
Im, Pesaran and Shin, W-stat test	0.583	0.720	-4.197	0.000
ADF - Fisher Chi-square test	15.224	0.508	45.676	0.000
PP - Fisher Chi-square test	11.100	0.803	94.565	0.000
I Renew Energy				
The Levin and Lin (LL) test	1.266	0.897	-5.054	0.000
Breitung t-stat test	0.824	0.795	-3.948	0.000
Im, Pesaran and Shin, W-stat test	-1.300	0.096	-5.420	0.000
ADF - Fisher Chi-square test	22.913	0.116	60.258	0.000
PP - Fisher Chi-square test	18.948	0.271	98.390	0.000

J Electricity				
The Levin and Lin (LL) test	0.040	0.516	-3.087	0.001
Breitung t-stat test	-0.455	0.324	-3.192	0.000
Im, Pesaran and Shin, W-stat test	-0.106	0.457	-3.240	0.000
ADF - Fisher Chi-square test	18.623	0.288	40.323	0.000
PP - Fisher Chi-square test	20.670	0.191	86.302	0.000
K Coal				
The Levin and Lin (LL) test	-0.373	0.354	-7.073	0.000
Breitung t-stat test	-1.409	0.079	-2.783	0.002
Im, Pesaran and Shin, W-stat test	0.209	0.582	-5.369	0.000
ADF - Fisher Chi-square test	15.940	0.457	60.741	0.000
PP - Fisher Chi-square test	30.975	0.013	85.840	0.000
L Financial Development				
The Levin and Lin (LL) test	-0.129	0.448	-4.597	0.000
Breitung t-stat test	-0.068	0.472	-4.207	0.000
Im, Pesaran and Shin, W-stat test	0.194	0.577	-3.303	0.000
ADF - Fisher Chi-square test	12.609	0.701	41.452	0.000
PP - Fisher Chi-square test	13.318	0.649	58.216	0.000

5.2 Panel Cointegration tests

Pedroni and Kao (cointegration, tests) are applied to verify long run affiliation (relationship) between variables. Pedroni presents two types or set of cointegration tests. First one set is known as within dimension (four, statistics) and the second one set known as between dimension (three, statistics). Kao cointegration test is based on ADF t-statistic. According to the results of table 2, according to Pedroni test four out of seven (Two, within dimension and two, between dimensions) statistics verify long run affiliation between variables[1]. Findings of Kao test also verify long run (co integrated) affiliation between variables.

[1] In table 2 only four statistics (out of seven) of Pedroni test are shows, which confirm cointegration, exist.

Table 2 Panel Cointegration Tests: Cointegration Results for Effect of Disaggregated Energy on Growth Model 1

Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	-1.080475	0.1400	-1.774087	0.0380
Panel, ADF-Statistic	-2.676015	0.0037	-3.210655	0.0007

Between Dimension	Statistics	Probability
Group, PP-Statistic	-1.855673	0.0318
Group, ADF-Statistic	-3.669249	0.0001

Kao Test (ADF)

T-Statistic	Probability
-3.851607	0.0001

Model 2

Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	-2.248965	0.0123	-2.207200	0.0137
Panel, ADF-Statistic	-2.996807	0.0014	-2.977485	0.0015

Between Dimension	Statistics	Probability
Group, PP-Statistic	-2.691907	0.0036
Group, ADF-Statistic	-3.569155	0.0002

Kao Test (ADF)

T-Statistic	Probability
-3.375551	0.0004

Model 3				
Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	-2.405165	0.0081	-1.774693	0.0380
Panel, ADF-Statistic	-3.974744	0.0000	-3.860245	0.0001

Between Dimension	Statistics	Probability
Group, PP-Statistic	-2.321218	0.0101
Group, ADF-Statistic	-4.460319	0.0000

Kao Test (ADF)

T-Statistic	Probability
-2.978781	0.0014

Model 4				
Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	-2.802806	0.0025	-2.656664	0.0039
Panel, ADF-Statistic	-2.580231	0.0049	-1.855710	0.0317

Between Dimension	Statistics	Probability
Group, PP-Statistic	-3.248733	0.0006
Group, ADF-Statistic	-2.875622	0.0020

Kao Test (ADF)

T-Statistic	Probability
-3.939285	0.0000

Model 5

Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	-0.818635	0.2065	-0.528677	0.2985
Panel, ADF-Statistic	-2.825514	0.0024	-2.662490	0.0039

Between Dimension	Statistics	Probability
Group, PP-Statistic	-1.598260	0.0550
Group, ADF-Statistic	-2.967991	0.0015

Kao Test (ADF)

T-Statistic	Probability
-3.324884	0.0004

Panel Cointegration Results for Effect of Disaggregated Energy on Environment Model 1

Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	-2.367229	0.0090	-2.612085	0.0045
Panel, ADF-Statistic	-2.401970	0.0082	-2.490458	0.0064

Between Dimension	Statistics	Probability
Group, PP-Statistic	-2.908373	0.0018
Group, ADF-Statistic	-3.191967	0.0007

Kao Test (ADF)

T-Statistic	Probability
-5.038002	0.0000

Model 2				
Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	-2.038687	0.0207	-2.210664	0.0135
Panel, ADF-Statistic	-2.756769	0.0029	-2.750251	0.0030

Between Dimension	Statistics	Probability
Group, PP-Statistic	-2.122669	0.0169
Group, ADF-Statistic	-2.724895	0.0032

Kao Test (ADF)	
T-Statistic	Probability
-4.133711	0.0000

Model 3				
Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	-1.694946	0.0450	-2.768176	0.0028
Panel, ADF-Statistic	-2.660295	0.0039	-4.031972	0.0000

Between Dimension	Statistics	Probability
Group, PP-Statistic	-2.827510	0.0023
Group, ADF-Statistic	-4.519864	0.0000

Kao Test (ADF)	
T-Statistic	Probability
-2.551942	0.0054

Model 4				
Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	0.011638	0.5046	-0.792805	0.2139
Panel, ADF-Statistic	-1.405323	0.0800	-2.124235	0.0168

Between Dimension	Statistics	Probability
Group, PP-Statistic	-0.679307	0.2485
Group, ADF-Statistic	-2.549327	0.0054

Kao Test (ADF)	
T-Statistic	Probability
-2.619363	0.0044

Model 5				
Within Dimension	Statistics	Probability	Weighted Statistics	Probability
Panel, PP-Statistic	-2.762566	0.0029	-2.832039	0.0023
Panel, ADF-Statistic	-3.329037	0.0004	-2.732168	0.0031

Between Dimension	Statistics	Probability
Group, PP-Statistic	-2.662500	0.0039
Group, ADF-Statistic	-2.819399	0.0024

Kao Test (ADF)	
T-Statistic	Probability
-1.860151	0.0314

5.3 Fully Modified OLS

For long run elasticity's FM, OLS technique is used. According to table 3(a) model 1, RGDP (real gross domestic product) rise 0.389% owing to 1% grow in C (capital), RGDP rise 0.329% owing to 1% grow in L (labor), RGDP rise 0.552% owing to 1% grow in total energy consumption, RGDP decline 0.093% owing to 1% grow in financial development, RGDP rise 0.123% owing to 1% grow in trade openness.

According to table 3(a) model 2, RGDP rise 0.323% owing to 1% grow in C, RGDP rise 0.331 % owing to 1% grow in L, RGDP rise 0.313% owing to 1% grow in electricity consumption, RGDP decline 0.093% owing to 1% grow in financial development, RGDP rise 0.232% owing to 1% grow in trade openness.

According to table 3(a) model 3, RGDP rise 0.390% owing to 1% grow in C, RGDP rise 0.630 % owing to 1% grow in L, RGDP rise 0.288% owing to 1% grow in petroleum consumption, RGDP decline 0.134% owing to 1% grow in financial development, RGDP rise 0.203% owing to 1% grow in trade openness.

According to table 3(a) model 4, RGDP rise 0.378% owing to 1% grow in C, RGDP rise 0.655 % owing to 1% grow in L, RGDP rise 0.265% owing to 1% grow in renewable energy consumption, RGDP decline 0.029% owing to 1% grow in financial development, RGDP rise 0.195% owing to 1% grow in trade openness.

According to table 3(a) model 5, RGDP rise 0.404% owing to 1% grow in C, RGDP rise 0.792 % owing to 1% grow in L, RGDP rise 0.035% owing to 1% grow in coal consumption, RGDP decline 0.111% owing to 1% grow in financial development, RGDP rise 0.350% owing to 1% grow in trade openness.

According to table 3(b) model 1, CO_2E rise 1.649% owing to 1% grow in RGDP, CO_2E (carbon dioxide emissions) decrease 0.030% owing to 1% grow in $RGDP^s$ (real gross domestic product square), CO_2E rise 1.091% owing to 1% grow in total energy consumption, CO_2E rise 0.061% owing to 1% grow in financial development, CO_2E rise 0.079% owing to 1% grow in trade openness.

According to table 3(b) model 2, CO_2E rise 1.814% owing to 1% grow in RGDP, CO_2E decrease 0.021% owing to 1% grow in $RGDP^s$, CO_2E rise 0.479% owing to 1% grow in electricity consumption, CO_2E rise 0.103% owing to 1% grow in financial development, CO_2E decrease 0.136% owing to 1% grow in trade openness.

According to table 3(b) model 3, CO_2E rise 2.540% owing to 1% grow in RGDP, CO_2E decrease 0.041% owing to 1% grow in $RGDP^s$, CO_2E rise 0.596% owing to 1% grow in petroleum consumption, CO_2E decrease 0.001% owing to 1% grow in financial development, CO_2E rise 0.404% owing to 1% grow in trade openness.

According to table 3(b) model 4, CO_2E rise 4.140% owing to 1% grow in RGDP, CO_2E decrease 0.068% owing to 1% grow in $RGDP^s$, CO_2E rise 0.224% owing to 1% grow in renewable energy consumption, CO_2E rise 0.001% (insignificant) owing to 1% grow in financial development, CO_2E rise 0.589% owing to 1% grow in openness (trade).

According to table 3(b) model 5, CO_2E rise 4.271% owing to 1% grow in RGDP, CO_2E decrease 0.065% owing to 1% grow in $RGDP^s$, CO_2E rise 0.017% (insignificant) owing to 1% grow in coal consumption, CO_2E rise 0.005% (insignificant) owing to 1% grow in financial sector, CO_2E rise 0.137% (insignificant) owing to 1% grow in openness (trade).

All the results of this study are empirically and theoretically acceptable. The sign of energy consumption on economic growth and CO_2E is expected to be positive, results also support positive sign. Financial development sign can be positive or negative depends on investment decisions, if investment decisions have asymmetric information then sign of financial development would be negative on economic growth. Findings also prove that development in financial sector negatively impact on economic growth, empirically (Loaayza and Ranciere, 2004) also verify that development in financial sector negatively impact on economic growth.

Theoretical and experimental verification express that coefficient of financial development can be positive or negative on CO_2E. Development of financial sector can provide higher level of financing at a very low level of costs, this facility also provide for environmental projects. These kinds of projects have much importance for government in both private and public sector. Government also encourage private sector to invest in environmental projects for reduce CO_2E. Development in financial sector can increase environment performance as said by Claessens and Feijen (2007). In developing nations laws and regulatory authority forces firms to decrease CO_2E or improve environment performance (Dasgupta et al, 2001). Some other writers such as (List and Co, 2000; Soysa and Neumayer, 2004) also conclude that coefficient of financial development on CO_2E is negative. Zhang (2011) concludes that coefficient of financial development on CO_2E is positive by reason of inefficient distribution of financial resources to enterprises. Some other writers such as (Cole and Elliot,2005 ; Feridun,2006) also conclude that that coefficient of financial development on CO_2E is positive.

Sign of Trade openness may also be positive or negative as "Hecksher Ohlin theory postulates that under free trade, developing countries (mostly middle and low income countries) would focus on the production of goods that are rigorous in factors in which they have a comparative advantage, such as labor and natural resources". Thus, trade causes the movement of goods produced in one country for either consumption or further processing. More consumption of goods and further processing of goods, which takes place due to greater trade openness, is a source of pollution. Hence, "the H-O theory actually perceives that pollution is stimulated from further processing and manufacturing of goods, which results from greater trade openness".

Jalil and Feridun (2011) conclude that trade openness has + impact on emissions; Grossman and Krueger (1995) also conclude that dirty industry in developing nations is a cause of pollution. The indication (sign) of trade openness on emissions (CO_2) can be negative; the reason behind this is that, "due to trade openness any nation can reach international market which enhances the market share among countries" (Shahbaz e al, 2012). Due to competition, nations will use scarce resources for efficiency and import cleaning technology for lower CO_2E (Runge, 1994; Helpman, 1998).

Table 3(a) Fully Modified OLS Results for Effect of Disaggregated Energy on Growth

Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Capital	0.389*** (10.101)	0.323*** (7.101)	0.390*** (8.138)	0.378*** (7.891)	0.404*** (7.851)
Labor	0.329*** (3.004)	0.331** (2.585)	0.630*** (5.688)	0.655*** (6.363)	0.792*** (7.098)
T Energy	0.552*** (7.371)				
Electricity		0.313*** (5.792)			
Petrol			0.288*** (3.971)		
Renew				0.265*** (5.033)	
Coal					0.035** (2.149)
FD	-0.093*** (-3.150)	-0.093*** (-2.897)	-0.134*** (-3.707)	-0.029 (-0.781)	-0.113*** (-2.943)
TO	0.123** (2.239)	0.232*** (4.090)	0.203*** (3.096)	0.195*** (3.094)	0.350*** (5.121)

Note: in brackets, T Statistics

*** P<0.01, ** P<0.05, * P<0.10

Table 3(b) Fully Modified OLS Results for Effect of Disaggregated Energy on Environment

Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
GDP	1.649*** (4.506)	1.814*** (7.222)	2.540*** (5.990)	4.140*** (7.428)	4.271*** (4.617)
GDPS	-0.030*** (-4.456)	-0.021*** (-4.580)	-0.041*** (-5.357)	-0.068*** (-6.311)	-0.065*** (-3.763)
T Energy	1.091*** (15.817)				
Electricity		0.479*** (12.301)			
Petrol			0.596*** (8.621)		
Renew				0.224*** (3.177)	
Coal					0.017 (0.694)
FD	0.061*** (2.633)	0.103*** (3.979)	-0.001* (-1.761)	0.001 (0.924)	0.005 (0.104)
TO	0.079* (1.731)	-0.136*** (-5.216)	0.404*** (3.935)	0.589*** (4.196)	0.137 (1.346)

Note: in brackets, T Statistics

*** P<0.01, ** P<0.05, * P<0.10

5.4 Panel Causality

According to table 4(a) short run dynamics illustrate that bidirectional causal affiliation found between electricity consumption and economic growth, petroleum use and economic growth. Unidirectional causal connection found between renewable energy consumption to economic growth, coal consumption to economic growth and total energy consumption to economic growth. ECT (Error, correction term) shows adjustment speed it (speed of time, in which deviations will remove) and also tells long run causality. According to table 4(a) long run relationship also exist.

According to table 4(b) bidirectional causal affiliation establish between total energy consumption and CO_2E, and petroleum use and CO_2E. Unidirectional causal connection found between electricity consumption to CO_2E, renewable energy consumption to CO_2E and coal consumption to emissions. ECT also confirms long run causal relationship.

Table 4(a) Panel Causality Results for Effect of Disaggregated Energy on Growth

Model 1	Short run						Long run
Dependent variables	Δ GDP	Δ TEnergy	Δ Capital	Δ Labor	ΔFD	ΔTO	ΔECT
Δ GDP	-	0.57***	0.17**	0.18*	-0.15*	0.22**	-0.03***
Δ TEnergy	1.727	-	0.30*	0.31	0.26**	0.38*	-0.01***
Model 2	Short run						Long run
Dependent variables	Δ GDP	Δ Elec	Δ Capital	Δ Labor	ΔFD	ΔTO	ΔECT
Δ GDP	-	0.31***	0.51***	0.09*	-0.53***	0.45***	-0.03***
Δ Elec	3.15***	-	-1.62*	-0.29	1.67***	-1.44***	-0.01***
Model 3	Short run						Long run
Dependent variables	Δ GDP	Δ Petrol	Δ Capital	Δ Labor	ΔFD	ΔTO	ΔECT
Δ GDP	-	0.24*	0.81***	0.02*	-0.20***	0.20***	-0.08*
Δ Petrol	12.30***	-	10.05***	0.36	2.54***	2.46***	-0.01*
Model 4	Short run						Long run
Dependent variables	Δ GDP	Δ Renew	Δ Capital	Δ Labor	ΔFD	ΔTO	ΔECT
Δ GDP	-	0.32***	0.30	0.35**	-0.06*	0.01*	-0.04***
Δ Renew	16.02	-	22.29**	7.52	1.38	2.19*	-0.01***
Model 5	Short run						Long run
Dependent variables	Δ GDP	Δ Coal	Δ Capital	Δ Labor	ΔFD	ΔTO	ΔECT
Δ GDP	-	0.01*	0.93***	-0.07*	-0.19***	0.06	-0.03**
Δ Coal	7.53		1.49*	5.51	1.94	2.72*	-0.01***

Note: ECT represents error correction term, * significant at 10%, ** significant at 5%, *** significant at 10%.

Table 4(b) Panel Causality Results for Effect of Disaggregated Energy on Environment

Model 1	Short run						Long run
Dependent variables	Δ CO2	Δ TEnergy	Δ GDP	Δ GDPS	Δ FD	Δ TO	ΔECT
Δ CO2	-	0.96***	3.02***	-0.06***	0.22***	0.03	-0.08**
Δ TEnergy	0.74**		2.82**	-0.06*	0.08	0.35*	-0.03***
Model 2	Short run						Long run
Dependent variables	Δ CO2	Δ Elec	Δ GDP	Δ GDPS	Δ FD	Δ TO	ΔECT
Δ CO2	-	1.49*	18.22**	-0.31**	1.91**	-1.91**	-0.01***
Δ Elec	1.42		24.6***	-0.46***	1.095*	1.41**	-0.01***
Model 3	Short run						Long run
Dependent variables	Δ CO2	Δ Petrol	Δ GDP	Δ GDPS	Δ FD	Δ TO	ΔECT
Δ CO2	-	0.84***	7.19***	-0.13***	-0.32***	0.33**	-0.04***
Δ Petrol	2.26***		-16.29***	0.30***	0.72***	0.76***	-0.02***
Model 4	Short run						Long run
Dependent variables	Δ CO2	Δ Renew	Δ GDP	Δ GDPS	Δ FD	Δ TO	ΔECT
Δ CO2	-	0.50***	11.8***	-0.20***	0.75***	0.32*	-0.02***
Δ Renew	2.46		12.20*	-0.28**	0.85*	0.19	-0.01***
Model 1	Short run						Long run
Dependent variables	Δ CO2	Δ Coal	Δ GDP	Δ GDPS	Δ FD	Δ TO	ΔECT
Δ CO2		0.33*	3.94***	-0.07**	0.07*	0.62	-0.01***
Δ Coal	3.02		11.92**	-0.22**	0.22	1.89*	-0.01**

Note: ECT represents error correction term, * significant at 10%, ** significant at 5%, *** significant at 10%.

CHAPTER 6

Conclusion, and Policy Implications

An extensive literature has been done on energy consumption and economic growth, energy consumption and environment. Previous studies mostly use total energy consumption. This study uses disaggregated data of energy consumption for find affiliation between various types of energy sources, economic growth and environment.

Results of Panel Cointegration shows, long run affiliation (connection) between variables. FM, OLS confirms that all forms of disaggregate energy consumption have positive, and significant impact on economic growth. Results also explain that all forms of disaggregate energy consumption have positive and significant impact on CO_2E (except coal consumption). EK curve hypothesis also survive (exist) in all models, which shows that economic growth is a solution for environment rather than a problem.

Panel causality through VECM elaborate that bidirectional causal connection found between electricity consumption and economic growth, petroleum consumption and economic growth, total energy consumption and CO_2E, and petroleum consumption and CO_2E. Unidirectional causal affiliation found renewable consumption of energy to economic growth, coal consumption to economic growth, and total energy consumption to economic growth, electricity consumption to CO_2E, renewable energy consumption to CO_2E and coal consumption to CO_2E. Error correction term shows that deviations will remove with specific speed of adjustment.

Long run judgments (from results) have beneficial policy implications for, private and public sector investors of energy production. Empirical results also highlighted disaggregate energy sectors, in which economic growth and sustainable development can be achieved. Demand strategies from various forms of energy consumption can also be achieved.

Bidirectional causal link between electricity consumption and economic growth, petroleum consumption and economic growth, unidirectional causal connection renewable EC to economic growth, coal consumption to economic growth, total energy consumption to economic growth, tells that any energy conservation policy (for, environment safety) may dangerous for economic growth. On other hand, bidirectional causal affiliation among total energy consumption and CO_2E, and petroleum consumption and CO_2E, unidirectional causal relation electricity consumption to CO_2E, renewable energy consumption to CO_2E and coal consumption to CO_2E explains that consumption of energy increase economic growth but also pollute environment. Need to adopt sustainable development policy according to empirical results which increase economic growth and keep environment level at sustainable level.

According to empirical results government needs to promote renewable energy sector because its increase economic growth and its impact on environment degradation is low as compare to other sectors. Investment in renewable energy sector is beneficial for private and public sector. For this purpose cost and benefit analysis, of various forms of energy sector needs to be adopt.

Limitations of this study are that some other forms of energy consumption data are not available for all countries.

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