Environmental Kuznets Curve and Decomposition analysis of CO_2 emissions: Empirical evidence from Pakistan

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CERTIFICATE

This is to certify that this thesis entitled: **"Environmental Kuznets Curve and Decomposition analysis of CO_2 emission: Empirical evidence from Pakistan"** submitted by Mr. Muhammad Saqib is accepted in its present form by the Department of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree of **Master of Philosophy in Economics**.

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Abstract

Over the last few decades, the share of Carbon emissions shows increasing trend in the total greenhouse gases which led to climate changes across the globe and particularly in Pakistan. The purpose of this thesis is threefold: i) to explore the trend of carbon emission in Pakistan with reference to historical policy changes especially environmental policies; ii) to empirically examine the Environmental Kuznets Curve (EKC) hypothesis using ARDL Bound testing approach for Pakistan over the period 1970-2015; and iii) to decompose the carbon emissions into its driving factors over the period 1970-2013 by using LMDI method. The results have shown that there exist an EKC in the long run as well as in the short run for Pakistan. The decomposition analysis suggests that population effect and economic growth effect are the major factors towards the positive changes in CO_2 emissions in Pakistan. In addition, energy intensity has negative impact on CO_2 emissions. The analysis reveals that increase in the use of renewable energy source is best strategy to achieve sustainable economic development in Pakistan.

Chapter 1

Introduction

1.1 Background

The remarkable progress of human civilization in 20th century is driven by the scientific and technological advances. There is a rapid increase in the extraction of natural reserves like materials, minerals, fossil fuels and biomass. This expansion in consumption of natural resources has created serious concerns. The global climate has been changing at much higher rate than the natural variability. This human-induced global climate change has adverse impacts on economic sectors, particularly in countries situated at lower latitudes and subtropics/tropics. Many countries are now well aware that sustainable economic growth requires a reduction in resource use, while human welfare stresses that there should be increase in economic activities but the impact of these activities on environment must be lessen.

There is a global agreement on climate change known as Kyoto protocol extends the 1992 United Nations framework convention on climate change (UNFCCC). The 5th assessment report of Intergovernmental panel on climate change (IPCC), states that the human activity, especially, use of fossil fuels to fulfil energy requirements has disturbed the environment of the world and the side effects of these activities will have to be bear by the whole world[1].

The purpose of the negotiations between the countries of the world in 21st annual meeting of United Nations Framework Convention on Climate Change (UNFCCC) is

[1] Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., ... & Dubash, N. K. (2014). *Climate change 2014: synthesis Report. Contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change* (p. 151). IPCC.

to set an agreement between countries of the world to control the greenhouse gas (GHG) emissions up to a level where temperature of the world could not exceed 2^{o} (Pre-industrial level).

According to 5th Assessment Report from the IPCC, the impact of activities by the human on the environment system is evident (IPCC, 2013). The energy consumption is the main factor among these human activities which is generating greenhouse gases and causing carbon emissions to increase. Increasing use of fossil fuel leads to GHG concentration which in turns leads to greenhouse effect and global warming. Since GHG emissions are considered negative externalities, the countries which are responsible for extreme GHG concentration impose external costs to other countries. Developing countries are more at risk because they cannot bear the costs of disasters and damages. It is noted that CO_2 emissions are the main contributor (60%) among all the greenhouse gases (Khan et al. 2004).

Being the integral part of economic development, a higher economic growth requires a huge amount of energy consumption (Siddiqui, 2004). Increasing energy consumption from non-renewable sources is one of a key contributor in the environmental degradation. Increase in energy consumption is causing environmental issues by producing energy-related CO_2 emissions. Increase in energy consumption due to rise in production and consumption cause significant increase in related CO_2 emissions.

1.2 Motivation and Problem Statement

Although, Pakistan has less contribution towards the global carbon emissions such as 0.8 percent and is ranked at 135th amongst all the countries while estimating the share in global emissions, but is facing extremely large consequences of climatic change. It is estimated that Environmental degradation costs about 6% of GDP annually for Pakistan economy, and is considered as the 12th most vulnerable country of the world that will have to bear large consequences of climate change (Khan, et al. 2004). The presence of high particulate materials in the air is a serious problem in most of the urban areas of Pakistan. The environmental quality is decreasing due to combustion of fossil fuels and increased motorization.

In recent years, Pakistan has experienced energy shortages to meet its energy demand. So Pakistan can be an interesting case study as it is facing energy issues. There is a need to study the relationship between energy use and economic growth for Pakistan. Moreover, direction of causal relationship between energy use and economic growth is also important in making of energy policies. If the causal relationship is such that energy consumption increases due to expansion in economic growth, then the policies should be design to save energy and as a result decrease in carbon emissions. But if the causal relationship is such that energy use causes economic growth then energy saving policies may have negative impact on economic growth.

Previous literature has been established to identify the relationship between carbon emissions and per capita income. Many studies have suggested that environmental pollution and economic growth exhibit an inverted u-shaped relationship. Such kind of relationship has also been referred to as the Environmental Kuznets Curve (EKC). According Environmental Kuznets Curve hypothesis, pollution increases faster than income growth in initial stages of economic development as people are more concern with their income and jobs, and give less value to the environment. Pollution declines at the later stage of growth after reaching to a turning point, as people start to give value to their environment. In order to identify the nature of environmental problems, some recent studies have also used the decomposition approach to investigate the factors responsible for changes in total CO_2 emissions.

Various questions emerge from this discussion: i) whether there exists an Environmental Kuznets curve for Pakistan; ii) can energy efficiency be helpful in reducing energy intensity?; and iii) whether structural change in the economy from agriculture to industry and services affects emissions levels?. This thesis tries to answer these questions.

1.3 Objectives of the thesis

The whole objective of this thesis is to test the existence of Environmental Kuznets Curve (EKC) and decompose the CO_2 emission into its driving factors. More specifically, we have following objectives:

i) To explore the trend of carbon emission in Pakistan with reference to historical policy changes especially environmental policies;

ii) To examine the Environmental Kuznets Curve (EKC) hypothesis using ARDL Bound testing approach for Pakistan over the period 1970-2015;

iii) To decompose the carbon emission into its driving factors using log mean divisia index (LMDI) method.

1.4 Contribution of the thesis

This study will add value into the existing literature by adding a financial development variable in EKC analysis to check its impact on total carbon emissions in Pakistan. The study will also decompose the aggregate energy-related CO_2 emissions into its different driving factors for the period 1980-2013. Previous studies are based on period wise decomposition for the case of Pakistan. For example, Attari,et al. (2011) and Khan and Jamil (2015) both studies are based on fixed base year decomposition technique. This study will use time series decomposition analysis to explore the trend of CO_2 emissions. Moreover, the current study will also incorporate the role of renewables in decomposition analysis.

1.5 Methodology

This thesis applies ARDL bound testing approach to test the Environmental Kuznets curve (EKC) hypothesis for Pakistan by using data 1970 to 2015. Moreover, in order to find out the contributing factors towards the Carbon Dioxide emissions we will use log mean Divisia index (LMDI) method.

1.6 Organization of the thesis

In this chapter we have come to the point that CO_2 emissions produced by energy consumption are the main reasons of environmental degradation. Now we want to explore this specific idea in context of Pakistan and our objective is to find out the factors responsible for changes towards the overall level of CO_2 emissions. In chapter 2 we will present the literature review about the EKC hypothesis in first section and next section will detail the literature review of decomposition analysis. Chapter 3 will present a graphical situation of CO_2 emissions in Pakistan, Furthermore; we will also discuss the national environmental policies adopted to control environmental issues in the different time periods in Pakistan. Chapter 4 is consisted of model specification and data sources for EKC analysis and decomposition analysis. Empirical results and discussions are presented in chapter 5. Concluding remarks and suggestions are given in chapter 6.

Chapter 2

Literature review

2.1. Introduction

In recent decade, the link between environment and economic growth has been receiving increasing attention of researchers, and a comprehensive literature on the relationship between environmental degradation and per capita income has been established. All of the studies are at the same point of view that environmental pressure increases in the initial stage of economic growth and slows down at advanced stage as an economy grows. This type of relationship is called "Environmental Kuznet curve" (EKC). According to EKC, there exists an inverted-U relationship between economic growth and environmental quality.

Pollution increases with higher rate in the beginning of industrialization because of much greater use of natural resources, people are more concern with their jobs and incomes and give less priority to their clean environment (Dasgupta et al., 2002). People start to give value to their environment in the later stage of industrialization as their incomes grow with expansion in the economy and emissions level declines. The basic motivation in empirical studies on EKC has been to find out whether increase in economic growth cause environmental problems or it is a solution to environmental issues. Most of the researchers argue that economic growth leads to environmental degradation, however it may improve the environmental quality (Beckerman, 1992) and in developing nations economic growth can be a useful tool to enhance environmental quality (Panayotou,1993).

According to Dinda (2004) as economy grow the output increases with more use of natural resources; wastes and emissions level go up as by-product and environmental quality declines. So, scale effect has adverse effect on environmental quality in the early stage of economic development. However, as income raises, the economy starts to change its structure from industry to service (composition effect) and gradually increases the production of cleaner activities that are less pollutant. Finally, economy moves towards service and technology intensive industry from energy intensive, spending on research and development (R&D) increases and dirty technologies are replaced by new environment friendly technology (technological effect). According to EKC hypothesis, the initial negative impact of scale effect on environment will be outweighed by positive impacts of the composition and technological effects that tend to improve environmental quality.

2.2. Existence of EKC: Empirical Evidence across the Globe

In early research work on Environmental Kuznets Curve (EKC) theory many researchers tried to investigate the association between carbon emissions and real income (Shafik, 1994; Shafik and Bandyopadhyay, 1992). They found that there exist an increasing positive relationship between CO2 emissions and economic growth. However, Schmalensee, Stoker, and Judson (1998), opposed the above statement and showed that the relationship between CO_2 emissions and economic growth is "inverted-u shaped". Later on according to de Bruyn, van den Bergh, and Opschoor (1998), the "inverted-u-shaped" phenomena was temporary and they found that this relationship end up with N-shaped relationship. Friedl and Getzner (2003) empirically found N-type relationship for a single country. Galeotti and Lanza (2005) also found the same relationship for group of countries.

The Environmental Kuznets Curve theory has been tested by using different variables such as trade openness, economic growth, financial liberalization and energy use to examine their effect on environmental quality. Halicioglu (2009) explained initially the effects of the trade openness on carbon emissions, economic development and energy use.

Tiwari (2011) has argued that commercial energy consumption is essential factor to achieve economic growth for developing nations. Commercial energy use is a vital factor of production function that causes CO_2 emissions to increase. Energy consumption has positive relationship with economic development and CO_2 emissions but has negative impact on population and capital.

Congregado et al (2016) analyse the existence of EKC by applying the methodology proposed by Kejriwal and Perron using data for the period of 1973 to 2015. They allow different activities across time and identify them through economic sector. The outcomes show that there exist EKC in USA only when they allow for structural breaks.

Bozkurt and Akan (2014) study the relationship between economic development, CO_2 emission, and energy use for period 1960-2010 in Turkey. The results suggest that energy consumption has a positive relation with economic growth while carbon emissions have negative effect on economic development.

Narayan and Narayan (2010) explore the relationship between economic development and environmental quality for 43 developing countries by using panel data estimation and time series estimation technique. The results based on individual countries suggest that for Kuwait, Jordan, Iraq, Yemen, Qatar, UAE, Argentina, Venezuela, Algeria, Kenya, Nigeria, Congo, Ghana, and South Africa – CO_2 emissions have been decreasing over time. Furthermore, they also test the EKC hypothesis for panel of countries and found that in long-run CO_2 emissions are low while in the short-run are high..

Shahbaz and Lean (2012) investigated the association between energy use, economic growth, financial liberalization, urbanization and industrial development for period 1971 to 2008 in Tunisia. The ARDL method for co-integration and Granjer causality technique was used for the analysis. The results indicate that there exists a long-run relationship between the variables. Bidirectional long-run causalities were found between energy use and financial liberalization, industrialization and financial growth and energy use and industrial development.

Shahbaz, et al. (2013) studies the dynamic relationship between energy use, economic development and carbon emissions in Romania for 1980-2010. ARDL bound testing approach was used to test long run cointegration among variables. The results reveal that there exists a long run association among variables. In addition, EKC was also found for both the long run and short run period.

Tiwari et al. (2013) investigate the relationship between coal consumption, trade openness, economic development and CO_2 emissions for 1966-2009 in India. The results suggest that EKC exist both in the long run and in the short run. Trade openness and coal use effect the CO_2 emissions. In addition, trade openness Granjer cause coal use, economic development and carbon emissions.

Seetanah and Vinesh (2010) analyse the association between economic development and carbon emissions for Mauritius. They apply rigorous econometric regression and found that carbon emissions are closely related to economic development, however they were unable to find turning point of EKC and thus no EKC "U" shape was found.

Ang (2008) explore the relationship between economic output, CO_2 emissions and energy use in Malasia for period 1971-1999. The findings of the paper indicate that in the long run pollution and energy use have positive relation with economic growth. Furthermore, economic development cause energy use both in long run as well as in short run.

Soytas et al. (2007) explore the influence of energy use and economic development on carbon emissions in USA. They found that economic growth does not Granjer cause carbon emissions in long run for USA, however energy consumption does.

2.3. Decomposition Analysis: Review of Methodologies

Energy consumption being an important factor for economic growth, consequently leads to increase carbon emissions. The decomposition analysis is a very useful tool that is used to study the reasons for changes in CO_2 emissions. There are basically two types of indices that are being employed in decomposition analysis (a) Laspeyers index (b) Divisia index, both indices have been used in the past studies depending on the nature of the data. In addition, further extensions have also been made in these indices, the log mean divisia index (LMDI) is one of these extensions and has been used in many recent studies. According to Ang (2005) LMDI approach is preferable to all other existing decomposition approaches due to its unique property of handling zero values in the data, using energy consumption data on disaggregated level it is possible to have zero values in the data, LMDI handle this situation by putting small values in place of zero values (Ang and Liu, 2005), before 2005 all other techniques were unable to handle zero values in the data. Moreover, LMDI I called "perfect decomposition" because of zero residuals in this technique. Many studies suggest that Lespyer index is not suitable in case of developing nation (Ang and Liu, 2007) because this method has residuals that may also be significant.

Previous literature has focused on identifying the factors responsible for changes in total CO_2 emissions and most of the studies have concluded that economic activity effect and energy intensity effects are the main contributor factors towards the changes in overall CO_2 emissions (see for example, Nasab et al., 2012; akbostanci et al., 2009; sun et al., 2012; Alves and Mouthinho, 2013).

Lise (2006) decomposes the carbon emissions for the period of 1980-2003 in Turkey. The decomposition analysis used Refined Lasperes index method and found that development of the economy (the scale effect) is the largest factor that increases the carbon emissions. Moreover, change in the structure of the economy toward industrialization and carbon intensity also increases the carbon emissions level.

Wang, et al. (2011) calculated energy-related carbon emissions over the period 1995-2009 for China's province (Guangdong). They used log mean divisis index (LMDI) approach and showed that economic output and energy intensity are the main effects contributing towards energy-related CO_2 emissions.

Mahony (2013) explore the trend of CO_2 emissions over the period 1990-2010 for Ireland's economy. He employed the log mean divisia index 1 (LMDI1) technique in his analysis and results illustrate that affluence and population effects are the main contributor to CO_2 emissions, renewables has a little impact but it has grown in previous few years.

Paul and Bhattacharya (2004) decompose the carbon emissions form energy use in India for 1980-1996. They used complete decomposition method and results indicate that economic development is the key factor that bring changes in emissions level, energy efficiency and fuel substituting have decline the CO_2 emissions.

Pardo, et al. (2012) decomposes the energy consumption and CO_2 emissions for 1990-2008 in Mexican manufacturing industry. They apply additive log mean divisia index and found that structural and intensity changes play a significant role in increase of CO_2 emissions.

Nasab, et al. (2012) study the trend of carbon emissions of Iranian industrial and transport sector and results indicate that activity effect and intensity effect largely contribute to overall CO_2 emissions, while to some extent structural effect also contribute to the changes in carbon emissions.

Alves and Moutinho (2013) explore the trend of carbon emissions intensity over 1996-2009 in Portuguese industrial sector. They apply complete decomposition for the analysis and found that energy intensity is the most key determinant of the Carbon emissions intensity.

Mazur, et al. (2015) explore the link between CO2 emissions and economic progress for the period 1990-2010, used panel data on European union countries. Both the random effect and fixed effects are used to test the Environmental Kuznets Curve theory. The outcomes confirm that there is no U-shaped Environmental Kuznets curve in all 28 EU member state. The graphical analysis shows that there is turning point between CO2 emissions and income per capita reaches at 23,000 USD.

Xiao, et al. (2016) explore the main factors of Carbon emissions for China by using the structural decomposition method. They divide the forces both at national level and Industrial level into nine effects. Further, nine effects were divided into three types of fossil fuels energy use. The results confirm that the energy intensity effect has negative impact on carbon emissions. The change in the structure of energy sector is slow and the trend of the structural change shows that economy is shifting towards low carbon energy sector.

2.4. EKC and Pakistan

A little work has been done on EKC in Pakistan, for example, Ahmad and Long (2012) applied ARDL approach for the period of 1971-2008 and find out that there exists a Environmental Kuznets curve in long run for Pakistan.

Munir and Khan (2014) investigate the link between fossil fuel energy use and CO_2 emissions by using Granjer causality method. She concludes that energy consumption negatively affects the CO_2 emissions and there exists EKC. Furthermore, trade openness positively affects the carbon emissions while financial development reduces Carbon emissions.

Nasir and Rehman (2011) examined the EKC hypothesis by applying Johanson maximum likely hood method for the period 1978-2012, and found that EKC exist for Pakistan in long-run. In addition, energy use and trade openness also have impact on carbon emissions.

Shahbaz, et al. (2012) studies the association between CO_2 emissions, energy use, economic development and trade liberalization for the period of 1971-2009. The results suggest that there is a long run relationship between the variables and EKC hypothesis is valid for Pakistan.

Azhar, et al. (2007) used Johanson-Juselius cointegration method to test for long run relationship for the period 1971-2002, and found that there is a cointegrating vector, showing a effective long run relationship between the trade openness and environmental quality.

Haseeb and Azam (2015) explore the association between energy use, economic development, and carbon emissions for 1975-2013. They used Johansen cointegration and vector error correction method and the results indicate that there exist a long run relationship among economic progress, energy use and CO_2 emissions.

Amjad, et al. (2015) studies the relationship between carbon emissions, energy use, and economic development for the period 190-2012. They used Johansen cointegration approach for the analysis and conclude that EKC for the case of Pakistan is only valid for the long run but it does not hold in the short run. In addition, unidirectional causality exists from energy usage to CO_2 emissions.

Hussain and Ali (2016) empirically test the impact of economic growth, energy usage and trade openness on carbon emission in Pakistan for the period of 1980 -2015. They used Johanson co-integration technique and the results indicate that there exist EKC in long-run for Pakistan. The results also reveal that energy usage and trade openness have positive effect on CO_2 emissions.

The existing literature shows that financial development is yet not being incorporated in EKC empirical analysis in Pakistan. Financial development plays an important role in developing countries and is considered an important factor which brings changes in carbon emissions in different ways. So in this study we will try to add value to the existing literature by incorporating the financial development sector into the EKC analysis.

2.5. Decomposition Analysis in Pakistan

There are only two studies on decomposition analysis of carbon emissions for the case of Pakistan due to data limitations.

Attari, et al. (2011) analyse the impact of carbon emission on economic development by constructing the regional analysis of Pakistan, India and China. They applied decomposition analysis and provide the detail information regarding the carbon emissions.

Khan and Jamil (2015) study the energy related carbon emissions trend for the period of 1990-2012 in Pakistan. They used LMDI method and results show that activity effect, structural effect and intensity effects are three main factors responsible for changes in emissions; however activity effect is the largest contributor.

These two previous studies are based on fixed base year decomposition technique. So there is a need to explore the CO_2 emissions trend by using time series decomposition technique to get complete information through the historical background.

2.6 Conclusion

Most of the previous studies suggest that there exists a association between CO_2 emissions and economic development; however, there exist a contradiction about the shape of the relationship between these variables, and some researchers empirically found U-shape while others have suggested N-shape relationship. It has been argued that developed countries tend to have N-shape relationship while developing nations U-shape relationship. The role of the financial sector in EKC analysis for Pakistan is missing in the literature.

The decomposition literature suggests that activity effect and energy intensity effects are the main contributors towards the changes in carbon emissions. In next chapter we will graphically examine the trend of CO_2 emissions and will also discuss the national environmental policies in order to understand the situation of CO_2 emissions in Pakistan.

Chapter 3

Trend Analysis

3.1. Introduction

Energy is vital to different sectors of an economy and is essential requirement for any nation that wants to develop its economy and improve living standards of its people. Energy demand increases as the economy comes out from poverty resulted from increase in income level. Since the supply of energy resources are becoming less secure due to volatility in prices the lowest cost energy resources are becoming important. Earlier coal was the cheapest source of energy but now days is being considered the most climate risky one. Therefore, many countries are trying to find low-cost gas as alternative to coal. Innovations are taking place in renewables energy and there is rapid increase in renewable energy sources but fossil fuels still are the dominant sources of energy around the globe. The economies are shifting towards renewable resources due to global warming effect caused by CO_2 emissions.

Pakistan being a populous country in the world has been ranked at sixth position. Pakistan fulfils its most of the energy requirement through oil and gas resources. Domestic production of oil is not enough to meet its energy demand as a result Pakistan has to import large amount of oil from Middle-east countries.

The main users of oil are transport and power sector. During the fiscal year 2015, the share of oil consumption in transport sector and power sector has increased by 50% and 42% respectively that was 49% in transport sector and 40% in power sector during fiscal year 2012. During the fiscal year 2016, these share remained 55%and 35% respectively for transport sector and power sector. The increase in the share of oil in transport sector is due to decline in oil prices while decrease in the share of oil in power sector is due to the shift of oil by a cheaper source gas in this sector.

In 2013-14, industrial sector consumed 34.6% and transport sector consumed 32.5% energy share from total energy consumption. Agriculture products are the major exports of Pakistan. Agricultural products are considered less CO_2 emitter than those of industrial goods. Agriculture sector is considered less harmful to the environment as compare to industrial sector. However, a significant rise in the share of energy consumption in industrial sector over the years has increased the level of CO_2 emissions in Pakistan. Furthermore, Pakistan imports such products which are considered highly emitting contaminated gases, i.e. fertilizers and other chemicals.

The composition of energy share is changing due to substitution of expensive oil resource with cheaper source gas. However, share of oil has again started to increase due to gas load management.

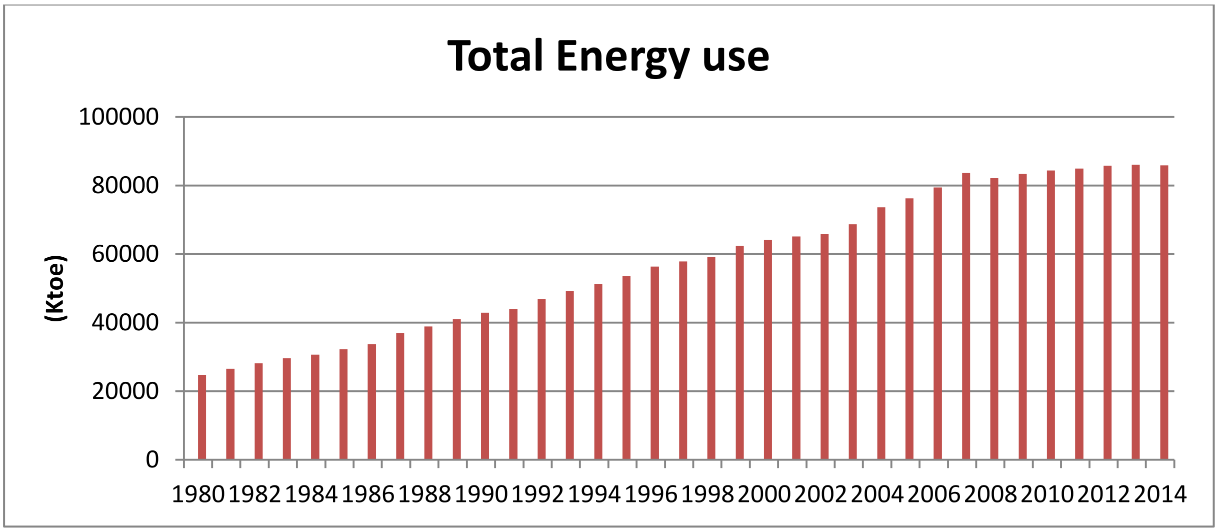
3.2. Trend Analysis of CO_2 emissions

It is argued that sustainable economic development is only achievable through sustainable environment improvement. In 2005, Pakistan introduced an environmental policy to control the emissions level for sustainable economic development. National Environmental Policy (NEP) has the objective to keep the environment clean through sustainable economic expansion for the better life standard of the public. Economic growth in Pakistan has been motivated by all the sectors of the economy comprising industry, agriculture and services. The higher growth rate for the period 2000 to 2006-07 in Pakistan was mainly due to the expansion in industrial sector. This high growth in industry was led by the increase in energy consumption causing environment degradation in the economy. In 2013-2014, industrial sector used 34.6% of total energy used while 32.5% was used by transportation. Although total energy use was down by -0.91% in 2013-14 as compared to the previous year, but the energy use by transport sector was increased by 2.6% in 2013-14.

The increase in share of oil consumption to meet transportation demand since 2003-04 is considered the main reason of CO_2 emissions. The replacement of natural gas for oil in electricity production has increased the portion of gas in total energy use, and now natural gas is the 2^{nd} largest source of emissions. Coal consumption is at number 3, produces more than 50% of CO_2 of gas.

Growing energy demand due to increase in consumption has led to increase in total energy consumption over the last four decades (fig. 3.1). Energy consumption was 39.82 Mtoe in 2014; industrial sector was the main user with 34.6% share followed by transport sector with 32.5% share in total energy consumption (GOP, 2014). Gas and oil were the major primary energy supplier sources with 46.3% and 34.4% shares respectively.

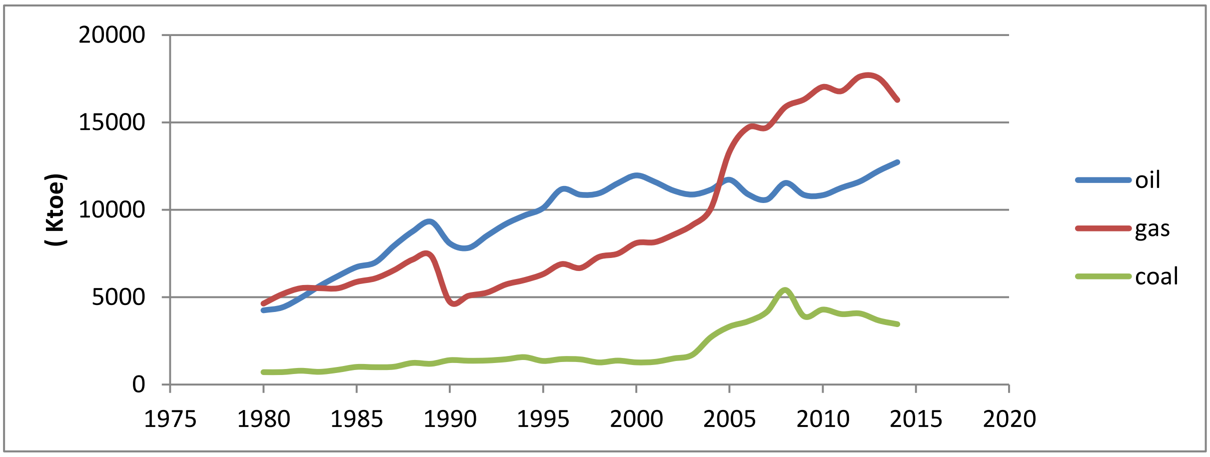
Figure 3.1 Total energy use in Pakistan from 1980-2014.



Data source: World Bank Annual Report on energy (2014)

There are three main sources for energy consumption in Pakistan, oil, gas and coal; the use of gas and coal has increased in last decade (fig.3.2). In 2013-14 the share of gas was 40.9% in total energy consumption and oil was stood at 2^{nd} with 31.9% share and the share of coal was 8.7%. There was a significant decrease in the consumption of oil between the period 2000-01 and 2005-06 due to the increase in price of crude oil since 2001 (GOP,2016). Thus oil being an expensive source for the power sector was substituted with a cheaper source (gas) in that period.

Figure 3.2 Pakistan's energy consumption by fuel type over 1980-2014

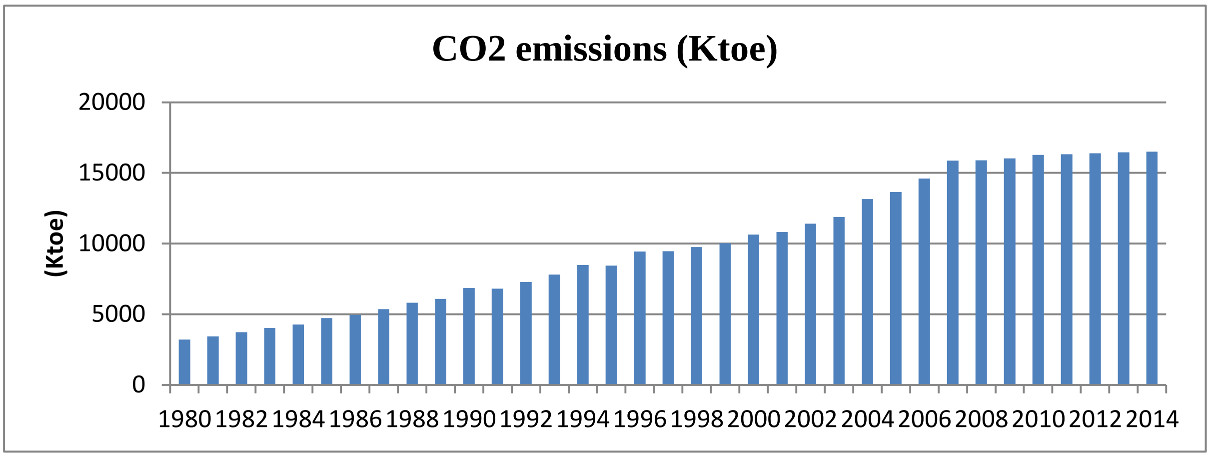


Data source: Annual energy year book of Pakistan (2014)

This increasing trend of energy consumption is causing associated CO_2 emissions to increase (fig.3.3). Carbon emissions are generated due to the use of energy consumption of fossil fuels like coal, gas and oil. CO_2 Emissions were recorded 32 Ktoe in 1980 and increased 413% after 33 years in 2013. The share of natural gas in the total CO_2 emissions has also increased because of the change in fuel mix in the economy during last decade (fig. 3.4). Fossil fuels such as coal and oil are considered more carbon intensive than gas and renewables.[2]

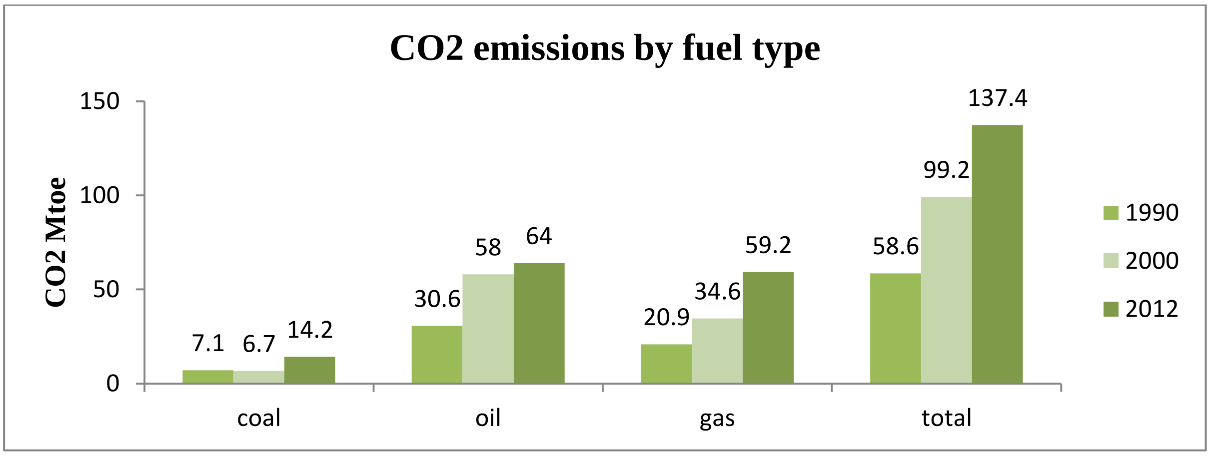
[2] International Energy Agency (IEA), 2001. CO_2 Emissions from Fossil Fuel Combustion (2001 Edition)

Figure 3.3 Total CO_2 emissions for Pakistan over 1980-2014.



Data source: World Bank Annual Report on energy (2014)

Figure 3.4 $\mathbf{CO_2}$ emissions by fuel type in Pakistan for period 1990-2012.



Data Source: World Bank Annual Report on energy (2014)

3.3 National Environment Policy of Pakistan

Pakistan and other developing countries around the world are well aware now about the fact that, rapid economic growth and development put heavy burden on sustainability. There is a global awareness of the world's worsening condition of environment. The growing awareness was a result of understanding the importance of natural resources. Environmental protection is considered the common concern of whole mankind. As a result, thousands of environmental organizations have been established. In Pakistan, Pakistan Environment Protection Council (PEPC) is responsible to secure the living environment and for controlling the pollution.

In past, different policies and strategies have been undertaken by the Government of Pakistan to overcome the environmental problems. A National conservation strategy (NCS) was developed in 1992 after almost a decade of debate and study. The NCS is the environment policy in Pakistan; it explains the environmental condition in Pakistan and suggests policies to overcome environmental issues.

In 1993, Government of Pakistan announced National Environmental Quality Standards (NEQS) for industrial sector to use new environment friendly technologies in production process. It was also applicable to municipal discharge of sewerage.

The National Environmental Action Plan was established in 2001 to follow the National Conservation Plan; it focuses on the four core programs; (1) clean drinking water (2) clean air (3) managing waste material and (4) environment sector management. The United Nations Development program is supportive to this program under the NEAP sporting program (NEAP-SP).

Fast population growth and growing urbanization has led to environmental degradation in the country. Urbanization has impacted the large cities and creating traditional environmental problems such as polluted water and air, etc. These problems called for a sound national environment policy and formulation of national environmental policy (2005-2015) was approved in 2005-06. The purpose of the policy was to improve the country's environment, better living standard of the people, cooperation among civil society, government agencies, and different sectors. Environmental policy 2005-2015 discusses the problems like (1) energy efficiency and renewable resources (2) water management (3) livestock and agriculture (4) forestry (5) climate change, pollution and air quality (6) biodiversity.

Sanitation is one of the basic necessities, which is an essential tool for success in the fight against hunger, poverty, child death, gender inequality and women empowerment. In 2006, Pakistan's sanitation policy was introduced with the objective to provide sufficient sanitation for better living standard of the public.

Water is a critical resource for sustained economic growth in Pakistan, population growth, rapid increase in urbanization and industrialization are putting immense pressure on water resource. During 20th century, Pakistan experienced an expansion in agriculture production which can be termed as "Green revolution" through the development of water resources. In 2010, the formulation of National water policy was an essential requirement in order to optimize the development of both surface and underground water and to improve crop per drop.

The national drinking water policy gives a framework to address the issues facing Pakistan in providing safe and clean water to the people. The aim of this policy is to offer access to safe water at affordable cost in efficient manner and to ensure reduction in morbidity and mortality occurrence caused by the water borne diseases.

National forest policy was introduced in 2015; mitigation and adoptive measures to extreme events are the focus of this policy. The objective of the policy is to restore, develop and maintain the natural forests.

Rangelands play an important role in the livestock as more than 60% of livestock feed is met by rangelands. In Pakistan, more than 60% of total area is covered by rangelands. Rangelands have also a significant impact on the livelihood of large number of poor people by rearing of animals and getting different kinds of products and services. National rangelands policy, 2010 was introduced with the vision to manage potential productivity level, to contribute significantly to the living conditions of the dependent people towards enhancement of livestock in the economy besides preserving ecological system and minimizing the impacts of climate change and loss of biodiversity.

3.4 Conclusion

Over the years, increasing trend of CO_2 emissions in Pakistan is a serious threat to the environment. The use of fossil fuels for energy requirements are the main reason of CO_2 emissions. Although different environment related policies have been adopted in Pakistan in different time periods but still there is lot of work to do about new innovations and policies in renewable sources to overcome the environment problems.

Chapter 4

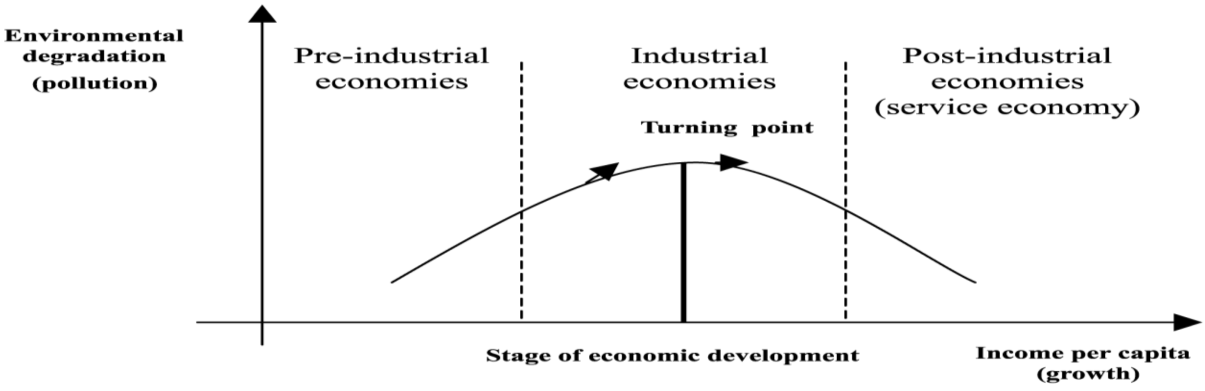
Model specification, Data and Methodology

4.1 Introduction

This chapter consists of data source and methodology used in this study to investigate whether EKC exist for the case of Pakistan. First we will discuss about the methodological process of EKC analysis and the data source for its estimation. In section two, we will briefly compare the different decomposition techniques in order to sort out the best methodology to be used in this study.

4.2 Model specification: EKC

The environmental Kuznets curve theory states that there is a relationship between environmental quality and economic growth. In 1955, Kuznets presented the idea that income inequality first rise with the expansion in the economy and falls in the later stages when development proceeds. Later on the same idea was used in environmental studies where income inequality variable was replaced by environmental degradation indicators such as Carbon emissions. As shown in figure below, environmental degradation tends to increase at pre-industrial stage then reaches to a turning point at industrial level and then it starts to decline when development reaches to service economy. With the development of the economy income of people rise, now they are well aware of environmental degradation and they demand for clean environment.



Source: Panayotou (1993)

In literature most of the researchers have used Carbon emissions as a proxy for environmental degradation. In initial stages, modelling of EKC hypothesis, real income and real income square were the explanatory variables; income per capita square gives the turning point after taking its derivative. Later on some additional explanatory variables were also included such as energy use, trade liberalization, financial expansion and population size. Energy consumption is vital to the development of an economy; as an economy grows it require more energy to be used in different sectors. However, energy use can lead to environmental degradation if it relies on the carbon-intensive resources such as fossil fuels. Environmental degradation tends to decline with the change in the economy from energy intensive sector towards knowledge-based and service sectors. In addition, moving towards less carbon-intensive resources of energy such as wind, solar and biogas can improve the environment condition.

Trade openness causes an expansion in the economy. Economic growth caused by trade openness gives rise to the energy demand, which then is generated by resources that are harmful pollutant. On the other hand, through trade liberalization foreign traders may transfer modern environment friendly technologies to the local economy that can improve the environment conditions. Similarly, financial development may also reduce environment pollutants when the financial resources are directed towards environment friendly projects.

Foreign direct investment can harm the environment in the host country if it has pollution-intensive industries and weak environmental laws. On the other hand, less developed countries can reduce pollution through technology transfer by foreign direct investment Dinda(2004).

Generally, the increase in the energy consumption will result in expansion in the economy and as a result increase in CO_2 emissions, so the relationship between CO_2 emissions and energy use is expected to be positive. The sign of GDP coefficient is likely to be positive under the EKC hypothesis and the coefficient of the turning point is likely to be negative according to the theory. According to Grossman and Krueger (1991), developing nations are more likely to have dirty industries that cause environmental degradation, so the association between trade openness and carbon emissions is normally positive for the case of developing country. Financial development creates the opportunity for developing nations to use new technology and consequently to improve their environmental quality through clean and environment friendly productions. On the other hand financial growth may enhance economic development; it may increase pollution and decrease in environmental quality. So the association between carbon emissions and financial development is ambiguous depends upon the financial development of a country Finally, the sign of coefficient for foreign direct investment is also likely to be positive in developing countries as they tend to have weak environmental laws and allow other developed countries to shift dirty industries in developing nations.

Our study follows closely the methodology of the recent study (Ozturk and Acaravci, 2013). A quadratic equation is defined to examine the long-run relationship among carbon emissions, energy use, economic development, Trade liberalization, foreign direct investment, and financial development in order to analyse the EKC hypothesis in Pakistan.

4.3 Estimation methodology of EKC analysis

Our study is based on time series data; so first we check the stationarity of all variables to be used in this estimation and then decide about a suitable technique to run the regression equation.

Data Stationarity

Augmented dickey fuller unit root test is used to check whether variables are integrated of degree "0" or "1". When all the variables are integrated at the same order then we can apply error correction model for all series. However, when all the series are not integrated at same order then we use ARDL approach to analyse the relationship between variables for long run and short run..

Auto Regressive Distributive Lag technique

ARDL is used on a single equation, and will analyse the short run and long run association among the variables simultaneously. Narayan (2004) said that ARDL method is handy when sample size is small. Johensan and Engel-Granjer techniques are not reliable for small samples.

Bound testing

The bounds test method is constructed by the joint F-statistic or Wald statistic it means calculated to distinguish the long-run association among the variables.

Let suppose we have a functional form

$$\mathrm{CO_2} = f(\mathrm{Y}, \mathrm{Y}^2, \mathrm{E}, \mathrm{TO}, \mathrm{DC}, \mathrm{FDI})$$

And the regression line is

$$CO_2 = a_o + b_1 lnE + b_2 lnY + b_3 lnY^2 + b_4 lnTO + b_5 lnDC + b_6 lnFDI + \varepsilon$$

Now the null Hypothesis for bound testing is

H_0 : b_1= b_2=b_3=b_4=0 (no long run association exist)

and the alternative hypothesis is

H_1 : b_1= b_2=b_3=b_4 ≠0 (long run association exist)

Pesaran et al. (2001) provide critical value bounds, when calculated F-statistic is higher than the upper bound value, we reject null hypothesis, indicating there exists a long run association. If calculated F-statistic is lower than the upper bound value, we are unable to reject the null hypothesis of no long run association.

The functional form and econometric regression line is as follows:

$$CO_2 = f(Y, Y^2, E, TO, DC, FDI)$$

$$CO_2 = a_o + b_1 lnE + b_2 lnY + b_3 lnY^2 + b_4 lnTO + b_5 lnDC + b_6 lnFDI + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

CO_2	CO_2 emissions per capita
E	energy consumption
Y	GDP per capita
Y^2	Square of GDP per capita

TO	Trade openness, measured by the exports (% of GDP) + imports (% of GDP).
DC	domestic credit to private investment
FDI	Foreign direct investment
ε	Error term.

Fundamentally, the ARDL bounds testing technique of cointegration consists of two steps for analysing long-run association. In first step we check for the existence of long run association among all variables in the equation. The ARDL model for Eq. (1) is

$$\mathrm{CO_2} = \alpha_1 + \sum_{g=1}^{a_1} \alpha_{2g}\, \Delta \mathrm{CO}_{t-g} + \sum_{h=0}^{b_1} \alpha_{3h}\, \Delta \mathrm{lnE}_{t-h} + \sum_{i=0}^{c_1} \alpha_{4i}\, \Delta \mathrm{lny}_{t-i} + \sum_{j=0}^{d_1} \alpha_{5j}\, \Delta \mathrm{ln}y^2{}_{t-j}$$

$$+ \sum_{k=0}^{e_1} \alpha_{6k}\, \Delta \mathrm{lnDC}_{t-k} + \sum_{m=0}^{f_1} \alpha_{7m}\, \Delta \mathrm{lnTO}_{t-m} + \sum_{n=0}^{g_1} \alpha_{7n}\, \Delta \mathrm{lnFDI}_{t-n} + \beta_1 \mathrm{CO}_{t-1}$$

$$+ \beta_2 \mathrm{lnE}_{t-1} + \beta_3 \mathrm{lny}_{t-1} + \beta_4 lny^2{}_{t-1} + \beta_5 \mathrm{lnDC}_{t-1} + \beta_6 \mathrm{lnTO}_{t-1}$$

$$+ \beta_7 \mathrm{lnFDI}_{t-1} + \varepsilon_{1t}$$

Δ is the first difference and ε_t is the random error term. This lin-log model will analyse the effect of energy use and economic development on CO_2 emissions. Trade openness, foreign direct investment, and Domestic credit to private investors are also used as independent variables.

The data used in the empirical model of EKC is obtained from the World Bank database 2015. Energy consumption (kg of oil equivalent), CO_2 emissions (metric tons per capita), domestic credit to private investors (% of GDP), Trade openness (% of GDP), GDP per capita and Foreign direct investment (net inflows, BOP) are all in Current US$, calculated at constant market prices.

4.4 Decomposition Analysis

To examine and understand the past changes in economic or environmental indicators, it is helpful to distinct elements behind these changes. Index decomposition analysis is a method that has been developed to decompose the indicator into its different elements at sectoral level. This technique is related to index number problem in economics and statistics. However, it has been widely used in environmental field to decompose changes in aggregate carbon emissions, energy intensity and energy use into its different driving forces to check the relationship between economic development and environment quality. The main application areas of this methodology are energy demand sector and energy supply sector, energy linked GHG emissions, energy efficiency trends and cross country comparisons.

There are two ways to decompose the aggregate indicator: Additive decomposition and Multiplicative decomposition. Additive decomposition is more useful when we are concerned with absolute changes while multiplicative decomposition is handy when relative changes being required. The decomposition is said to be perfect if the sum or product of the considered effects is just equal to the overall observed change in the aggregate indicator. But some of the methods do not satisfy this property and leave an unexplained residual term which makes difficult to interpret the results. Decompositions are carried out in fixed base years manner and time series manner. In fixed base year decomposition all the years between initial period and final period are ignored. This technique is useful when there is few data available. While the rolling base year or time series decomposition has advantage that patterns can be tracked from year to year and hence more information may be extracted from the analysis.

In literature different decomposition techniques have been used. In early research work on decomposition analysis laspeyres index and Paasche index were frequently used.

One of the main advantages of this technique is that it is easy to calculate and understand. The weighted terms are fixed and not changing over the time. The limitations of these indices were that laspeyres index overestimates the changes, while Paasche index underestimate the changes. Some of the improvements were made to overcome these issues related to these indices and the result was Marshall-Edgeworth index, Walsh index and Fisher index.

Ang and Zhang (2000) pointed out that methods earlier to 1995 permanently leave a residual term when the decomposition is completed. The Laspeyres index was refined in such a way that no residual term left out after decomposition is done, this refined index was called "Refined Laspeyres index".

Boyd et al. (1987) suggested that Divisia index approach is a substitute for the Laspeyres index. This index is a weighted average of relative logarithmic growth rates. Further extensions have been made on this index such as Arithmetic Mean Divisia Index method (AMDI) and Log Mean Divisia Index method (LMDI). The Log Mean Divisia Index method (LMDI) further extends to LMDI1 and LMDI2. LMDI method is considered the best method in index decomposition analysis when there are some problems with data. LMDI technique has the property of handling negative and zero values in data and it is a perfect decomposition with no residual terms. Moreover, time reversal test can also be applied on LMDI method (Ang, 2007).

4.5 Estimation methodology for decomposition analysis

In constructing an IDA, the analysis starts with defining a function of total CO_2 emissions which has to be decomposed into different factors. These 'factors' are going to observe changes in total CO_2 emissions and frequently stated by the Kaya identity (Kaya, 1990). Some developments have been made to this Kaya Identity, for example LMDI 1 is used in many studies (Nasab et al., 2012; Akbostanci et al., 2009; Mahony, 2013).

Due to its higher features, LMDI is found to be the most appropriate for decomposing energy-related CO_2 emissions in Pakistan. The identity suggested by Zhang and Ang (2001) is helpful to decompose changes in CO_2 emissions and it uses the following variables:

E = Total Energy consumption

E_i = Energy use of fossil fuel type i

C = Total CO_2 emissions

C_i = carbon emissions by fossil fuel type i

Y = GDP

P = Population

Now it leads to the identity as

$$C=\sum_i C_i=\sum_i (E_i/E)(C_i/E_i)(E/Y)(Y/P)P \quad \text{..} \quad (2)$$

Suppose,

S=E_i/E, share of fossil fuel type i in total energy use.

F= C_i/E_i, the CO_2 emission coefficient for fossil fuel type i.

I = E/Y, the energy intensity

G = Y/P GDP per capita

P = population

The LMDI technique is further divided into two types. 1) Additive decomposition,2) Multiplicative decomposition. Additive decomposition is used to measure absolute changes in total CO_2 emissions while multiplicative decomposition is applied to measure relative changes in total CO_2 emissions. In this study we use multiplicative decomposition method to decompose overall CO_2 emissions. The general decomposition identity formula is given as follow:

$$C = \sum_{i=1}^{n} C_i = \sum_{i=1}^{n} X_{1,i}, X_{2,i}, X_{3,i}, X_{4,i}, \dots \dots \dots, X_{n,i}$$

Where C is overall change and $X_{1,i}$……….$X_{n,i}$ Are the factors responsible for changes in C. As we are interested in multiplicative decomposition, the formula for multiplicative technique is given as follow:

$$C_{tot} = C_t / C_0 = C_{emc} C_{ffse} C_{int} C_{ypc} C_{pop}$$

ΔC_{tot} is total change in CO_2 emissions level from 1980-2014. ΔC_{emc} Represents the change in total CO_2 emissions due to emission effect; change in carbon emissions due to a unit use of fossil fuels (oil, gas, coal and solid biomass). ΔC_{ffse} Represents the change in CO_2 emissions due to substitution of fossil fuel type in the economy; a technological effect. ΔC_{int} is the intensity effect measured by the change in energy consumption due to a unit change in GDP due to the structural change, it is an indicator of energy efficiency, technological choices, change in behaviour, and change in life style of people. ΔC_{ypc} represents the change in total carbon emissions due to the change in economic activity. ΔC_{pop} shows changes in carbon emissions due to the change in the number of habitants in a country. From Ang and Liu (2001), the succeeding LMDI1 formulae used to each of the effects;

$$\boldsymbol{C_{emc}} : \exp\left(\sum_i \frac{(C_i^T - C_i^0)/(lnC_i^T - lnC_i^0)}{(C^T - C^0)/(lnC^T - lnC^0)} \ln\left[\frac{F_i^T}{F_i^0}\right]\right)$$

$$C_{ffse} : \exp\left(\sum_i \frac{(C_i^T - C_i^0)/(lnC_i^T - lnC_i^0)}{(C^T - C^0)/(lnC^T - lnC^0)} \ln\left[\frac{S_i^T}{S_i^0}\right]\right)$$

$$C_{int} : \exp\left(\sum_i \frac{(C_i^T - C_i^0)/(lnC_i^T - lnC_i^0)}{(C^T - C^0)/(lnC^T - lnC^0)} \ln\left[\frac{I^T}{I^0}\right]\right)$$

$$C_{ypc} : \exp\left(\sum_i \frac{(C_i^T - C_i^0)/(lnC_i^T - lnC_i^0)}{(C^T - C^0)/(lnC^T - lnC^0)} \ln\left[\frac{G^T}{G^0}\right]\right)$$

$$C_{pop} : \exp\left(\sum_i \frac{(C_i^T - C_i^0)/(lnC_i^T - lnC_i^0)}{(C^T - C^0)/(lnC^T - lnC^0)} \ln\left[\frac{P^T}{P^0}\right]\right)$$

This thesis uses the period over 1980 to 2014. Energy related data is reported in annual energy balance sheets of Pakistan energy year book series, the data consists of overall energy consumption by fuel category. The data used in this study has been converted to kilo tonnes of oil equivalent (ktoe) for energy source of coal, oil, gas and renewables. The data is also consist of data on carbon emissions (except of renewables) calculated by U.S. Energy Information Administration. Energy consumption data for renewables is obtained from International Energy Agency (IEA) for period 1990-2014. As the data on CO_2 emissions for renewables is not available so renewable energy consumption data is being converted into CO_2 emissions by using the formula presented by Intergovernmental panel on climate change (IPCC). As data set on CO_2 emissions for renewables (primary solid biomass) is not available, so we have to calculate it according to the formula presented by intergovernmental panel on climate change (IPCC).

Step 1: final energy consumption data in tons of oil equivalent is collected from International Energy Agency (IEA).

Step 2: Now convert the unit TOE (tons of oil equivalent) into common energy unit "Terra Joule" by the formula, TJ= TOE*41868/10^6. It is converted into TJ unit because carbon emissions factors are presented in tons per terra joule.

Step: 3 now calculating carbon content by multiplying TJ values with CEF (carbon emission factor) of solid biomass.

Step 4: in last step we multiply the result calculated in step 3 with (44/12) to get final CO_2 emissions for solid biomass.

4.6 Conclusion

ADF unit root tests will be used to all the series to check whether in our study ARDL technique should be used or not. We will empirically test the impact of GDP, GDP square, energy consumption, trade liberalization, foreign direct investment (FDI) and domestic credit to private investors (DC) on the Carbon emissions. For decomposition analysis we will decompose overall Co2 emissions into oil, gas and coal carbon emissions by applying LMDI1 technique.

Chapter 5

Empirical results and discussion

5.1 Environmental Kuznets Curve (EKC) analysis

In order to estimate the EKC hypothesis in Pakistan over the period 1970-2015, first of all we have converted all the series in log form because GDP per capita series and foreign direct investment series were so large as compare to small values of dependent variable CO_2 emissions. We also convert the remaining explanatory series into log to make it Lin-log model. Then we apply Augmented Dickey Fuller unit root test to each series to check whether series are stationary or non-stationary. This will also provide us the justification to use ARDL or VAR technique.

5.1.1 ADF test for stationarity

The summary statistics for the Augmented Dickey Fuller unit root test are given in Table 1. The outcomes are showing that lnTO and lnFDI series are stationary at level i.e. series are integrated of I (0) and all other series (CO_2, lnDC, lnEC, lnGDP and $\ln GDP^2$) are stationary at first difference i.e. series are integrated of I (1). The results of Augmented Dickey Fuller (ADF) unit root tests are providing justification of ARDL approach. Furthermore, we also analyse the graphical representations of all the series to check the possibility of structural breaks in the date. There was no structural break found in the data.

Table 5.1 Test of the stationarity for Series

Variable	Parameter	ADF cal	Prob.	Trend/Intercept	Inference
CO2	-0.57	-3.38	0.001	None	1st difference
lnGDP	-0.73	-4.93	0.0000	None	1st difference
lnGDP2	-0.75	-4.99	0.0002	Intercept	1st difference
lnE	-0.84	-5.45	0.0003	Both	1st difference
lnDC	-0.85	-5.56	0.0000	Intercept	1st difference
lnFDI	-0.57	-4.17	0.0107	Both	Level
lnTO	-0.301	-3.33	0.0192	Intercept	Level

5.1.2 Bounds Test for co-integration

We have used Bound Testing approach to examine whether there exist a long run association between variables or not. The F-test for co-integration provide a clear proof of long run relationship between CO_2 emissions, GDP, Square of GDP, energy consumption (E), Trade openness (TO), Domestic credit to private investors (DC) and Foreign direct investment (FDI) (See Table 5.2).

Table 5.2 Results of Bound Test for Co-integration

ARDL Bounds Test		
Test Statistic	Value	K
F-statistic	9.526	6
Critical Values		
Significance level	Lower Bound value	Upper Bound value
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

The value of F-statistic is given in 2nd column. The lower and upper bound values are given in column 2nd and 3rd respectively. The value of F-statistic "9.526" is greater than the lower bound value of 3.15 even at 1% level of significance that leads to rejection of the null hypothesis, and we conclude that there exists a long-run association among the variables.

5.1.3 Estimates of Environmental Kuznets curve (EKC) Model

The long-run results of the EKC model are stated in Table 5.3. The dependent variable is CO_2 emissions which is proxy for environmental quality whereas lnE, lnGDP, $\ln GDP^2$, lnFDI, lnDC and lnTO are independent variables.

Table 5.3 Long-run effects of EKC Model

Variable	Coefficient	Probability
Constant	-4.826	0.003
lnGDP	4.619	0.053
lnGDP2	-2.359	0.047
lnE	0.390	0.014
lnDC	-0.116	0.028
lnFDI	0.032	0.004
lnTO	-0.015	0.713

The outcomes show that 1% increase in GDP/capita will raise carbon emissions by 0.0462 time while the negative sign of GDP/capita square (GDP2) appears to verify that carbon emissions starts to decline when income raises to a certain level. This means per capita CO_2 emissions increase as real income increases to some threshold level, after reaching to that threshold level per capita CO_2 emissions began to drop with increase in per capita real income. These results are supporting the Environmental Kuznets Curve hypothesis in Pakistan economy. These results are also supported by Ahmed and Long (2012) and Shahbaz, et al. (2012).

The results reveal that 1% increase in energy use will bring about 0.0039 time positive change in carbon emissions. The use of more fossil fuels in order to meet energy requirements cause CO_2 emissions to grow. This finding is in line with Hussain and Ali (2016).

On the other hand, the results show that Pakistan's trade liberalization has no significant long-run effect on carbon emissions. These results are in line with Jayanthakumaran, et al. (2012) also stated positive relationship between international trade and CO_2 emissions but it is statistically not significant. Nasir and Rehman (2012) found that trade openness increases the CO_2 emissions by enhancing economic growth and similar results were found by Halicioglu (2009). On the other hand, Shahbaz, et al. (2012) reported that international trade increases the environmental quality through implementation of new technology in domestic production.

We observed that financial development has an inverse relationship with carbon emissions in the long-run. It is noted that 1% increase in domestic credit to private investors will bring about 0.0012 units negative change in carbon emissions. It implies that financial development adds in reducing CO_2 emissions through the channel of banks by providing loans to firms for environment friendly technology and projects. This finding is in line with Tamazian et al. (2009) found that financial development offers developing to adopt modern technology, the environment friendly production and as a result improvement in environment at large scale. However, Zhang (2011) pointed that bank loans provide the support for Chinese companies to access external finance and increase investment scale. This causes economic growth to rise with the expansion in CO_2 emissions.

Lastly, our results show that foreign direct investment tends to improve environmental degradation. It is noted that 1% increase in foreign direct investment causes units positive change in CO_2 emissions. Our results reveal that Pakistan's economy is not relying on technology transfer by the source of foreign direct investment that can enhance environment quality. Furthermore, weak environmental laws in country may provide the opportunity for developed nations to shift their dirty industries here. Our results are in line with Jensen (1996), however, Zarsky (1999) pointed out that in adoption of global environmental standard, multinationals engaged in foreign direct investment will likely to transfer its modern green technology to the host country.

The short-run effects of EKC analysis are given in table 5.4. The results from the table show that the short-run dynamics also indicating that there exists an Environmental Kuznets curve for the case of Pakistan. The results of diagnostics tests are given in Appendix C.

Table 5.4 Short-run results of EKC Model

Variable	**Coefficient**	**Probability**
CO2(-1)	-0.213	0.262
lnGDP(-1)	6.252	0.009
lnGDP2(-1)	-3.005	0.011
lnE(-1)	1.155	0.001
lnDC(-1)	0.245	0.004
lnFDI(-1)	-0.022	0.010
lnTO(-1)	0.027	0.541

5.2 Decomposition Analysis

In section 5.1 the results suggested that there exists an inverted- u relationship between economic development and carbon emissions. However, ARDL model has not presented a clear picture of driving forces of CO_2 emissions. Recently some studies have used Index decomposition analysis to explore the trend of total CO_2 emissions. Decomposition analysis is a helpful tool to study the emissions trend deeply. In this section we will apply decomposition technique to explore the trend of CO_2 emissions; we decompose the CO_2 emissions for period 1980-2014 by using the energy sources of Gas, Coal and Oil. Furthermore, we also decomposed the CO_2 emissions for period 1990-2014 by using energy sources Gas, Coal, Oil and primary solid biomass (proxy for renewables), the reason of using shorter time period for this analysis is that the data for primary solid biomass is only available for period 1990-2014. Renewables are considered the least carbon intensive source of energy, so it is useful to include the renewables in the decomposition analysis.

The results of complete time series decomposition by using LMDI1 approach for time period 1980-2014 are presented in Appendix A. The results of decomposition after including the data of renewables are presented in Appendix B. The accumulated effects are divided in three time periods 1980-1990, 1990-2000 and 2000-2014, and are presented as index change in Table 5.8 and as annual percentage growth in Table 5.9. The accumulated decomposition results for the whole period 1980-2014 (fig. 5.2) explain that the activity effect (C_{ypc}) is the dominant positive effect; has also been proved in many former studies. The population effect has positive effect on total CO_2 emissions and the emissions coefficient (ΔC_{emc}) has also a little positive influence on CO_2 emissions. The energy intensity is only the factor which has negative effect on carbon emissions while Fossil fuels substitution effect is having small negative effect during 2000-2006. The total positive effects have outweighed total negative effects that are why total CO_2 emissions are increasing for the whole period 1980-2014.

Table 5.5 Accumulated Decomposition of Pakistan's energy $\mathbf{CO_2}$ from 1980 – 2014

Years	**Δ Ctot**	**ΔCffse**	**ΔCint**	**ΔCypc**	**ΔCpop**	**ΔCemc**
1980-1990	1.497011	1.010329	0.877285	1.225349	1.378267	1.000065
1990-2000	1.497218	0.995708	0.813555	1.438581	1.284721	1.000052
2000-2014	1.548524	1.017465	0.462611	2.457889	1.338353	1.000115
1980-2014	3.470787	1.023562	0.330175	4.332678	2.369808	1.000232

Table 5.6 Decomposition of Pakistan's energy $\mathbf{CO_2}$ emissions in annual % growth rates

Years	**Δ Ctot**	**ΔCffse**	**ΔCemc**	**ΔCint**	**ΔCypc**	**ΔCpop**
1980-1990	0.280736	0.013064	3.55E-05	-0.03174	0.009576	0.289802
1990-2000	0.532617	-0.00429	5.24E-05	-0.18645	0.438581	0.284721
2000-2014	1.281550	0.022583	0.000115	-0.53739	1.457889	0.338353
1980-2014	3.183542	0.031496	0.000202	-0.63559	2.569731	1.2177

Fig. 5.1 Accumulated decomposition of Pakistan's energy carbon emissions 1980-2014

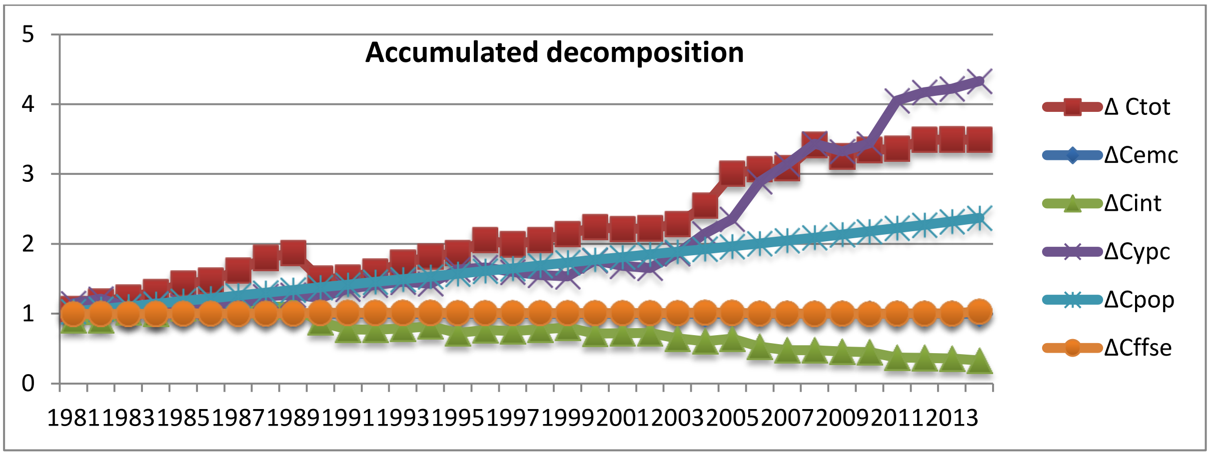


Fig. 5.2 Results of decomposition analysis (Emissions in Ktoe)

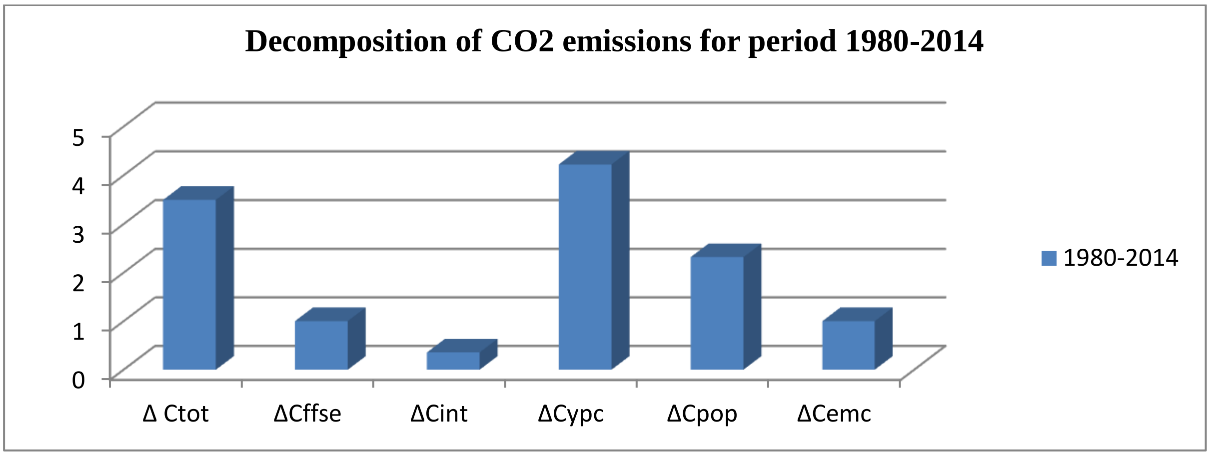


Figure 5.3 presents the complete decomposition for period 1980-2014; the index is showing the total change in 2014 from the base period of 1980. The results show that the activity factor is the larger contributor of changes in total CO_2 emissions. Population effect is the 2nd largest contributor, as population of Pakistan is increasing the economy requires more energy consumption and relying on fossil fuels like oil, gas and coal generating more CO_2 emissions. The intensity effect is showing negative impact in total CO_2 emissions which means that total CO_2 emissions are decreasing over the period due to intensity effect. The reason of decrease in energy intensity can be either improvement in method of production and it can be attributed as energy efficiency or it may be due to the energy shortages in the country that has decreased the use of energy less than the level of its demand. Consequently,

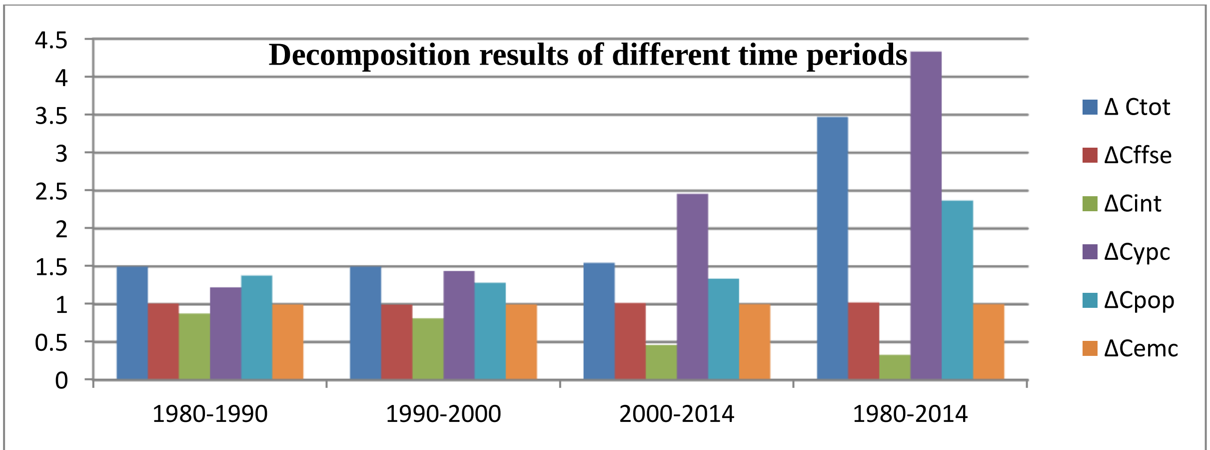
the energy intensity has decreased. The value of Fossil fuel substitution is also less than one which means that it is also effecting negatively the total CO_2 emissions. This result can be attributed to the substitution of natural gas for oil consumption since 2002-03 in the economy. Since, gas is less carbon intensive source of energy so total CO_2 emissions have decreased to some level due to this substitution of energy source. The coefficient of carbon emissions effect has positive effect to total CO_2 emissions. The outcomes are précised as follow:

1. The scale effect of economic expansion are the main driving forces of total CO_2 emission in Pakistan. Population effect is contributing to increase emissions but the activity effect has the dominant positive effect.

2. The energy intensity effect is lessening the energy requirement to produce a unit of output and is the main negative force in decreasing the carbon emissions.

3. The analysis explains four different periods of economic development trends and energy-related emissions trends. The high economic growth period 1980-1990 with increase in emissions level, and slowdown in economic growth during the period 1990-2000 with small decrease in total emissions and the high economic growth period 2001-06 and decline in 2008-11 with decrease in total emissions (fig.5.4).

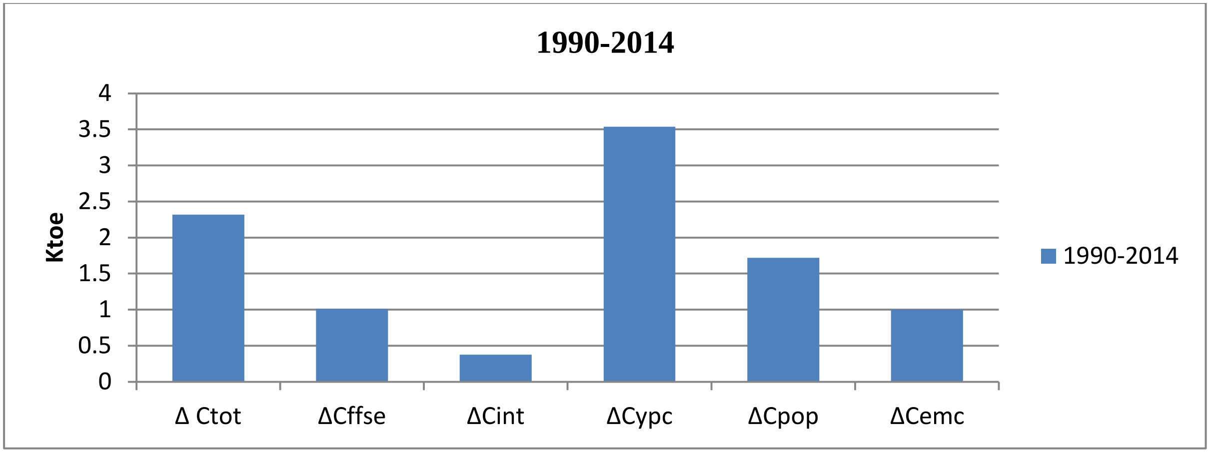
Fig. 5.3 Results of decomposition analysis (Emissions in Ktoe)



4. The accumulated driving forces which are decreasing emissions are offset by the driving forces increasing emissions, resulting to increase in energy-related total emissions.

5. The emission coefficient effect and fossil fuel substitution effect both participate to limit the growth of emission but these effects are minor and are negligible when incorporating the renewable data in the decomposition analysis (fig.5.5). The decomposition analysis results after including renewables data for period 1990-2014 are given in Table 5.10, while results in annual percentage growth are presented in Table 5.11.

Fig. 5.4 Results of decomposition analysis after including Renewables data.



6. Carbon emissions start to decline in period 1990-2000, attributable to the slowdown in economic growth and decrease in energy intensity. While population (ΔC_{pop}) effect continues to impact positively. The negative impact of energy intensity on emissions levels over the period 1980-2014 can be attributed to the energy crises and shortfall in energy supply. Energy demand is not fulfilled during the last few years due to gap between supply and demand of energy, thus energy requirements to economic growth are not up to the mark and there is decrease in energy intensity.

The effect of the activity (ΔC_{ypc}) can be seen as the largest contributor throughout the time series 1980-2014, especially, from period 2002-2008. Significant increase in economic development caused increase in energy use and hence rapid increase in associated carbon emissions.

Pakistan has also experienced a population growth. Energy requirements have also increased after increase in the number of habitants. Use of fossil fuels to meet energy requirements led emissions level to increase. (ΔC_{pop}) effect is 2nd largest contributor to the CO_2 emissions.

The fossil fuel substitution effect mainly measures the replacement of gas and coal for oil. The accumulated decomposition results show that there is decreasing trend in the (ΔC_{ffse}) effect from period 2000 to 2005-06. The reason of this is the substitution of natural gas for oil consumption, so the impact of this substitution on total emissions level is negative in this period because natural gas is less carbon intensive as compare to oil. However, due to gas load management, the share of oil consumption was again started to increase and associated emissions level to rise again. Moreover, Pakistan is now moving towards more pollutant fuels such as coal. The overall effect of change in fuel mix is negligible as compare to largest effect of activity (ΔC_{ypc}) and population (ΔC_{pop}).

The third largest contributor to the emissions level is the energy intensity effect. (ΔC_{int}) effect has shown a declining trend since 1990, causing CO_2 intensity to decline, which is a good sign for the economy. The decrease in intensity is due to improved technology and better methods of production.

The emission effect (ΔC_{emc}) is attributable to change in carbon due to unit use of fossil fuels like coal, oil and gas. (ΔC_{emc}) effect has positive impact on total emission level for the period 1980-2014. (ΔC_{emc}) effect has shown a declining trend after 2000, can be attributed to change in fuel quality and technology.

Table 5.7: Decomposition of Pakistan's energy CO_2 after including renewables data.

Years	Δ Ctot	ΔCffse	ΔCint	ΔCypc	ΔCpop	ΔCemc
1990-2000	1.667299	1.003111	0.806443	1.442481	1.285932	1.111124
2000-2014	1.279128	1.128617	0.481636	2.11560	1.269191	0.876371
1990-2014	2.132689	1.132128	0.388412	3.05171	1.632094	0.973756

Table 5.8 Decomposition of Pakistan's energy CO_2 emissions in annual % growth rates after including renewables data.

Year	Δ Ctot	ΔCemc	ΔCint	ΔCypc	ΔCpop	ΔCffse
1990-2000	0.546468	0.099729	-0.10512	0.257425	0.219497	0.024771
2000-2013	0.279128	-0.12363	-0.51836	1.115601	0.269191	0.128617
1990-2014	0.978131	-0.03623	-0.56899	1.660209	0.547774	0.156574

5.3 Conclusion

We apply ARDL technique to test the EKC hypothesis in Pakistan for the period 1970-2015. Our outcomes show that there exists Environmental Kuznet curve in Pakistan both for long-run and short-run period. We found that energy use, GDP/per capita and foreign direct investment have positive effect on CO_2 emissions in the long run while domestic credit to private investors has negative impact on CO_2 emissions.

For decomposition analysis we used LMDI1 technique for the period of 1980-2014. The results reveal that activity effect, population effect and energy intensity effect are the main contributors towards the changes in overall CO_2 emission level. Activity effect and population effect bring positive changes in carbon emissions while energy intensity has negative impact on CO_2 emissions.

Chapter 6

Conclusion

Our study has examined the relationship between economic development, energy use, Trade openness, financial growth, foreign direct investment and Carbon emissions in Pakistan for the period 1970-2015. The F-bound test for co-integration provides the indication of long-run relationship among variables. The outcomes suggest that there exist a long run relationship among variables. The outcomes also support for an EKC in Pakistan economy. It means CO_2 emissions initially increase as per capita GDP increases, after reaching a certain point (turning point of EKC) CO_2 emissions starts to decline with further increase in GDP per capita. We found that energyue, GDP/per capita and foreign direct investment have positive effect on CO_2 emissions in the long run while domestic credit to private investors has negative impact on CO_2 emissions. Furthermore, trade liberalization has positive effect on carbon emissions but it is statistically insignificant.

This study also explores the trend of carbon emissions by using LMDI1 decomposition approach over the period 1980-2014 for Pakistan economy. The analysis decomposes the CO_2 emissions into its different factors such as activity effect, intensity effect, population effect emission coefficient effect and substitution effect by using four types of energy sources; oil, gas, coal and renewables. The results suggest that activity effect is the key driving force of changes in total carbon emissions, Population effect is the 2nd largest contributor to changes in total carbon emissions. Intensity effect is the only single negative effect, which minimize the CO_2 emissions. The fossil fuel substitution effect bring negative changes in CO_2 emissions for period 2000-2005; due to substitution of natural gas for oil, as gas is less carbon intensive energy source so this substitution bring negative changes in carbon emissions for this specific time period. In addition, the emission coefficient effect is contributing positively in total carbon emissions due to pure quality of fossil fuels.

Pakistan is heavily relying on the natural resources of oil and gas for energy use and these natural resources are depleting rapidly and causing environmental problems. Pakistan has abundant resources of coal; in near future we can use of these coal resources by introducing clean technology for coal use. In addition, we should focus on energy efficient policies, especially in the industrial sector by using new technology. Energy efficiency will definitely decrease the energy intensity and as a result the emissions level will also decline. Furthermore, Investments in renewable energy projects should be enhanced.

There is a need of effective implementation of environmental laws and regulations both at federal and local level. The development and research in environmental sector in Pakistan are still unattainable, modern technology and environment friendly projects are important for sustainable development. Therefore, there should be an environmental tax like green tax to minimize carbon emissions.

It is suggested that financial sector should create loans for the firms to support those investment plans which are considered environment friendly and should assign funds to energy sector for growth of renewables sector to make clean environment. It is also important for the Government to make a reasonable industrial policy in order to direct the foreign direct investment toward clean and environment friendly production. Government can play a positive role in upgrading the structure of the industry with new technology, reducing energy use and creating an energy-saving environment.

For further research, it will be very useful to focus on the role of institutions in Environmental Kuznets curve analysis. Variables such as institutional quality and democracy can help to explore EKC in order to study the effect of environmental policies on carbon emissions. Lastly, due to limited data availability of renewables data in the decomposition analysis the results in this study can be much improved in the future by including more variables in the renewable energy sources.

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Appendix A

Years	Δ Ctot	ΔCffse	ΔCint	ΔCypc	ΔCpop	ΔCemc
1980-1981	1.084237	0.996384	0.898723	1.156165	1.03538	1.011468
1981-1982	1.183863	1.039393	0.965709	1.063253	1.03721	1.069479
1982-1983	0.978466	0.994979	1.140685	0.895631	1.036823	0.928394
1983-1984	1.022047	1.030356	0.951331	1.050763	1.034205	0.959491
1984-1985	1.096173	1.034008	1.052846	0.967774	1.033072	1.00713
1985-1986	1.090386	0.987252	1.019045	0.991425	1.033257	1.058011
1986-1987	1.077999	1.001353	1.05206	1.012922	1.033291	0.977669
1987-1988	1.06592	1.060271	0.90912	1.119352	1.03206	0.957226
1988-1989	1.067095	0.981923	1.011763	1.0132	1.030952	1.028283
1989-1990	1.045429	0.770776	1.049043	0.968104	1.028892	1.29802
1990-1991	1.046788	0.983684	0.905224	1.10186	1.027334	1.038506
1991-1992	1.029944	0.995099	0.995525	1.041123	1.026421	0.972898
1992-1993	1.106471	1.026115	0.992915	1.03093	1.02557	1.027159
1993-1994	1.092058	1.011345	1.032709	0.982931	1.025589	1.037223

1994-1995	1.03278	0.984188	0.891932	1.142417	1.025882	1.003867
1995-1996	1.087942	1.044956	1.007979	1.018953	1.025848	0.988141
1996-1997	1.006057	0.945865	1.041583	0.961537	1.025294	1.035823
1997-1998	1.016555	1.005946	1.025703	0.97213	1.024677	0.989061
1998-1999	1.086607	0.988704	1.043823	0.988749	1.024406	1.039492
1999-2000	1.02498	1.020672	0.870464	1.153384	1.023654	0.977128
2000-2001	0.954491	0.971573	1.038405	0.957499	1.021566	0.96722
2001-2002	0.995165	0.995258	1.009785	0.980774	1.019565	0.990255
2002-2003	1.016841	0.984206	0.917178	1.112871	1.018322	0.993994
2003-2004	1.036635	1.035282	0.922822	1.129409	1.017446	0.94425
2004-2005	1.049281	1.115007	0.938605	1.079	1.017171	0.913516
2005-2006	1.091396	0.983794	0.852367	1.193385	1.017744	1.071598
2006-2007	1.060612	0.959862	0.955208	1.075614	1.017958	1.056485
2007-2008	0.996729	1.10989	0.896199	1.079623	1.017868	0.911862
2008-2009	1.015902	0.94631	1.022154	0.972674	1.01806	1.060623
2009-2010	1.027441	1.013293	0.965409	1.028897	1.018441	1.00231

2010-2011	0.992439	0.999144	0.854178	1.155437	1.018613	0.988035
2011-2012	1.02808	1.024557	0.965556	1.025406	1.018854	0.994731
2012-2013	0.990878	0.998591	0.973617	1.010922	1.018976	0.98938
2013-2014	1.045367	1.012355	0.96765	1.011453	1.01956	0.99453
1980-2014	3.495546	1.002942	0.355575	4.223066	2.320488	1.000232

Appendix B

Years	**∆ Ctot**	**∆Cffse**	**∆Cint**	**∆Cypc**	**∆Cpop**	**∆Cemc**
1990-1991	1.008203	0.983684	0.905223	1.10186	1.027334	0.972898
1991-1992	1.05983	0.995099	0.995525	1.041123	1.026421	0.972898
1992-1993	1.078806	1.026114	0.992915	1.03093	1.02557	1.027159
1993-1994	1.052907	1.011345	1.032709	0.982931	1.02559	1.037223
1994-1995	1.028245	0.984187	0.891932	1.142417	1.025882	1.003867
1995-1996	1.098652	1.044956	1.007979	1.018953	1.025849	0.988141
1996-1997	0.971539	0.945865	1.041583	0.961537	1.025294	1.035823
1997-1998	1.027691	1.005946	1.025703	0.97213	1.024677	0.989061
1998-1999	1.044225	0.988704	1.043823	0.988749	1.024406	1.039492
1999-2000	1.047345	1.020672	0.870463	1.153385	1.023654	0.977128
2000-2001	0.986615	0.971573	1.038405	0.957498	1.021566	0.96722

2001-2002	1.005358	0.995258	1.009785	0.980773	1.019565	0.990255
2002-2003	1.02591	0.984206	0.917177	1.112872	1.018322	0.993994
2003-2004	1.115615	1.035282	0.922821	1.12941	1.017446	0.94425
2004-2005	1.180037	1.115007	0.938605	1.079001	1.017171	0.913516
2005-2006	1.021527	0.983794	0.852367	1.193386	1.017744	1.071598
2006-2007	1.004529	0.959862	0.955208	1.075615	1.017958	1.056485
2007-2008	1.109146	1.10989	0.896199	1.079623	1.017868	0.911862
2008-2009	0.951228	0.94631	1.022154	0.972674	1.018061	1.060623
2009-2010	1.028777	1.013293	0.965409	1.028897	1.018441	1.00231
2010-2011	1.005101	0.999144	0.854177	1.155437	1.018613	0.988035
2011-2012	1.038149	1.024557	0.965555	1.025406	1.018854	0.994731
2012-2013	1.001707	0.998591	0.973616	1.010922	1.018976	0.98938
2013-2014	1.005643	0.985647	0.983452	1.024536	1.019675	0.96875
1990-2014	2.132689	1.132128	0.388412	3.051716	1.632094	0.973756

Appendix C: Diagnostic Tests

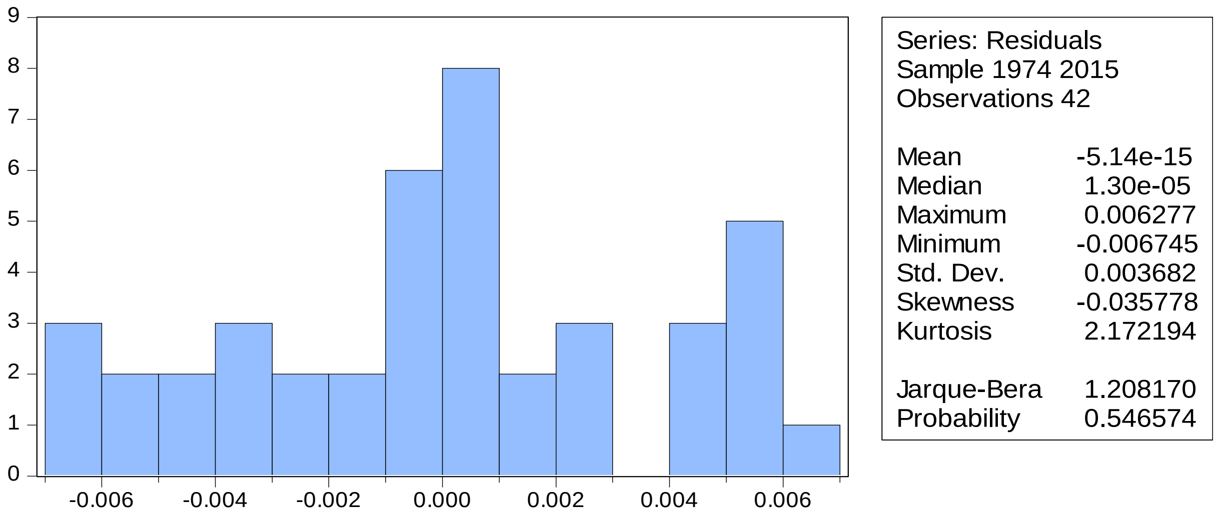
The results of J-B test and LM test are given in Table 5.5 and 5.6 respectively. The corresponding P-value "0.55" of the Jarque-Bera value (1.208) in Table 5.5 is greater than 0.05 which leads to accept null hypothesis of normality test and we conclude that the residuals are normally distributed.

Normality Test:

$H_{0:}$ Residuals are normally distributed

Reject H_0 when P-value <0.05

<u>Test of Normality</u>



Serial Correlation LM test:

$H_{0:}$ no serial correlation among the residuals

Reject H_0 when P value <0.05

The p value “0.103” is clearly larger than 0.05 in table 5.6, so we accept the null hypothesis and we conclude that there is no serial correlation among the residuals.

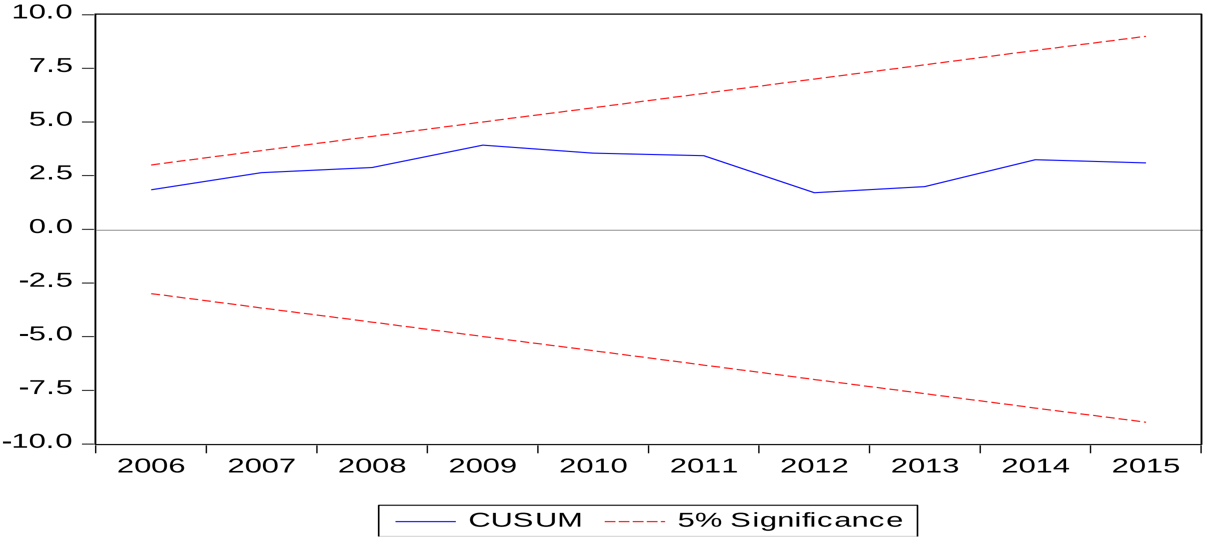
Test of Serial correlation

Serial Correlation LM Test:			
F-stat	0.486	Prob. F(2,8)	0.632
R-squared	4.549	Prob. Chi-Square(2)	0.103

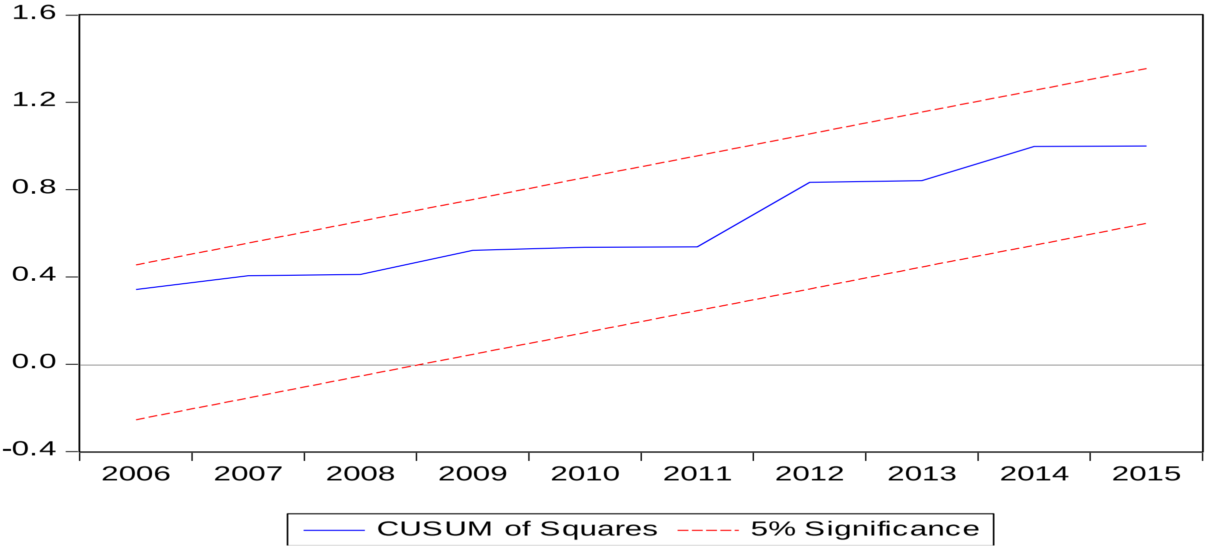
Stability Test:

Now we have to plot the cumulative sum of recursive residuals CUSUM and cumulative sum of recursive residuals of square CUSUMSQ to check the stability of the model. The graphs given below show that the model is stable as trends of CUSUM and CUSUMSQ statistics staying within the critical rejection regions (Fig.5.1). The outcomes of graphs indicate that our ARDL model’s estimates are stable both for short run and for long run.

CUSUM and CUSUMSQ test.



Cumulative sum of recursive Residuals



Cumulative Sum of Squares of Recursive Residuals

Heteroscedasticity Test:

$H_{0:}$ There is no heteroscedasticity

Reject H_0 when P-value <0.05

Now we check for heteroscedasticity, in table 5.7 the observed R squared value "6.55" and its corresponding P-value is 1.000 which is greater than 0.05 and it leads to accept null hypothesis that there is no heteroscedasticity in the data.

<u>Test of Heteroscedasticity</u>

Heteroscedasticity Test			
F-stat	2.166	Prob. F(31,10)	0.0982
R-squared	36.55	Prob. Chi-Square(31)	1.000