THE IMPACT OF POPULATION, AFFLUENCE AND TECHNOLOGY ON THE ENVIRONMENTAL DEGRADATION: EVIDENCE FROM HETEROGENEOUS INCOME PANELS

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ABSTRACT

Efficient utilization of scarce resources is always the prime aim of every state to ensure social welfare, while maintaining clean and green environment to sustainable development. The growing threats of global warming and climate changes have called for more sensible attention of the policy makers. Therefore, this study is an attempt to empirically investigate the linkages between population, affluence, technology, and environmental degradation for selected low, lower middle, upper middle, and high-income countries using disaggregate and aggregate panel data over the period 1980-2015. After checking the stationary properties of the data, Pedroni (1999) tests of cointegration were implemented for cointegration purposes. The FMOLS was employed for parameters estimation. The results show that population, nonrenewable energy consumption, urbanization, population growth, international trade and total energy consumption are the main culprits of CO_2 emissions in all selected panels whereas renewable energy consumption is found helpful in curbing the amount of CO_2 emissions. In addition, GDP growth, FDI and financial development are found having insignificant relationship with CO_2 emissions. Finally, results of Granger causality suggest that the population size, population density and urbanization are usually granger causes of CO_2 emissions. The findings of the study suggest important policy implications. This study recommends scientific planning for urban development, developing environmental awareness among urban residents, encouraging the adoption of more fuel-efficient vehicles, increasing the entire costs of private transport as a few measures to lower the energy consumption and CO_2 emissions. Furthermore, it is advised that policymakers should regulate such policies to trigger international trade activities as international trade detracts CO_2 emissions. In this regard, exploring the alternative energy policies, such as developing energy conservation strategies, decreasing the energy intensity, increasing the energy efficiency, and increasing the utilization of cleaner energy sources can prove better strategies to handle this issue.

Keywords: Population, Affluence, Technology, CO_2 emissions, Sustainable Development

ABSTRAK

Kecekapan penggunaan daripada sumber yang terhad adalah sentiasa menjadi matlamat utama di setiap peringkat bagi memastikan kebajikan sosial, di samping mengekalkan persekitaran yang bersih dan hijau untuk pembangunan lestari. Ancaman yang semakin meningkat daripada pemanasan dan perubahan iklim global meminta perhatian yang lebih bijak dari pembuat dasar. Oleh itu, kajian ini mencuba untuk menyiasat hubungan secara empirik antara populasi, afluen, teknologi, dan degradasi alam sekitar bagi negara-negara berpendapatan rendah, lebih rendah, menengah atas, dan tinggi terpilih dengan menggunakan data panel disagregat dan agregat sepanjang tempoh 1980-2015. Selepas memeriksa ciri-ciri kepegunan data, ujian kointegrasi Pedroni (1999) dilaksanakan untuk tujuan kointegrasi. FMOLS digunakan untuk penganggaran parameter. Keputusan menunjukkan bahawa populasi, penggunaan tenaga yang tidak dapat diperbaharui, perbandaran, pertumbuhan penduduk, perdagangan antarabangsa dan jumlah penggunaan tenaga merupakan penyebab utama pelepasan CO_2 dalam semua panel yang terpilih manakala penggunaan tenaga yang dapat diperbaharui didapati membantu dalam membendung jumlah pelepasan CO_2. Di samping itu, pertumbuhan KDNK, FDI dan kemajuan kewangan didapati mempunyai hubungan signifikan dengan pelepasan CO_2. Akhirnya, keputusan daripada hubungan sebab dan akibat Granger mencadangkan bahawa saiz penduduk, kepadatan penduduk dan pembandaran biasanya penyebab pelepasan CO_2. Dapatan kajian menunjukkan implikasi dasar yang penting. Kajian ini mencadangkan perancangan saintifik untuk pembangunan bandar, membangunkan kesedaran alam sekitar dalam kalangan penduduk bandar, menggalakkan penggunaan kenderaan bahan api yang lebih cekap, meningkatkan keseluruhan kos pengangkutan swasta sebagai ukuran untuk mengurangkan penggunaan tenaga dan pelepasan CO_2. Selanjutnya, pembuat dasar dinasihatkan melaksanakan dasar-dasar untuk mencetuskan aktiviti perdagangan antarabangsa sebagai perdagangan antarabangsa yang mengurangkan pelepasan CO_2. Dalam hal ini, meneroka dasar tenaga alternatif, seperti membangunkan strategi pemuliharaan energi, mengurangkan intensiti tenaga, meningkatkan kecekapan tenaga, dan meningkatkan penggunaan sumber tenaga yang lebih bersih membuktikan strategi yang lebih baik untuk menangani isu ini.

Kata Kunci: Populasi, Afluen, Teknologi, Pelepasan CO_2, Pembangunan Lestari

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LIST OF ABBREVIATIONS

AIC	Akaike's Information Criterion
ARDL	Autoregressive Distributed Lag
ASEAN	Association of South East Asian Nations
BRICS	Brazil, Russia, India, China and South Africa
Btu	Quadrillion British Thermal Unites
CCR	Canonical Cointegration Regression
CO_2	Carbon Dioxide
DOLS	Dynamic Ordinary Least Square
ECT	Error Correction Term
EKC	Environmental Kuznets Curve
EU	European Union
FDI	Foreign Direct Investment
FEM	Fixed Effects Model
FMOLS	Fully Modified Ordinary Least Square
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GMCI	Global Manufacturing Competitiveness Index (GMCI)
GMM	Generalized Method of Moments
GNP	Gross Domestic Product
IAA	Innovative Accounting Approach
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JML	Johansen Maximum Likelihood
MENA	Middle East and North Africa
MNCs	Multinational Companies
OCED	Organization for Economic Co-operation and Development
PHH	Pollution Heaven Hypothesis
PLS	Partial Least Square
R&D	Research and Development
REM	Random Effects Model
SO_2	Sulfur dioxide
STRIPAT	Stochastic Impacts by Regression Population, Affluence, and Technology
TY	Toda Yamamoto
UAE	United Arab Emirates
UN	United Nation
US	United States
VECM	Vector Error Correction Model
WEF	World Economic Forum
2SLS	Two-stage Least Square
3SLS	Three-Stage Least Square

CHAPTER 1

INTRODUCTION

Chapter 1 begins with the introduction and background of the study in Section 1.1. The problem of the study is stated in Section 1.2. The research questions and objectives are provided in Section 1.3 and Section 1.4, respectively. The significance of the study is discussed in Section 1.5 followed by the scope of the study under Section 1.6. The structure of the study is presented in Section 1.7. Finally, Section 1.8 provides the conclusion of the chapter.

1.1 Background of the Study

The increasing global warming threatens, and climate changes have called for more attention and discussion of global environmental issues. An increase in air and ocean temperatures leads to melting of snow and rising of average sea level are unambiguous evidences of global warming. Intergovernmental panel on climate change (IPCC) has predicted that by the year 2100, there would be a possible increase of 1.1^{0}C to 6.4^{0}C in global temperature and a rise of 16.5cm to 53.8cm in sea level (IPCC, 2013).

In this context, it will not be an exaggeration to mention that Greenhouse Gases (GHGs) emissions is the main cause of global warming and GHGs result primary from the combustion of fossil fuels. The fossil fuels come from the non-renewable sources like oil, coal and gas and contribute mainly in the CO_2 emissions. The world CO_2 emissions show increasing trends due to the massive consumption of fossil fuels and non-renewable energy consumptions in the rapid urbanization and industrialization. The CO_2 emissions due to non-renewable energy consumption are one of the main issues of air pollution and global warming (IEA, 2016).

In recent years, many countries have faced the challenge of producing more energy to meet their growing energy demand, while at the same time struggling to reduce the CO_2 emissions. Energy is at the heart of the problem and should form the core of the solution therefore, the analysis suggests that continuing to use energy as it is done today, without a change in policy government by the major energy consuming countries would be a way to quickly increase dependence. The problem of energy security faced by energy importing countries is equally significant (Hedenus, Wirsenius, & Johansson, 2014).

1.1.1 Energy Consumption

Energy which is defined as a key input to produce goods and services has significant role in economic growth and development. It is a vital component in economic growth functioning either directly or as a complement to other factors of production. The traditional Neo-classical growth model considers energy as intermediate inputs whereas land and labor as basic factors of production. On the other hand, the biophysical and ecological view advocates is that energy plays a key role in income determination. Thus, the economies heavily dependent on energy use shall be significantly affected by changes in energy consumption (J.-H. Yuan, Kang, Zhao, & Hu, 2008). For the past three decades, the world has experienced spectacular increase of energy consumption to sustain its growing economy. An increase of 176.38 percent was recorded in the world energy consumption during the 1980 - 2013 (World Bank, 2014). The trends of world energy consumption are presented in Figure 1.1. It shows that in 1980 the world energy consumption was 1452.90kt and after a short decrease it again shows increasing trends in 1988 with 1467.84kt energy consumption. Finally, the world energy consumption 1894.27kt was recorded in 2013.

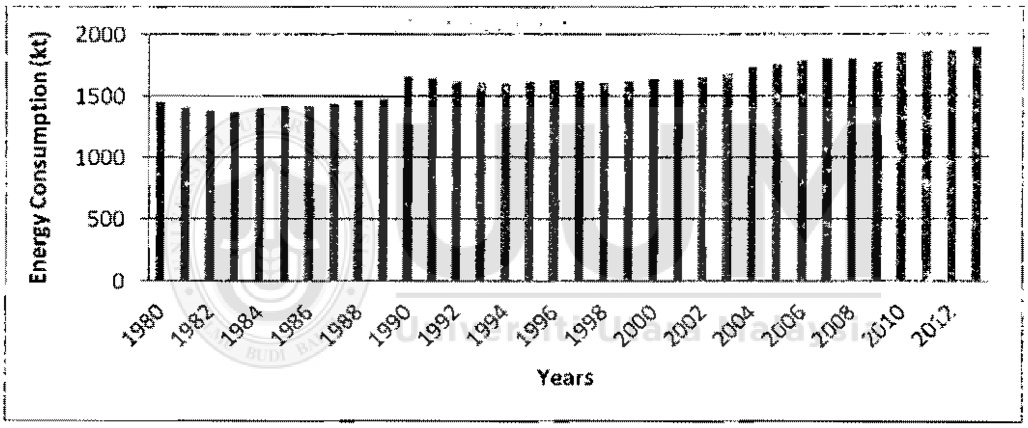

Figure 1.1
World Energy Consumption, 1980 – 2014
Source: World Bank, 2016

The energy consumption in the different sectors is the main source of CO_2 emissions. According to IPCC (2015), CO_2 emissions from electricity and heat sector are ranked first, transport sector is ranked second, industry sector third and residential sector remained at fourth. Figure 1.2 shows the contribution in CO_2 emissions from different sectors.

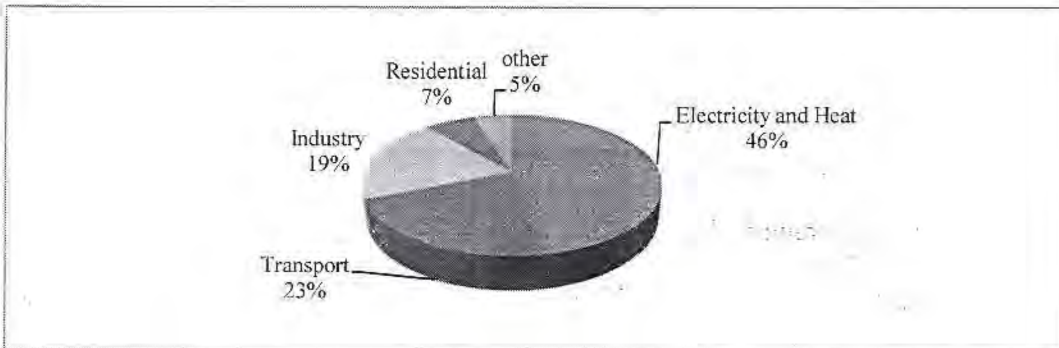

Figure 1.2
Annual CO_2 Emissions by Sector, 2015
Source: IPCC, 2014

Furthermore, non-renewable energy comes from sources that will run out or will not be replenished in the future. Most of the non-renewable energy consumption comes from conventional sources such as coal, oil and natural gas that are also called fossil fuels. An extensive increase in non-renewable energy consumption was recorded but the sources of energy production differed by regions and income levels. The non-renewable energy consumption by sources is presented in Figure 1.3. The facts show that coal consumption is ranked first among all fossil fuels during 1980 – 2015, followed by oil and natural gas consumption.

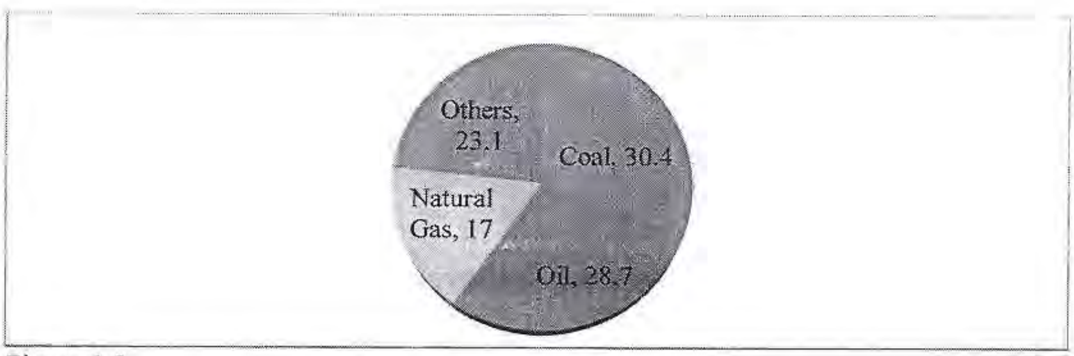

Figure 1.3
Non-renewable Energy Consumption by Sources, 1980 – 2015.
Source: International Energy Agency (IEA), 2015

The global trends of total energy consumption, non-renewable energy consumption and CO_2 emissions for 1990, 2000 and 2010 are presented in Table 1.1. It is observed that total energy consumption, non-renewable energy consumption and CO_2 emissions are simultaneously increasing. Hence, increasing total energy and non-renewable energy consumptions lead to increase in the amount of CO_2 emissions.

Table1.1
Global Trends of Energy consumption, Non-renewable Energy Consumption and CO_2 Emissions, 1990, 2000, 2010

	1990	2000	2010
Energy Consumption (kt)	8574178	9788864	12515722
Non-renewable Energy Consumption (%)	80.82	79.96	80.80
CO_2 Emissions (MT)	22,222,874	24,807,255	33,615.389

Source: World Bank, 2015.

In addition, energy consumption in different sectors also shows increasing trends. For example, energy consumption in industry sector reached first with 51.7 percent contribution and transportation sector remained second with 26.6 percent contribution. Similarly, residential and commercial sectors utilized 13.9 percent and 7.8 percent energy (IEA, 2015) respectively. Figure 1.4 shows the trends of world total energy consumption and fossil fuels consumption during 1980 – 2014. The high consumption of fossil fuels energy in different sectors significantly contributed to in the CO_2 emissions.

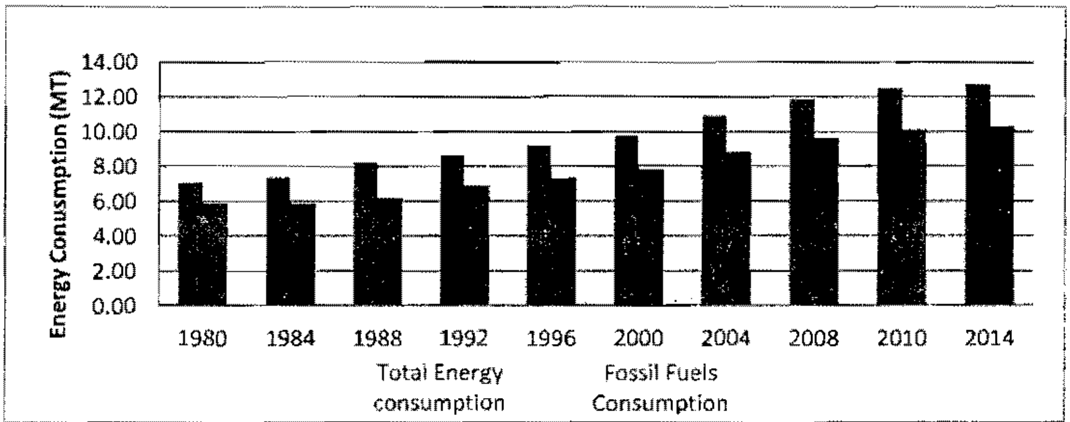

Figure 1.4
World Energy Consumption per year, 1980-2015
Source: IEA, 2015

Recent facts show that most of total energy and fossil fuels energy are utilized by high income countries, but the contribution of upper middle income and lower middle-income countries cannot be ignored. The top ten total and fossil fuels energy consumption countries are listed in Table1.2. It shows that China is an upper middle income and leading energy consumption country whereas, US is a high-income country and ranked second in total energy consumption as well as in fossil fuels consumption. Similarly, India is lower middle-income country and stands at third highest energy consumer in the world in 2014. According to facts, seven highest energy consumption countries are categorized as high income, such as, US, Russia, Japan, Germany, South Korea, Canada and France.

Table1.2
Top Ten Total and Non-Renewable Energy Consumption Countries in 2014

Country	Category (Income Level)*	Total Energy Consumption (MT)**	Fossil Fuels Energy Consumption (MT)***	% from the Total
China	Upper Middle	3,013	2660.47	88.3
US	High Income	2,187	1828.33	83.6
India	Lower Middle	819	592.13	72.3
Russia	High Income	730	664.30	91.0
Japan	High Income	455	431.34	94.8
Germany	High Income	323	259.04	80.2
Brazil	Upper Middle	293	159.97	54.6
Korea	High Income	267	232.82	87.2
Canada	High Income	254	187.19	73.7
France	High Income	253	250.72	99.1

Source: * World Bank, 2014 Classification.
** and ***Global Energy Statistical Yearbook, 2015.

1.1.2 Economic Growth

Ensuring balance between economic growth and sustainable environment has become an important policy issue in recent years. Policies aiming at bringing cleaner environment without affecting economic growth rates are being put forward with an ambition to reduce dependence on non-renewable energy resources, ensuring energy security and eradicating poverty. The relationship between sustainable environment and economic growth is however linked through the relationship between energy consumption and economic growth. Understanding the true nature of relationship between energy consumption and economic growth is important for the formulation of optimal energy and environmental policies.

The studies such as Mirza and Kanwal (2017) suggested that energy consumption in economic activities have main contribution in the CO_2 emissions. The economic activities like economic growth, financial development, foreign direct investment (FDI), industrialization and international trade consumed massive amount of energy and consequently emit high CO_2.

Since the seminal work of Kraft and Kraft (1978), it is considered that energy consumption and economic growth are related to each other however, there is no consensus among economists on the direction of causality between these two variables (Apergis & Payne, 2009a). The nexus between energy consumption and economic growth has remained questionable across datasets, regions and methodologies.

Economic growth is an increase in the capacity of an economy to produce goods and services, compared from one period to another. It can be measured in nominal or real terms, the latter of which is adjusted for inflation. Traditionally, aggregate economic growth is measured in terms of gross national product (GNP) and gross domestic product (GDP), although alternative metrics are sometimes used (World Bank, 2015). Economic growth in the world remains lackluster, with little prospects for a turnaround in 2016 (UN, 2016). The trends of economic growth from 2007 - 2017 are presented in Figure 1.5. The world economy is projected to grow by 2.9 percent in 2016 and 3.2 percent in 2017. Economic growth is benefiting the society by increase the level of health, education, improved technology and infrastructure. Contrary, it is also hurting the environment by pollutant emissions.

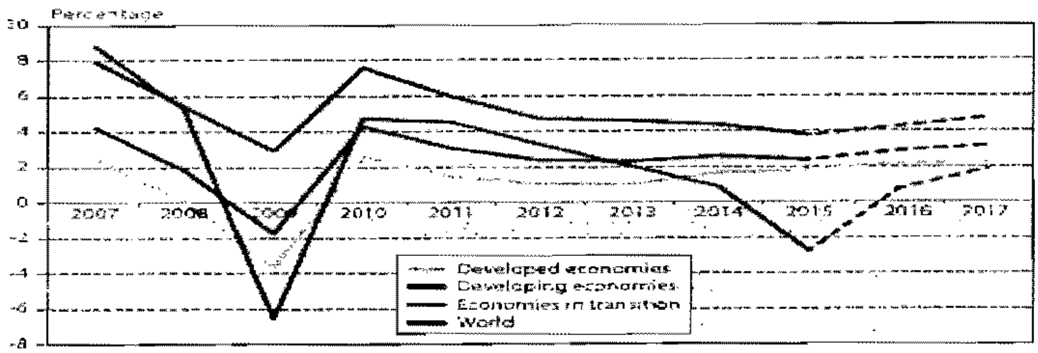

Figure 1.5
World Economic Growth 2007 – 2017
Source: Global Economy Outlook, 2016

1.1.2.1 Financial Development

The Financial Development Report (2011) published by the World Economic Forum (WEF) defines financial development as 'the factors, policies, and institutions that lead to effective financial intermediation and markets, as well as deep and broad access to capital and financial services' (WEF, 2011, p. 13). In a similar vein, Beck and Levine (1999) puts forward that an ideal measure of financial development would capture 'the ability of the financial system to research firms and identify profitable ventures, exert corporate control, manage risk, mobilize savings, and ease transactions.' These definitions assign a major role to the effectiveness of financial intermediaries and stock markets.

A financial system consists of financial institutions, commercial banks and financial markets. At a broader level, a robust and efficient financial system promotes growth by channeling resources to their most productive uses and fostering a more efficient allocation of resources. A stronger and better financial system can also lift growth by boosting the aggregate savings rate and investment rate, speeding up the accumulation of physical capital. Financial development also promotes growth by strengthening competition and stimulating innovative activities that foster dynamic efficiency (Estrada, Park, & Ramayandi, 2010). The WEF developed an index to measure the financial development in a country. This index formulated based on seven different pillars such as institution environment, business environment, financial stability, banking financial service, non-banking financial services, financial markets and financial access. Top 20 countries with high score of financial development are presented in Table 1.3.

Table1.3
Top Twenty Countries with High Score of Financial Development in 2014

Rank	Country	Score (1-7)	Rank	Country	Score (1-7)
1	Hong Kong	5.31	11	Germany	4.61
2	US	5.27	12	Denmark	4.53
3	United Kingdom	5.21	13	Norway	4.52
4	Singapore	5.10	14	France	4.43
5	Australia	5.01	15	Korea Republic	4.42
6	Canada	5.00	16	Belgium	4.30
7	Japan	4.90	17	Finland	4.24
8	Switzerland	4.78	18	Malaysia	4.24
9	Netherlands	4.73	19	Spain	4.22
10	Sweden	4.71	20	Ireland	4.14

Source: The Financial Development Report, 2014

Most of the developed countries have elevated level of financial development. For example, Hong Kong is ranked first with 5.31 score out of seven and followed by the US, Singapore and Australia.

Financial development increases economic growth and boosts energy consumption but impact on environment is another area of concern. There are mainly two points of views which are mentioned that financial development either increases the energy consumption and CO_2 emissions or introduces energy efficiency and decreases the CO_2 emissions. Some of the studies suggest that CO_2 emissions increase because financial development alleviates the credit constraints and helps the economic output to expand which results in more energy consumption and higher CO_2 emissions. According to Sadorsky (2010), efficient financial intermediation encourages the customers to take loans and buy big ticket items like automobiles, which increases CO_2 emissions. Susmita Dasgupta, Laplante, and Mamingi (2001) suggest that development of stock market results in low financing cost, easing the liquidity limitations for listed enterprises, allowing them to expand output, increase energy consumption and hence, CO_2 emissions.

On the contrary, it is argued that financial sector development boosts investment in technologies that are energy efficient and thus reduces CO_2 emissions. J. A. Frankel and D. Romer (1999) argued that financial development in a country draws more FDI and causes higher level of Research and Development (R&D) that leads to better environment. Bello and Abimbola (2010) found that increase in financial development brought technological improvement that led to lower emissions.

1.1.2.2 Foreign Direct Investment

FDI refers to direct investment equity flows in the reporting economy. It is the sum of equity capital, reinvestment of earnings, and other capital. Direct investment is a category of cross-border investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is resident in another economy. Ownership of 10 percent or more of the ordinary shares of voting stock is the criterion for determining the existence of a direct investment relationship (World Bank, 2016).

FDI inflows have rapidly increased during the past two decades in almost every region of the world Recently, both inward and outward FDI inflows show increasing trends in the world. In 2015 the US is ranked first with FDI inflows $92.4 billion. Similarly, the UK with $72.2 billion is ranked second, Canada with $53.9 billion is ranked third, Australia is ranked fourth with $51.9 billion and Netherland with $30.3 billion remains at fifth position in the world. These top five FDI inflows host economies have 40.6 percent share in the world FDI inflows. Recent inward and outward FDI flows and stock are presented in the Table 1.4.

Table1.4
The World FDI Inflow and Stock, 2012 – 2014

FDI flows	$Million			% of GDP		
Years	2012	2013	2014	2012	2013	2014
Inward	1,402,887	1,467,233	1,228,263	7.9	8.0	6.5
Outward	1,283,675	1,305,910	1,354,046	7.3	7.1	7.2
FDI stock	$Million			% of GDP		
Inward	22,073,175	26,034,894	26, 038, 824	30.0	34.4	33.6
Outward	22,527,186	25,975,000	25,874,757	30.8	34.6	33.7

Source: World Bank, 2015

This revitalizes the long debate in both academic and policy spheres about the advantages and related costs of FDI. Indeed, FDI inflows may provide direct capital financing, generate positive externalities, and consequently stimulate economic growth through technology transfer, spillover effects, productivity gains, and the introduction of new processes and managerial skills. FDI is one of the key macroeconomic indicators and based on the general perception, FDI promotes the economies of the host country in the developing world and as a result FDI gets a high priority in their development agenda. The countries provide subsidies, incentives, relaxation in taxes, local market access and duty exemptions to attract more FDIs and expect that this will contribute positively to their economies (Blomström & Kokko, 1998; Javorcik, 2004; Shahbaz, Nasreen, & Ozturk, 2016). On the contrary, empirical studies like Asghari (2013) and Blanco, Gonzalez, and Ruiz (2013) suggested that foreign investors prefer to invest in those countries which have relatively lax environmental regulations. Furthermore, multinational Companies (MNCs) shift high polluted industries from developed world to developing countries and hence, it results in the increase the level of pollutions.

1.1.2.3 Industrialization

Industrialization is the process by which an economy is transformed from primarily agricultural to one based on the manufacturing of goods. Individual manual labor is often replaced by mechanized mass production, and craftsmen are replaced by assembly lines. In the recent years, industrialization is rapidly increased and contributing heavily in the economies of developing countries. The industrial revolution propelled industrialization as the predominant paths to economic modernization. Global Manufacturing Competitiveness Index (GMCI) (2016) argues over the ongoing influence which manufacturing has on driving the global economies. From its influence on infrastructure development, job creation, and contribution to GDP on both an overall and per capita basis, a strong manufacturing sector creates a clear path towards economic prosperity. In 2015, manufacturing in the US alone generated more jobs than any other sector, employing 12.3 million workers.

Recently, manufacturing related activities among global nations are rapidly evolving. Manufacturing earnings and exports are stimulating economic prosperity causing nations to increase their focus on developing advanced manufacturing capabilities by investing in high-tech infrastructure and education. Figure 1.6 shows that the six focus nations like US, China, Japan, Germany, South Korea, and India, collectively account for 60 percent of world's manufacturing GDP, demonstrating the influence these nations have on global manufacturing trends.

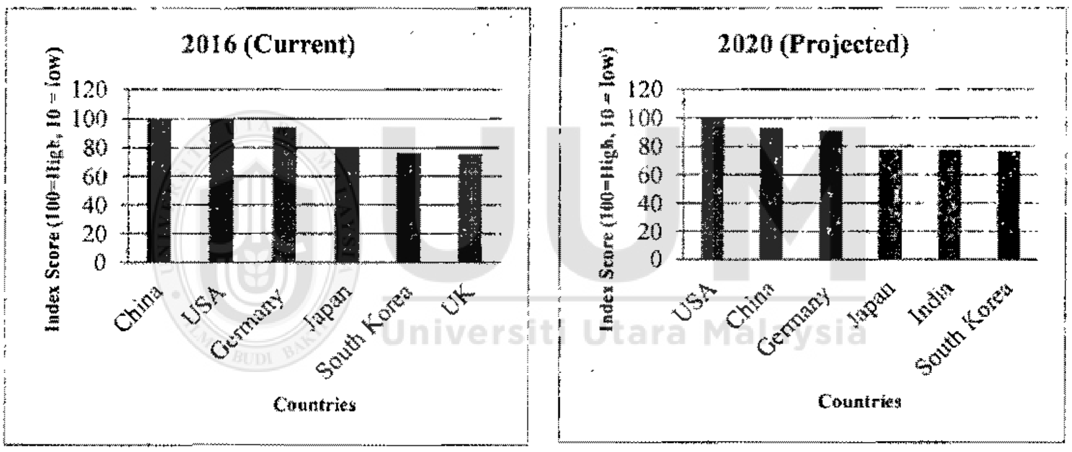

Figure 1.6
Global Manufacturing Competitiveness Index Raking by Country, 2016, 2020 (Projected).
Source: Deloitte Touche Tohmatsu Limited and US Council on Competitiveness, 2016.

On the other side, rapid industrialization in developing countries has led to economic growth and an increase in the demand of energy. Energy affects industrial production through different channels. First, energy is a fundamental input of production and that during the production process energy is required for equipment and machinery. Second, energy is also needed as transportation fuel to import and export the manufactures goods or raw material. Hence, energy remains an essential requirement in the increase of industrial production as well as in the increase of a nation's export and import. In addition, most of the energy consumption in the industrial production is from non-renewable resources which lead pollutant emissions such as CO_2 emissions. Contrary, it is suggested that during the industrial revolution at initial stage pollution emissions increases due to lack of environmental policies and old machinery. At the later stage, pollution relatively decrease due to improvement in polices and replace old machinery with latest. Hence, there is less pollution emissions during the industrial production in these countries.

1.1.2.4 International Trade

International trade has increased dramatically in the last 10 years, rising from $6.5 trillion in 2002 to around $12 trillion in 2006 to reach around $18 trillion in 2011 (World Bank, 2015). Developed countries remain the main destination of international trade flows, with total imports valued at about $10 trillion. As of 2011, developing countries' export value is like that of developed countries (around $9 trillion). Trade flows from and to developing countries largely involve middle income countries (about half) and high-income countries (about one-third). Low income countries account for a small, albeit increasing share of developing countries' trade; about 10 percent of exports and 12 percent of imports in 2011 Least developed countries (LDCs) only account for a minor, although also increasing, fraction of developing country trade (WDI, 2016). According to facts, international trade has a major part in the GDP growth. The ten highest GDP and total international trade countries from 1980 to 2016 are reported in the Table 1.5.

Table1.5
Top Ten Countries with Highest GDP and Total Trade from 1980 to 2016

Countries	GDP Billions ($)	Imports Billions ($)	Exports Billions ($)	Total Trade Billions ($)
World	1,051,368	320,261	315,557	635,818
US	223,244	42,350	32,767	75,119
China	87,969	16,565	19,072	35,639
Japan	71,558	14,524	15,819	30,344
Germany	49,127	23,583	25,843	49,427
UK	38,109	15,321	14,386	29,708
France	37,178	14,487	14,280	28,768
Italy	29,747	10,846	11162	22,009
Brazil	24,306	3,587	3,479	7,067
Canada	21,667	9,371	9,713	19,085
India	21,605	5,064	4295	9,361

Source: World Development Indicators, 2016

On the other side, international trade entails movement of goods produced in one country for either consumption or further processing to other country. Production of those goods is not possible without effective use of energy. Other things being same, international trade increases economic activities which stimulate domestic production and hence economic growth. A surge in domestic production reshapes energy demand because of expansion in domestic production. Hence, due to international trade the higher rises the production, the greater is the energy consumption (Cole, 2006; Shahbaz, Hye, Tiwari, & Leitão, 2013b; Shahbaz, Lean, & Farooq, 2013). Similarly, another group of economist suggested that international trade enables developing economies to import advance technologies from developed economies. The adoption of advanced technology lowers energy intensity. The economic consequences of advance technologies implementations consume less energy and produce more output.

However, the impact of international trade on the pollutant emissions is another predicament. As mentioned earlier that the share of international trade to the world GDP has increased from 39 percent in 1990 to 59 percent in 2011 (World Bank, 2014). This significant contribution of international trade to the world economic growth has thus made the world economy more dependent on it. But such an increase in consumption and production of goods to boost international trade also becomes a source of pollutant emissions since this rapid increase in international trade depends largely on logistics and transportation, which require a large consumption of energy in the form of fossil fuels.

1.1.3 Population

1.1.3.1 Population Size

Global population growth accounts to around 75 million annually, or 1.1 percent per year. The global population has grown from one billion in 1800 to 7 billion in 2012. It is expected to keep growing and estimated to reached at 8.4 billion by mid – 2030, and 9.6 billion by mid - 2050 (WPF. 2015). Rapid increases in the population will affect the environmental quality through increase the demand of energy. Each person creates some demands on energy for the necessities of life, food, shelter, clothing and water. Hence, the greater is the number of people, the higher is the demand of energy and environmental degradation.

1.1.3.2 Urbanization

Urbanization is a phenomenon of economic and social modernization. It is not only the process of transforming rural labor from agricultural-based economy to urban areas where industrial and service sectors prevail, but it also involves a process of structural transformation of rural areas into urban areas. A rapid growth in urbanization has been recorded during last two decades. The global population in urban areas has increased from 0.746 billion in 1950 to 3.9 billion in 2014 (UN, 2014). Recently, the world is undergoing the largest wave of urban growth in history. More than half of the world's population now lives in towns and cities, and by 2030 this number will swell to about 5 billion. Much of this urbanization will unfold in Africa and Asia, bringing huge social, economic and environmental transformations. Since urbanization is a result of economic development, it can increase energy demand. The growing urban population needs additional resources consumption, thus building more pressure on the already fragile ecosystem.

Evidently, in 2014 more than 66 percent energy has been consumed and approximately 70 percent pollutants were emitted by urban cities (IEA, 2014). However, theories of ecological modernization and urban environmental transition recognize the positive and negative impact of urbanization on the environmental quality but it is difficult to draw any early conclusion (Sadorsky, 2014).

1.1.3.3 Population Density

Population density is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes (World Bank, 2016). Generally, population density in the world shows increasing trends. In 1980 only 34.20 persons were living per square kilometer which increased to 56.62 persons per square kilometer in 2015. Table1.6 shows the top ten most densely populated countries in 2015

Table1.6
Top Ten Most Densely Populated Countries in 2015

Country	Person/seq.km	Country	Person/seq.km
Macao SAR china	19,392.93	Bahrain	1788.61
Monaco	18,865.50	Maldives	1363.87
Singapore	7,828.85	Malta	1347.91
Hong Kong	6,957.80	Bermuda	1304.70
Gibraltar	3,221.70	Bangladesh	1236.81

Source: World Bank, 2016

The impact of population density on environmental degradation is controversial subject of study. The study like Brant Liddle (2004) and Saidi and Hammami (2015) argue that energy demand depends on per capita energy consumption and population density have positive impact of per capita energy consumption. The more densely populated a country becomes, the higher is the energy demand and consequently results in the increase in the CO_2 emissions. On the other side, studies suggested that the populous and highly urban cities have less demand for personal transport, therefore, the energy consumption and CO_2 emissions may show a decrease.

1.2 Problem Statement

Based on the report of IPCC (2014), it is estimated that the average global temperature would increase between 1.1 °C and 6.4 °C in the next century. Most importantly, an increase of merely 2 °C would expect to lead to a major change in the natural ecosystems and a rise of sea levels that may threaten the lives of 50 percent of the world population who live in coastal areas such as Tokyo, Bombay, Shanghai, New York, Lagos, Jakarta, Los Angeles, Buenos Aires, Manila, Rio de Janerio, Karachi, Osaka, Bangkok, Istanbul, Penang, Kuala Lumpur and Lima (Lau, Choong, & Eng, 2014). Scientists have also found that the major greenhouse gases, for example, CO_2 emissions contribute greatly to the problem of global warming. Unlike sulfur dioxide (SO_2) whose impact is more local, whereas CO_2 emissions cause problems on a global scale (Fodha & Zaghdoud, 2010).

There are several reasons behind the rapid increase in CO_2 emissions. However, energy consumption is one of leading culprits of high CO_2 emissions. Energy is considered to be the life line of an economy, the most vital instrument of socio economic development and recognized as one of the most important strategic commodities. In the era of globalization, a rapidly increasing demand for energy and dependency of countries on energy indicates that energy will be one of the major problems in the world in the next century. Traditional growth theories focus much on labor and capital as major factors of production and ignore the importance of energy in the growth process (David I Stern & Cleveland, 2004). There are although several factors of production, but the significant role of energy cannot be ignored. It is evident that almost 80 percent energy comes from fossil fuels and non-renewable resources which undoubtedly significantly contribute creating environmental pollutant and global warming (Heidari, Turan Katircioğlu, & Saeidpour, 2015; Olugbenga A. Onafowora & Oluwole Owoye, 2014; Shahbaz, Hye, Tiwari, & Leitão, 2013a).

Most of energy is consumed in the macroeconomic and demographic activities such as international trade, financial development, FDI, industrial production, population growth, urbanization and population density. Several prior studies have investigated that these factors have though contributed to economic growth, their impact on the energy consumption and environment is still a controversial subject of discussion. The empirical studies investigated such factors and concluded that the energy demands have been decreased owing to technological improvement which has eventually improved the quality of environment and lessened the emissions (Shaari, Hussain, Abdullah, & Kamil, 2014; Shahbaz, Hye, et al., 2013a). on the contrary, some studies such as Akbostancı, Tunç, and Türüt-Aşık (2011) and M. J. Alam, Begum, Buysse, and Van Huylenbroeck (2012) argue that such factors that increase the energy consumption owing to massive production eventually degrade the environmental quality and upsurge emissions. Therefore, extensive use of energy to enhance economic growth and development and its impact on environment are mutually linked problems.

Natural ecosystem is imperative for improving standard of the living organism. Issues like CO_2 emissions due to extensive energy consumption are serious issues of the natural environment The issue of global warming due to high CO_2 emissions got substantial attentions from international forums. In a statement UN Secretary-General Ban Ki Moon stated that....

> If the trillions to be spent are directed towards low-carbon goods, technologies and services, we will be well on our way towards a more sustainable, equitable and climate-resilient world. But if we continue to invest in dirty, fossil fuel-intensive development, the consequences for all countries will be dire.......
> (UN Climate Change Summit, 23rd Sep 2014, Page no5).

Several empirically investigated by several studies. These studies have been performed in different countries and with various modeling methods, approaches and findings. These studies are dealt with several theoretical, empirical and econometric issues. The existing literature shows mixed results due to the use of a variety of econometric techniques such as regression analysis, correlation, univariate causality, panel cointegration, autoregressive distributed lag (ARDL) model, vector error correction model (VECM), Innovative accounting approach (IAA), fully modified ordinary least square (FMOLS) and generalized method of movement (GMM).

Furthermore, most of the panel studies frame indefinite group of countries whose characteristics are not similar such as panel of Brazil, Russia, India, China and South Africa (BRICS) countries, panel of Organization for Economic Co-operation and Development (OECD) countries, panel of Association of South and East Asian Nations (ASEAN) countries and panel of South Asian Association for Regional Cooperation (SAARC) countries. For example, BRICS countries include high income country (Russia), upper middle-income countries (China and South Africa), and lower middle-income country (India) and all of the countries have different structures of economy. Hence, the selection of indefinite panels is one of the reasons in getting controversial results.

To summarize, thus CO_2 emissions due to extensive energy consumption in macroeconomic and demographic activities is the main issue of global climate change and sustainable development. Although there are several studies that have discussed this issue but provide inconclusive and controversial results due to deficiency of appropriate theory, incompatible econometric methods and selection of indefinite panel of countries. Therefore, inconclusive empirical evidence cannot help economic policy planners to formulate lucid and wide-ranging sustainable economic plans to prolong a long run economic growth without polluting the environment. Hence, to investigate the impact of macroeconomic and demographic indicators on the CO_2 emissions by selecting definite panel of countries using appropriate modeling method is imperative for sustainable economic plans

1.3 Research Questions

In accordance with the background of the study and the problem statement discussed in the preceding sections, this study is mainly designed to address following core questions:

i) Do energy consumption, economic growth and population increase the level of CO_2 emissions in the selected heterogeneous income panels?

ii) Are energy consumption, economic growth and population responsible for the of the CO_2 emissions in the selected heterogeneous single countries?

iii) Is there any causality between CO_2 emissions, energy consumption, and population in the selected heterogeneous income panels countries?

1.4 Research Objectives

Generally objective of this study is to examine the impact of population, affluence and technology on the environmental degradation in the heterogeneous income panel countries. Based on the research questions, the study was devoted to achieving the following specific research objectives:

i) To investigate the effect of energy consumption, economic growth and population on CO_2 emissions in the selected heterogeneous income panels.

ii) To examine the effect of energy consumption, economic growth and population on CO_2 emissions in the selected heterogeneous single countries.

iii) To confirm the causality between energy consumption, economic growth, population and CO_2 emissions in selected heterogeneous income panels.

1.5 Significance of the Study

The global warming due to high CO_2 emissions is a worldwide issue. A considerable attention therefore is given by researchers globally to investigate the relationship between macroeconomic and demographic indicators and CO_2 emissions by using energy consumption as a mediator in different regions and countries by applying advanced econometric methodologies. Numerous studies have also dealt with the relationship between energy consumption and pollutant emissions. These studies have been performed in different countries and with various modeling methods, approaches and findings. The review of past literature reveals that most of the studies pay attention either on the nexus of energy consumption and CO_2 emissions where little effort has been made to test whether these two are linked under the same framework. However, only a few studies have investigated the relationship between macroeconomic and demographic indicators and CO_2 emissions using role of energy consumption as mediator.

The review of previous studies also concludes that most of the studies selected indefinite panel of countries, empirical and econometric techniques, which is also a reason of controversial results. Hence, this study selects panels of countries based on income levels such as high income, upper middle income, lower middle income and low-income countries. In addition, the current study is one of the first research studies that have extended the STRIPAT model by adding GDP growth, financial development, FDI and international trade as an additional factor of afflucnce, urbanization and population density as an additional factor of population and total energy consumption, nonrenewable energy consumption and renewable energy consumption as factors of technology.

Finally, results of this study will help economic and environmental policy planners of the selected countries to formulate lucid and wide-ranging energy plans to curb the CO_2 emissions, to improve energy supply, to protect environment and to prolong sustainable economic growth and development.

1.6 Scope of the Study

The research questions and objectives of the study were investigated since data collected for the duration between 1980 and 2015. World Bank has classified countries into four various categories on the basis of income level such as low income, lower middle income, upper middle income and high-income countries. This study is based on the data of top ten CO_2 emitting countries during 1980 - 2015 selected from each income level. According to some facts the US is the highest pollutant emitting country at global level and among high income countries. Russian Federation, Japan, Germany and UK; Canada, Italy, France, South Korea, Poland and Australia are selected as a top ten CO_2 emitting countries from among high income countries. Similarly, China, Mexico, South Africa, Iran, Brazil, Turkey, Thailand, Venezuela, Romania and Malaysia are selected from upper middle-income countries. In addition, from lower middle-income countries, India, Indonesia, Egypt, Pakistan, Nigeria, Vietnam, Philippines, Syria, Morocco and Bangladesh are selected as they are most top ten polluted countries in this category. From the low-income countries Zimbabwe, Senegal, Ethiopia, Tanzania, Nepal, Benin, Mozambique, Congo, Togo and Niger are selected as a top ten CO_2 emitted countries during 1980 - 2015

1.7 Organization of the Study

The contents of this study are divided into five main chapters. Chapter 1 outlines the various important contents of this research topic. The specific contents are; background of the study, statement of the problem, research questions and objectives, significance, scope and structure of the study and finally a summary of the chapter. Chapter 2 reports the supporting theoretical and empirical literature and findings of past researches that are related to technology, affluence, population and CO_2 emissions in a STIRPAT framework. Chapter 3 provides methodology of the study. The results and findings of the study are presented in Chapter 4. Finally, Chapter 5 elaborates policy implications, recommendation and limitation of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides the review of literature relevant to energy consumption, economic growth, population and CO_2 emissions. This chapter has been divided into three main sections. The first section provides the theoretical literature review on the energy consumption, economic growth, population and CO_2 emissions. The second section elaborates the empirical literature available on this issue. The third section explains the literature gap. Finally, the conclusion is presented at the end of the chapter.

2.2 Theoretical Review

2.2.1 Traditional Neo-Classical Growth Model

Energy consumption which is considered as a fundamental driver of output has significant role in economic growth and development. It is a vital component in economic growth either directly or as a complement to other factors of production. The traditional Neo-classical growth model considers energy as intermediate inputs whereas land and labor as basic factors of production. Similarly, the biophysical and ecological view advocates is that energy plays an important role in income determination. Thus, the economies heavily dependent on energy use shall be significantly affected by changes in energy consumption (J.-H. Yuan et al., 2008).

Several prior studies have shown that energy consumption would likely lead to changes in CO_2 emissions. The energy consumption is also often a key determinant of CO_2 emissions. It is, therefore, worthwhile to examine the nexus between energy consumption and CO_2 emissions by considering them simultaneously in a modeling framework. Evidently, Ugur Soytas, Ramazan Sari, and Bradley T Ewing (2007b) investigated the dynamic relationship between energy consumption and CO_2 emissions. They explored that CO_2 emissions Granger cause income and energy consumption. A similar exercise was conducted by Ang, 2008 in France and Malaysia but the results indicated that energy consumption granger cause CO_2 emissions in France and in Malaysia as well (Eddine Chebbi, 2010) collected the Tunisian data to investigate the relationship between energy consumption and CO_2 emissions. The results indicated that energy consumption stimulates economic growth and thus Granger causes CO_2 emissions. In case of India, Ghosh (2009) investigated the causal relationship between energy consumption and CO_2 emissions by incorporating investment and employment as additional determinants of CO_2 emissions but reported no causality between energy consumption and CO_2 emissions.

Bélaïd and Abderrahmani (2013) examines the causal relation between energy consumption and CO_2 emissions using the Chinese data. The findings of the study reveal that energy consumption Granger causes CO_2 emissions which lead to environmental degradation. Using Turkish data Halicioglu (2009a) also reported feedback hypothesis between energy consumption and CO_2 emissions. Similarly, Odhiambo (2010) reinvestigated the causality between energy consumption and CO_2 emissions and also found unidirectional causality running from energy consumption to CO_2 emissions.

The study of M. J. Alam, Begum, Buysse, Rahman, and Van Huylenbroeck (2011) examined the link between energy consumption, economic growth and energy pollutants in case of India. Their empirical evidence revealed the bidirectional causal relationship between energy consumption and CO_2 emissions while neutral hypothesis existed between CO_2 emissions and economic growth.

In case of Bangladesh, M. J. Alam et al. (2012) detected the causal relationship between these variables and opined that variables are cointegrated for the long run. Their results reported the presence of feedback hypothesis between energy consumption and CO_2 emissions, while unidirectional causality is found running from CO_2 emissions to energy consumption. In case of Greece, Sharif Hossain (2011) investigated the causality between energy intensity, income and CO_2 emissions and concluded the existence of long run relationship between the series. The unidirectional causality is found running from economic growth to energy intensity and CO_2 emissions, while feedback hypothesis exists between energy intensity and CO_2 emissions. In case of India, M. J. Alam et al. (2011) examined causality between energy consumption, CO_2 emissions and economic growth and they found that causality between CO_2 emissions and economic growth is independent. J. Park and Hong (2013) examined the relationship between energy consumption, economic growth and CO_2 emissions in case of Korea and found long run relation between the variables and noted unidirectional causality economic growth to CO_2 emissions.

2.2.2 Environmental Kuznets Curve (EKC)

Relationship between economic growth and environmental degradation has been a widely discussed subject since the pioneering work of Nobel Laureate economist Simon Kuznets (1955a). Kuznets found a relationship between per capita income and income inequality as an inverted U-shaped curve. More precisely, if the per capita income increases, then the income inequality also increases at first and starts declining after a turning point. Hence, inverted U-shaped curve is found between per capita income and income inequality. Based on this idea studies like Grossman and Krueger (1991), Panayotou (1993) and Shafik and Bandyopadhyay (1992) also reported inverted U-shaped relationship between GDP per capita and environmental degradation. The increase in economic growth initially hurts environment due to the lack of environmental laws and policies but stops hurting after reaching critical high-income level called EKC.

Existing studies including Cropper and Griffiths (1994), Grossman and Krueger (1994), Hettige, Lucas, and Wheeler (1992), Martínez-Zarzoso and Bengochea-Morancho (2004) and Selden and Song (1995), among others investigated the relationship between income and emissions and validated the existence of the EKC. Recently, various studies validated the EKC using cross-sectional data, for instance, Lean and Smyth (2010) for ASEAN; Ozturk and Acaravci (2010a), for Central America and commonwealth of independent states; Pao and Tsai (2010) for BRIC countries; Pao and Tsai (2011) for Russia; K.-M. Wang (2013) for 138 developing and developed countries.

2.2.3 Pollution Halo and Pollution Heaven Hypothesis

The impact of FDI on the host country's environment has also been a subject of debate. Two conflicting hypotheses have been presented in previous studies, the pollution haven hypothesis and the pollution halo effect hypothesis. According to the halo effect hypothesis, the presence of foreign investors will spur positive environmental spill-overs to the host country (Albornoz, Cole, Elliott, & Ercolani, 2009) because MNCs have more advanced technology than their domestic counterparts and will tend to disseminate cleaner technology that will be less harmful to the environment (Görg & Strobl, 2005).

In contrast, the pollution haven hypothesis postulates that MNCs will look more into countries where environmental regulations are less strict (Cole & Elliott, 2005). This strategy might harm the environment in the host country if the issue is not taken seriously (Cole, Elliott, & Fredriksson, 2006). The results are both theoretically and empirically mixed (List & Co, 2000; Xing & Kolstad, 2002; Zarsky, 1999b). However, there is plenty of evidence suggesting that foreign MNCs tend to relocate the dirty industries in developing countries with lax environmental regulations rather than in developed countries, where the environmental regulations are very strict (Blanco et al., 2013; Brian R Copeland & Taylor, 2003). Therefore, depending on the nature of and the motives behind the MNCs, FDI can cause more emissions in the host countries. The effect of FDI on GHG emissions in particular has also been a subject of debate in the extant literature. The previous studies such as Hoffmann (2002) and Hassaballa (2013) have provided coherent justifications for using GHG (particularly CO_2) emissions as a proxy for pollution in general. This study argues that CO_2 is a primary source of global warming, and the variable is also highly correlated with such local pollutants as nitrogen oxide and Sulphur Dioxide.

2.2.4 Malthus and Boserup's School of Thoughts

The impact of population size on CO_2 emissions has been a widely discussed issue among researchers. Generally, there are two different perceptions on the impact of demographic factors on the environmental quality. First, Griffith (1967) argues that pressure of population on the resources cause environmental degradation while the second perception is of Boserup's who claims that an increase in population encourages the emergence of technological innovations, which leads to a negative impact of population size on the environment (Boserup, 1965b, 1981). In particular, Boserup deems a high population density to be a prerequisite for technological progress in agriculture. Accordingly, Malthusian scholars predict that the impact of population on greenhouse gases is more than proportional, while Boserupian academics state that this relationship does not exist or, if it does, it has a negative elasticity.

2.2.5 STIRPAT Model

A. Shi (2003), concerns over the impact of population pressure on environmental quality can be traced back to concerning about population change and natural resource scarcity. There are two different perspectives on the impact of demographic growth on environmental quality: the Malthusian tradition and the Boserupian approach. The

Malthusian tradition claims that environmental degradation takes place because of the pressure that the population puts on resources (Malthus, 1967). In contrast, the Boserupian perspective (Boserup, 1965a) holds that a population increase stimulates the appearance of technological innovations, which attenuate the negative impact on the environment. In particular, Boserup considers a high population density to be a prerequisite for technological progress in agriculture. Consequently, Malthusian scholars predict that the impact of population on greenhouse gases to be more than proportional, while Boserupian academics state that this relationship does not exist or, if it does, it has a negative elasticity.

Ehrlich and Holdren (1972) was first to use IPAT to describe how our growing population contributes to our environment, both positively and negatively. This took the form of an equation combining environmental impact (I) with population size (P), affluence (A, per capita consumption or production), and the level of environmentally damaging technology (T, impact per unit of consumption or production), known as I = PAT. (Chertow, 2000) reviewed the history of IPAT equation and its variants. This equation is a widely recognized formula for analyzing the impact of the population on environment (Harrison and Pearce, 2000), and is still used for analyzing the driving forces of environmental change (York, Rosa, & Dietz, 2003).

Waggoner and Ausubel (2002) revised this model by disaggregating T into consumption per unit of GDP (C) and impact per unit of consumption (T) so that I = PACT and they renamed it ImPACT. The main aim of the ImPACT model is to identify the key factors that can be changed in order to reduce environmental change and to identify some factors influencing those keys factors (York et al., 2003).

There is some controversy about I = PAT. Schulze (2002) proposes adding Behavior (B) into I = PAT, creating I = PBAT. He argues that people have many effective fashions, such as the change of their own behavior, in addition to reducing affluence or applying more efficient technology to reduce its environmental impact. But Schulze's approach has been subject to some criticisms. Diesendorf (2002) argues that some aspects of behavior are implicitly involved in each factor in the right-hand side of the equation I = PAT. Thus, B could only include those aspects of behavior that are not already included in P, A and T, and as such, B is very difficult to define precisely. However, whether using the model I = PAT, I = PBAT, or I = PACT, we get the proportionate impact of environmental change by changing one factor and simultaneously holding other factors constant. This is their fatal limitation. To overcome the limitation of these models, (York et al., 2003) reformulate IPAT into a stochastic model, naming it STIRPAT (for Stochastic Impacts by Regression on Population, Affluence, and Technology), in order to analyze the non-proportionate impact of population on environment.

Furthermore, York et al. (2003) introduce the concept of ecological elasticity in order to analyze environmental questions further. Ecological elasticity (EE) refers to the responsiveness or sensitivity of environmental impacts to a change in any of the driving factors. Thus, we can calculate the EE of any of the driving factors. The term population elasticity of impact (EEIP) refers to the responsiveness of an environmental impact to a change in population size. The term affluence elasticity of impact (EEIA) refers to the responsiveness of an environmental impact to a change in economic measurement of affluence (e.g., per capita GDP or GNP). The coefficients b and c in model (2) are respectively the EEIP and EEIA. York et al. (2003) did not discuss technology elasticity of impact because ecological elasticity is not applied to technology, and because no single operational measure of T is free of controversy.

2.3 Empirical Review

2.3.1 Review OF Empirical works based on the STIRPAT Model

The STIRPAT method has been applied by several scientists to investigate the effects of driving forces on pollutant emissions. For instance, York et al. (2003) study a non-linear relationship between emissions and factors such as population, urbanization and economic growth for 142 nations and find a positive relationship between emissions and the independent variables. In a similar study, York et al. (2003) conclude that the elasticity of CO_2 emissions with respect to population is close to unity. Y. Shi and Massagué (2003) finds a direct relationship between population changes and emissions in 93 countries over the period from 1975 to 1996. Using a sample of 86 countries during the period from 1971 to 1998, Cole and Neumayer (2004) study the effects of population size and several other demographic factors, including age composition, the urbanization rate and the average household size, on CO_2 and sulphur dioxide (SO_2) emissions. The results indicate that there is a U-shaped association between population size and SO_2 and a positive association between the urbanization rate and CO_2 emissions. Moreover, a higher average household size is found to decrease emissions. In contrast, a negative relationship between urbanization and CO_2 emissions is found by Fan, Liu, Wu, and Wei (2006) for developed countries over the period 1975 to 2000. The same result is obtained by These authors analyses the determinants of CO_2 emissions during the period of 1975 to 2003 and demonstrate that although the elasticity of emission-urbanization is positive in low-income countries, it is negative in middle upper and high-income countries.

S. Lin, Zhao, and Marinova (2009) add urbanization and industrialization factors to the basic model and name the new model STIRPUrInAT. These authors use this revised model to analyses environmental impacts in China from 1978 to 2006 and find that the population had the largest potential effect on environmental impact, followed by the urbanization level, the industrialization level, GDP per capita and the energy intensity. Similar to the study of Fan et al. (2006), a study by Poumanyvong and Kaneko (2010a) considers different development stages and provides evidence of positive effects of population, affluence and urbanization on CO_2 emissions for all income groups, low, middle and high. Considering aggregate CO_2emissions and CO_2 emissions from transport for 17 developed countries covering the period from 1960 to 2005, Brant Liddle and Lung (2010) reveal that the total population and economic growth positively influence these two types of emissions. However, urbanization has a positive and significant impact on only CO_2 emissions from transport. When improving this study by performing unit root and cointegration tests, Brant Liddle (2013) finds positive associations between GDP per capita and CO_2 emissions from transport and between the total population and CO_2 from transport. Using a panel of 29 provinces in China from 1995 to 2010, C. Zhang and Lin (2012a) show that population, affluence, industrialization and energy intensity increase CO_2 emissions for the whole sample, whereas the results are different across the different regions.

This section will be divided into three sub sections. The first section explains the past studies related to energy consumption (total energy consumption, renewable energy consumption and non-renewable energy consumption) and CO_2 emissions. The second section illustrates the prior literature related to economic growth (GDP growth, financial development, international trade, FDI and industrial production) and CO_2 emissions. Finally, the third section discusses the previous literature on the population size (population size, urbanization and population density).

2.3.2 Energy Consumption and CO_2 Emissions

This study utilized three different measurements of energy consumption such as total energy consumption, non-renewable energy consumption and renewable energy consumption to explore the relationship with CO_2 emissions. In the following sections this study reported studies on the relationship between total energy consumption, non-renewable energy consumption and renewable energy consumption and CO_2 emissions.

2.3.2.1 Total Energy Consumption and CO_2 Emissions

Energy plays an essential role in economic growth. According to traditional neo-classical growth model, energy is an intermediate whereas land and labor are basic factors of production. Thus, the economies heavily dependent on energy use are significantly affected by changes in energy consumption. Though energy consumption plays a vital role in economic growth, it also hurts the environment by emitting CO_2 emissions. Hence, an extensive use of energy to enhance economic growth and their impact on environment are the interlinked problems for sustainable development.

The relationship between energy consumption and economic growth, as well as economic growth and CO_2 emissions got substantial attention from the researchers in the last two decades. After 1970's energy crises, several studies such as Kraft and Kraft (1978), Akarca and Long II (1979), Akarca and Long (1980) and Yu and Choi (1985) investigate that energy consumption is one of the main factors of production and have positive significant affect the economic growth of host country. The past studies showed contentious and ambiguous results which may not be suitable for lucid and prolong policy implication across countries. The review of past literature found that most of the studies pay attention either on the nexus of energy consumption – economic growth or economic growth - CO_2 emissions where little effort has been made to test these two links under the same framework. The study of Ugur Soytas, Ramazan Sari, and Bradley T. Ewing (2007a) mentioned the criteria to evaluate the energy consumption – economic growth and economic growth – CO_2 emissions nexuses. The study argues that if there is unidirectional causality running from CO_2 emissions to economic growth then the relationship may be such that emissions occur during production and, as a result, income rises. In contrast, if there is unidirectional causality running from economic growth to CO_2 emissions, the relationship may be referred to as an Engel curve for an economic bad. Further, upon existence of bidirectional causation the variables directly affect each other and there is a feedback effect too.

The study of Ang (2007a) examined the relationship between energy consumption, CO_2 emissions and output in France from the period 1960-2007. The results of Granger causality reveal that economic growth exerts casual influence on energy consumption as well as CO_2 emissions in the long run and energy consumption cause economic growth in short run. The findings suggest that the higher the economic growth the more is the demand for energy, resulting in an increase in CO_2 emissions in France. Similar results have been found by Hwang and Yoo (2014) in Indonesia and Joo, Kim, and Yoo (2014) in Chili. James B. Ang (2008) also conducted a study on Malaysia and the results of VECM imply that economic growth of Malaysia significantly contributed to pollutant emissions and energy consumption during the 1971-1999. In Malaysia, it is not surprising that an increase in pollutant level induces economic if much energy inputs have been consumed in the production to promote heavy industry since an extensive energy consumption results in an increase in pollution.

Similarly, Soytas et al. (2007a) examined the linkages among economic growth, energy consumption and CO_2 emissions during 1960-2004 in the US. The study applied multiple econometric techniques such as Toda–Yamamoto (TY), variance decompositions and generalized impulse response in a multivariate framework. Their findings suggested that energy consumption is the main source of CO_2 emissions but it does not have any relationship with economic growth in case of the US. Since there is no evidence of relationship between energy consumption and economic growth, reduction in energy consumption will not hurt the economic growth. The results suggested that the US should decrease the energy consumption or formulate alternative policies such as switching over to renewable energy consumption, or decrease energy intensity as well as increase the consumption of cleaner energy to encounter the CO_2 emissions. Furthermore, Soytas and Sari (2009) studied the causality between energy consumption and pollutant emissions in Turkey. The results of the study suggested that there is strong evidence of relationship between energy consumption and economic growth but the increase in energy consumption was caused by CO_2 emissions in Turkey during 1965 - 2004. Another study on Turkey by Ozturk and Acaravci (2010a) explored the long run relationship between energy consumption and economic growth by using ARDL testing over the time period 1968 -- 2005. The results were in favor of long run relationship among all proposed variables at five percent significance level in Turkey during this period. The study of Ozturk and Acaravci (2010a) did not support the results of Soytas and Sari (2009) and Agan, Acar, and Borodin (2013) in case of Turkey. The inconsistency in the results of the same country might be due to different methodologies and time periods. It is not possible to formulate clear economic and environmental policies in the case of such contradictory results. However, these inconsistent and contradictory results open new horizon to reinvestigate the relationship in case of energy consumption and pollutant emissions.

Apergis and Payne (2009a) examined the relationship between energy consumption and CO_2 emissions among six Central American countries during 1971 – 2004. The results show that in short run both energy consumption and economic growth significantly affect CO_2 emissions. According to authors, these results are not surprising since energy consumption is a complement of production. The results demonstrate that energy consumption affect CO_2 emissions both in long run and short run. However, with the increase in economic growth, CO_2 emissions decline. Nicholas Apergis and James E. Payne (2010) also extended the work of Ang (2007a) and explored the relationship among economic growth, energy consumption and CO_2 emissions from 1992 – 2004 in 11 commonwealth countries. The Im, Pesaran, and Shin (2003) panel unit root test was used to test stationarity and FMOLS proposed by Pedroni (2001) was applied to test the co-integration. The results of the study suggest that energy consumption has a significant contribution to increase CO_2 emissions.

The study of Ozturk and Acaravci (2010a) presented comprehensive analysis on the relationship between energy consumption and CO_2 emissions. The study utilized panel data from 1960 – 2005 of 19 European countries including Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and UK. The results of bound test explain that an increase in the consumption of energy per capita, per capita GDP and square of per capita GDP contribute to CO_2 emissions in Denmark, Germany, Greece, Iceland, Italy, Portugal and Switzerland whereas in rest of the countries it shows insignificant relationship.

Furthermore, Feng, Sun, and Zhang (2009) explored the causality among energy consumption, economic growth and CO_2 emissions in China from 1960 – 2007. The results of multivariate framework suggest that energy consumption and economic growth, energy consumption and CO_2 emissions are complements of each other. The increase in energy consumption leads to economic growth and CO_2 emissions as well. Therefore, the government of China can pursue conservative energy policy and CO_2 emissions reduction policy in the long run without impeding economic growth. The results are consistent with the study of Chang (2010) in China over the period 1981 – 2006. In addition, Fei, Dong, Xue, Liang, and Yang (2011) also conducted study in China by applying dynamics Ordinary Least Square (DOLS) test over the period 1985 – 2007. The results suggest that there is cointegration between GDP per capita and energy consumption. The Granger causality results show that energy consumption causes economic growth and CO_2 emissions as well. For example, one percent increase in GDP per capita causes 0.48 percent and 0.41 percent increase in energy consumption and CO_2 emissions, respectively. Furthermore, in case of China, the most recent study on this issue has been conducted by (S. Wang, D. Zhou, P. Zhou, and Q. Wang (2011a)) by utilizing panel VECM and data over the period 1995 – 2007. A long run relationship shows comparable results as in the studies of C. Zhang and Lin (2012a) and Bélaïd and Abderrahmani (2013). However, causality results are totally different from all previous studies in case of China. The results also suggest that there is bi-directional causality between energy consumption and CO_2 emissions as well as energy consumption and economic growth.

The dynamic interrelationship in the output-energy-environment nexus is analyzed by applying panel cointegration technique and panel Granger causality link in the short run and long run time scale. There are many studies which suggest that panel-based tests are more accurate than individual series based tests for a short span of data (Al-Iriani, 2006). However, in the panel, it is difficult to apply one result on all other countries where economic structure is different from each other. For example study of Pao and Tsai (2010) explored the potential determinants of CO_2 emissions in case of Brazil, Russia, India and China over the period 1990 – 2005. The results of panel Granger causality revealed that energy consumption and economic growth are the complements of each other whereas energy consumption and CO_2 emissions also show the bi-directional causality.

Pao, Yu, and Yang (2011) explored the relationship between energy consumption, economic growth and CO_2 emissions in case of Russia during the 1990 – 2007. The results of Johansen Maximum Likelihood (JML) and OLS show that all the variables are significant in case of Russia. The results of the study suggest that in order to reduce emissions and avoid having a negative effect on economic growth, there is a need to improve infrastructure to get better energy efficiency. In other words, energy conservation is expected to increase the efficient use of energy; thus promoting economic growth and environmental quality. The results of this study are consistent with another study of the same authors Pao and Tsai (2011) in case of Brazil over the period 1980 – 2007.

There are several other studies that have been conducted in India on this issue, but the results are inconsistent. For example M. J. Alam et al. (2011) applied TY during 1971 – 2006 and explored that energy consumption leads CO_2 emissions and do not have relationship with economic growth in India. Whereas, in another study, Vidyarthi (2013) applied Johansen cointegration approach and Granger causality and explores that energy consumption leads to economic growth, a result opposite to the study of M. J. Alam et al. (2011). Another study of Yang and Zhao (2014) is the most recent study in case of India and shows results different from those in the study of M. J. Alam et al. (2011) and Vidyarthi (2013). The study has used Granger causality test during the period of 1970 – 2008 and suggest that all the variables are jointly causal to each other.

There are several other studies that have been conducted on the panel of different countries on this issue and found different results. A panel study has been conducted by (Saboori, Sapri, and bin Baba (2014)) on the OECD countries over the period 1960 – 2008. The study utilized FMOLS to confirm the long run relationship among all variables. The results suggest that energy consumption and economic growth as well as energy consumption and CO_2 emissions are complement to each other. Whereas, Al-mulali, Lee, Hakim Mohammed, and Sheau-Ting (2013) used Canonical Cointegration Regression (CCR) over the period 1980 -2008 in Latin American Caribbean Countries and found similar results. Salahuddin and Gow (2014) also explored that an increase in economic growth will increase the demand of energy which cause CO_2 emissions in all GCC countries. Similarly, Omri (2013) applied GMM in the period 1990 - 2011 and the results of 14 - Middle East and North Africa (MENA) countries shows same results as those of Salahuddin and Gow (2014). The mentioned studies have discussed previous literature related to energy consumption, economic growth and CO_2 emissions. It has been observed that whether it was a single country study or panel studies, each applied diversifying econometric techniques, but results were found inconsistent in each case.

2.3.2.2 Nonrenewable Energy Consumption and CO_2 Emissions

There are several studies that incorporate non-renewable energy consumption beside total energy consumption to investigate the relationship between economic growth and CO_2 emissions. The energy that comes from fossil fuels such as oil, coal and gas are commonly known as non-renewable energy. In fact, major part of energy comes from fossil fuels consumption which leads to rapid increase in GHG emissions and consequently global warming. This global nature of energy challenges needs to decrease and an efficient use of non-renewable energy resources. The continuous increase in GHG due to fossil fuels consumption has encouraged many countries to find alternative sources of energy that can meet their increasing demand of energy and save the environment. A decrease in the dependency on fossil fuels and an increase in the utilization of renewable energy consumption need proper policy formulation. The economic growth of many countries depends on fossil fuels consumption, for example, Bloch, Rafiq, and Salim (2015) explored that economic growth of China depends on coal consumption. Although coal consumption of China hurts the environment by emitting high level of CO_2 emissions but a direct reduction in the consumption may negatively affect economic growth.

Malaysia is one of the fastest growing countries in the ASEAN region. The rapid growing industries increase the demand of energy and 95 percent energy comes from the fossil fuels including oil, gas and coal which lead to pollutant emissions. The study of Azlina and Mustapha (2012) explored that huge consumption of non-renewable energies contributes in GHG emissions in case of Malaysia. Similar results have been found by Saboori, Sulaiman, and Mohd (2012a) during the period 1980 – 2009. Furthermore, industrial output and evolution towards export- oriented technologies in the ASEAN region have put more pressures on the amount of energy consumed. According to World Bank (2014), 90 percent of the energy requirement is met by the non-renewable energies which results in CO_2 emissions in the region. Additionally, Saboori and Sulaiman (2013) explored that although energy consumption contributes to the economic growth but it is also a main source of CO_2 emissions in most of the ASEAN countries. Similar results have been found by Arouri, Ben Youssef, M'Henni, and Rault (2012) in case of MENA countries. In contrast, the most recent study on ASEAN region Heidari et al. (2015) found that there exists no relationship between energy consumption, economic growth and CO_2 emissions during the time period of 1980 – 2008.

On the other hand, Shafiei and Salim (2014) explored the effect of non-renewable energy consumption on economic growth based on neoclassical economic growth model in case of 29 OECD countries during 1980 – 2011. The main findings of the study show that there is bidirectional causality between non-renewable energy consumption and economic growth. The results confirm the feedback hypothesis, which entails that a high level of economic growth leads to a high level of non-renewable energy consumption and vice versa in case of 29 OECD countries. Although, non-renewable energy consumption contributes to the economic growth, but it also causes the increase in CO_2 emissions (Bölük & Mert, 2014; Farhani & Shahbaz, 2014).

Moreover, fossil fuels specially coal consumption is a main source of CO_2 emissions. Thus, countries where a large portion of energy comes from coal consumption are emitting more pollutants (IEA, 2014). Menyah and Wolde-Rufael (2010b) explored the relationship between energy consumption, economic growth and CO_2 emissions in case of the coal abundant country South Africa over the period 1965 – 2006. The TY causality test shows expected results that coal consumption in South Africa is although important for economic growth, but it also produces high CO_2 emissions.

Coal is one of the major types of fossil fuels energy playing a vital role in the economic growth of the host countries. The study of Satti, Hassan, Mahmood, and Shahbaz (2014) explored the relationship between coal consumption and economic growth of Pakistan during 1974 – 2010. The results of VECM test show that coal consumption has positive effect on economic growth. The authors explain that the results of this study are not surprising since coal is a main source of energy consumption in Pakistan. Further, they also examined the relationship between coal consumption, economic growth and CO_2 emissions. The results of Granger causality show that there is bidirectional causality between coal consumption and economic growth in China. Since coal is the main source of electricity generation in China the decrease in coal consumption without appropriate policy may cause adverse effect on economy of China. Bloch, Rafiq, and Salim (2012) also found bidirectional causality between coal consumption and economic growth in case of China during 1977 – 2008. On the other hand, Menyah and Wolde-Rufael (2010b) revisited the casual relationship between coal consumption and economic growth for six major coal consumer countries. The results of VAR and TY causality test showed unidirectional causality running from coal consumption to economic growth in India and Japan, while the reverse, that is, economic growth to coal consumption in China and Korea. However, bidirectional causality is found between economic growth and coal consumption in case of the US and South Africa during the period 1965 – 2005. In addition, Asghar (2008) used ECM and TY causality test for the period 1971 – 2003 and explored that there is unidirectional causality running from coal consumption to economic growth in case of Pakistan.

The study of Bloch et al. (2015) explored the relationship between oil, coal and economic growth using both supply side and demand side framework. The ARDL and VECM test were utilized to investigate both short run and long run relationship. The results show that coal and oil positively contribute to Chinese economy during 1977 – 2013. Oil is one of the main fossil fuel and source of energy especially in developing countries. Therefore, conservation policies could hurt the economic growth. The study of (Shahbaz, Sbia, Hamdi, & Ozturk, 2014) investigated that oil consumption and CO_2 emissions depend on each other in case of Malaysian economy during 1965 – 2011. The study also suggests that since Malaysian economy is based on oil consumption, a direct reduction in the consumption of oil may cause adverse effect on the economy. Similarly, Wandji (2013) applied Granger causality and found unidirectional causality between oil consumption and economic growth in case of Cameroon. In addition, diesel is another type of fossil fuel which is normally used in transportation sector. Although proportionately the share of diesel among other fossil fuels is smaller than other fuels but still it is an important source of energy and contributes to the economic growth. The study of Lean and Smyth (2014) utilized ARDL and finds that diesel positively contributes to the Malaysian economy during 1980 – 2011. Thus, in this regard government should make sure the supply of diesel for strengthening the economy.

The environmental protection is another important challenge for the policymakers especially for a highly oil dependent economy such as Saudi Arabia. The oil is one of the major fossil fuels which emit high CO_2 emissions in the world. The 100 percent of energy consumption in Saudi Arabia comes from the oil consumption. There are only two main studies including Alshehry and Belloumi (2015) and K. Alkhathlan, M. Q. Alam, and M. Javid (2012b) which examined the factors of CO_2 emissions in case of Saudi Arabia. K. Alkhathlan, M. Alam, and M. Javid (2012a) used ARDL and VECM for the purpose to investigate long run relationship among all the variables over the period 1980 – 2008. The results imply that energy consumption and economic growth have positive and significant relationship. The energy consumption leads to a more economic growth and CO_2 emissions over the time period 1980 – 2008. Whereas, the most recent study Alshehry and Belloumi (2015) got almost comparable results as (Alkhathlan et al., 2012a) in case of Saudi Arabia.

Furthermore, Tamba, Njomo, Limanond, and Ntsafack (2012) applied Granger causality test and found similar results in case of Cameroon during 1975 – 2008. The results of S.-Y. Park and Yoo (2014) and (Wandji, 2013) supported the findings of Al-Mulali (2011) in case of MENA region; C.-C. Lee and Chiu (2011) in 6-developed countries; Abosedra, Dah, and Ghosh (2009) in Lebanon; Asghar (2008) in Nepal and (Zamani, 2007) in case of Iran where oil consumption play a crucial role in the economic growth.

Additionally, natural gas is another type of fossil fuel but as compared to other sources such as oil and coal it contains fewer CO_2 emissions. The previous literature shows that natural gas has contributed positively to the economy of the host countries. For example Shahbaz, Arouri, and Teulon (2014) explore the relationship between gas consumption and economic growth in Pakistan. The results of ARDL testing approach show that there is bidirectional causality between gas consumption and economic growth. These results support the findings of Shahbaz, Lean, et al. (2013) in case of Pakistan; Nicholas Apergis and James E Payne (2010) in panel of 67-countries and Zamani (2007) in Iran. Additionally, Asghar (2008) and J.-L. Hu and Lin (2008) found unidirectional causality running from gas consumption to economic growth in case of Bangladesh and Taiwan, respectively. Given that natural gas constitutes the primary source of energy, the conservation policies could harm growth and, therefore, it requires the policy makers to improve the energy supply efficiency as well as explore new source of energy.

2.3.2.3 Renewable Energy Consumption

There are several studies that incorporate renewable energy consumption beside non-renewable energy consumption and total energy consumption to investigate the relationship with economic growth and CO_2 emissions. The energy that comes from various sources such as biomass, wood, tide, wave, solar and wind is commonly known as renewable energy. The renewable energy is environment friendly, safe and unlimited as compared to fossil fuels energy. Consequently, a rapid increase in the world demand and consumption of renewable energy has been recorded. According to IEA (2014), renewable energy generation shows continuous increasing trends, it has increased 18 percent, 21 percent and 22 percent in 2007, 2012 and 2013, respectively.

Ben Aïssa, Ben Jebli, and Ben Youssef (2014) investigated 11-African countries during the period 1980 – 2008. The results of FMOLS show that renewable energy consumption is positively related with economic growth in 11-African countries. Furthermore, Robalino-López, Mena-Nieto, and García-Ramos (2014) and Nicholas Apergis and James E Payne (2010) also found similar results with the addition that renewable energy not only positively affect the economic growth but also helps to reduce CO_2 emissions in case of Ecuador and 20 - OECD countries. Slightly different results have been found by B. Lin and Moubarak (2014) in case of China. The study utilized time series data from 1977 – 2011 and ARDL test to confirm the relationship and direction of causality between renewable energy consumption and economic growth. The results show that increase in renewable energy contributes to the economic growth and vice versa and there is no evidence of relationship between renewable energy consumption and CO_2 emissions. The findings of Sebri and Ben-Salha (2014) in case of BRICS countries during 1971 – 2010 support the results of (B. Lin & Moubarak, 2014).

Whereas, the results of Apergis and Payne (2009a) suggested that renewable energy consumption does not have any relationship with economic growth in the US during 1949 – 2006. While comparing previous studies, Farhani and Shahbaz (2014) implied different results. The study applies FMOLS and DOLS for the period 1980 – 2009 and investigates that both renewable and non-renewable energy consumptions contribute to mitigate CO_2 emissions in MENA region countries. These results imply that further reductions of CO_2 emissions might be attained at the cost of economic growth. Further due to expansion of the production for rapid economic development these countries are consuming more energy, which results in more pollutant emissions. Thus, it is very crucial to formulate CO_2 emissions control policies in the whole region with respect to energy consumption for the sustainable development.

Ocal and Aslan (2013) applied TY causality and ARDL test to explore the relationship between renewable energy consumption and economic growth. The results show that renewable energy consumption negatively affects the economic growth of Turkey during the time period of 1990 – 2010. The results of the study suggest that renewable energy is an expensive source for developing countries, as abundant research studies have revealed that increase in income is a vital supporter behind increased renewable energy consumption. Although this does not mean that energy consumption is not vital for Turkish economy, it could be stated that the role of renewable energy consumption is relatively smaller than the other sources. Also, this result has vital consequences regarding policy, as it suggests that renewable energy limitations do not seem to damage economic growth in Turkey. In addition, another study Menyah and Wolde-Rufael (2010b) explored that there is no evidence of relationship between renewable energy consumption and economic growth in case of US during 1960 – 2007. Whereas, Menyah and Wolde-Rufael (2010b) argued that renewable energy consumption has not reached a level where it can make a significant contribution to emissions reduction.

Several studies examine that different types of renewable energy such as nuclear, wind, thermal, solar and hydro are positive contributors to the economic growth and are negatively related to pollutant emissions. For example, Omri, Ben Mabrouk, and Sassi-Tmar (2015) examined the relationship between nuclear energy and economic growth in case of 17 - developed and developing countries. The study utilized two-stage least squares (2SLS), three stage least squares (3SLS), and the GMM for the period 1990 – 2011 and explored that nuclear energy contributes to the economic growth of these countries. Similarly, results of Al-mulali, Fereidouni, and Lee (2014) suggested that nuclear energy consumption contributes to the economy as well as encounter the pollutant emissions in 30 major nuclear energy consuming countries. This result supported the findings of (Menyah & Wolde-Rufael, 2010b) in case of the US during 1960 – 2007. Additionally, Chang (2010) through Meta-Analysis explore that nuclear energy consumption and economic growth have bidirectional causality in G6 countries. Further, C.-C. Lee and Chiu (2011) used TY causality test and explored that there is bidirectional causality between nuclear energy consumption and economic growth in Canada, Germany and the UK but did not find evidence of relationship in France and the U.S. The same authors Lee and Chiu (2011b) founded same results of no relationship in six developed countries for the period of 1971 – 2006. While comparing with the other studies Wolde-Rufael and Menyah (2010) explore different results and suggest that although nuclear energy consumption helps to reduce the pollutant emissions specially CO_2 but it also hurts economic growth in nine developed countries during 1971 – 2005.

Similarly, numerous studies utilized different econometric techniques in various single as well as panels of countries over different periods. The findings of these studies suggest that renewable energies are contributors to the economic growth and help to reduce CO_2emissions (Bélaïd & Abderrahmani, 2013; Bilgili, 2012; Ohler & Fetters, 2014; Ozturk & Bilgili, 2015; Polemis & Dagoumas, 2013; Yildirim, Saraç, & Aslan, 2012; Zeb, Salar, Awan, Zaman, & Shahbaz, 2014). In contrast, Halkos and Tzeremes (2014) used least squares cross-section validation approach for the period 1990 – 2011. Their results suggested that although electricity comes from renewable source contributing to economic growth of advance economies, but there is no such relationship existing in developing economies. Similarly, Bilgili (2012) founded that biomass mitigate CO_2 in the US during the period 1990 – 2010.

2.3.3 Economic Growth and CO_2 Emissions

Environmental degradation due to rapid economic growth and extensive energy consumption are the interlinked problems. There are several macroeconomic factors that increase the demand of energy consumption and consequently hurt the environment by producing CO_2 emissions. The energy utilized for production and transportation purpose mainly comes from the fossil fuels which increases the CO_2 emissions. Shafiei and Salim (2014) investigated that the different sectors emit different levels of pollutants while consuming energy. The study of Mairet and Decellas (2009) explored that energy consumption in the service sector produce less CO_2 as compared to energy consumption in the industrial sector. In addition, several studies including Jayanthakumaran, Verma, and Liu (2012), Kasman and Duman (2015) and Kohler (2013a) scrutinized the determinants of CO_2 emissions. These studies investigate that factors including trade, industrial production, FDI, GDP per capita, service sector contribution to GDP, financial development, tourism and poverty are the determinants of CO_2 emissions.

Global warming has also been the subject of debate among researchers for the past three decades. The GHG emissions resulting from the human activities have been claimed to be the major cause of this development (Al-mulali & Che Sab, 2012; Jalil & Mahmud, 2009; Sharma, 2011). According to previous studies, energy consumption and level of economic development are among the most important causes of increased GHG emissions. This section of study reports the previous literature based on macroeconomic factors, energy consumption and CO_2 emissions.

The first stand of the researchers focuses on the relationship between economic growth and environmental degradation which has been a widely discussed subject since the pioneering work of Nobel Laureate economist Simon Kuznets found a relationship between per capita income and income inequality as an inverted-U-shaped curve. More precisely, if the per capita income increases, then the income inequality also increases at first and starts declining after a turning point. Hence, inverted U-shaped curve is found between per capita income and income inequality. Based on this idea studies like Grossman and Krueger (1991), Panayotou (1993) and Shafik and Bandyopadhyay (1992) also reported inverted U-shaped relationship between GDP per capita and environmental degradation. The increase in economic growth initially hurts environment due to the lack of environmental laws and policies but stops hurting after reaching critical high-income level called EKC. The possibility to explain inverted U-shaped relationship between economic growth and environmental degradation is based on three different channels that have been explored by David I. Stern (2004).

Existing studies including Cropper and Griffiths (1994), Grossman and Krueger (1994), Hettige et al. (1992) and Selden and Song (1995), among others investigated the relationship between income and emissions and validated the existence of the EKC. There are several studies that have empirically investigated the existence of EKC between environmental degradation and different economic and demographic variables by using single countries and panel data (Galeotti & Lanza, 1999; Grossman & Krueger, 1994; Halicioglu, 2009b; Kearsley & Riddel, 2010; Selden & Song, 1994; Shahbaz, Khraief, Uddin, & Ozturk, 2014; Shahbaz, Lean, & Shabbir, 2012; Shahbaz, Mutascu, & Azim, 2013). For instance, Dijkgraaf and Vollebergh (2005) find a statistically significant turning point and confirm the inverted – U shaped pattern for 11 out of 24 OECD countries. The study of Martínez-Zarzoso and Bengochea-Morancho (2004) analyzed 22 OECD countries using a pooled mean group estimator and provide evidence of an N-shaped relationship for the majority of these countries In contrast, X. Liu (2005) studies

24 OECD nations using panel data and finds that the EKC exists for CO_2 emissions. Similarly, the evidence supporting the EKC is found by Galeotti, Lanza, and Pauli (2006) for the OECD countries from 1950 to 1998. Canas, Ferrao, and Conceicao (2003) also find an inverted U-shaped relationship for 16 industrialized countries for the period from 1960 to 1998.

Considering nuclear power generation, Richmond and Kaufmann (2006) investigated the EKC for CO_2 using panel data for OECD countries and note that there is limited support for the EKC in the case of OECD countries. Iwata et al. (2011) also take into account nuclear energy and find poor evidence in support of the EKC hypothesis in the cases of 11 OECD countries. However, several studies examine the validity of EKC by using different variables. For instance, Sadorsky (2010) links the existence of EKC between environmental degradation and financial development, Luzzati and Orsini (2009) examines the same with energy consumption, Fodha and Zaghdoud (2010) with economic growth, Shafiei and Salim (2014) with financial development and Shahbaz, Khan, and Tahir (2013) with trade.

Recently, various studies validated the EKC using cross-sectional data, for instance, Lean and Smyth (2010) for ASEAN; Ozturk and Acaravci (2010a), for Central America and commonwealth of independent states; Pao and Tsai (2010) for BRIC countries; Pao and Tsai (2011) for Russia; K.-M. Wang (2013) for 138 developing and developed countries. But using time series data, Machado (2000), Mongelli, Tassielli, and Notarnicola (2006), Ang (2007a) , Tao, Zheng, and Lianjun (2008), Shiyi (2009), Dhakal (2010), M. J. Alam et al. (2012), Fodha and Zaghdoud (2010), Nasir and Rehman (2011), Shahbaz et al.

(2012), Shahbaz, Mutascu, et al. (2013), Shahbaz, Hye, et al. (2013a), and Kanjilal and Ghosh (2013) also supported the empirical presence of the EKC for Brazil, Italy, France, Malaysia, China, Tunisia, Pakistan, Romania and India.

2.3.3.1 Financial Development and CO_2 Emissions

In the past years numerous researchers such as Schumpeter (1934), Goldsmith (1959) and McKinnon (1993) have found a strong relationship between the financial development and economic growth. Those researchers have found that financial development can help to achieve stable economic growth, increase the country's saving, reduce the cost of information, and monitor costs. Beyond the factors of CO_2 emissions, financial development may also increase energy consumption. It may also stimulate technological progress in the energy sector aiming to reduce CO_2 emissions. Since, financial development contributes to CO_2 emissions through helping the manufacturing activities (Jensen, 1996). Financial development may also contribute to research and development activities and consecutively make better economic activities, and consequently, persuade environmental quality (J. A. Frankel & D. H. Romer, 1999), especially in developing countries (Frankel & Rose, 2002a). Accordingly, elimination of a nexus between financial development and CO_2 emissions may lead to omission of an important variable in the regression.

Numerous studies examine that financial development increases the demand of energy and consequently, contribute to the CO_2 emissions. In addition, Ziaei (2015) investigated the nexus between economic growth, energy consumption, financial development and

CO_2 emissions in 12 East Asia and Oceania and 13 European countries during 1989-2011. The results of panel VECM suggested that financial development leads to higher energy consumption and ultimately causes CO_2 emissions in these regions. However, another study Shahbaz, Mallick, Mahalik, and Loganathan (2015) explored the impact of economic growth, energy consumption and financial development on pollutant emissions in Malaysia. The ARDL bounds testing approach and VECM have been applied to confirm the long run, short run cointegration and causality among the said variables. The results suggest that there is long run cointegration among entire variable but as far as financial development and CO_2 emissions is concerned, financial development mitigate CO_2 emissions in Malaysia during the period 1971-2011. The study of Boutabba (2014) argued that since financial development increase the CO_2 emissions through an increase in energy consumption. The study suggested that, financial funding agencies including banks must invest in the installation of energy efficient heating and energy-efficient lighting and cooling apparatuses. While doing this, banks may give priorities, discount in interest rate and incentives to loans that are related to less emissions businesses.

In the recent years, a rapid increase in the urban population has changed the pattern of financial sector development that also led the increase in the energy pollutants, especially in developing world. For example Shahbaz, Salah Uddin, Ur Rehman, and Imran (2014) applied structural break unit root test and ARDL testing approach to examine the cointegration among electricity consumption, industrialization, trade openness, financial development and pollutant emissions in the presence of structural break in the series. Besides the other results, the findings show that the financial development increase CO_2 emissions for the period 1975-2010 in case of Bangladesh. Currently, Bangladesh is facing serious climate change problem and in this situation government should focus on the improvement of environment quality. The findings of the study also suggest that clean energy investment may reduce the threats on environmental quality. Another study of Al-Mulali and Sab (2012b) examined the role of financial development and economic growth on CO_2 emissions and energy consumption in SSA countries during the period 1980-2008. The results of panel Granger causality test suggest that first financial development has role in boost of economic growth and then both jointly lead to primary energy use and therefore contribute to the CO_2 emissions. The findings of this study recommend that an increase in energy productivity by increasing energy efficiency, implementation of energy savings projects, energy conservation, and energy infrastructure subcontracting are some actions to achieve the goal of sustainable development. Furthermore, same authors Al-mulali and Sab (2012a) examined the relationship between energy consumption, economic and financial development and CO_2 emissions in 19 different countries for the period 1980-2008. The results indicate that economic and financial development goals are achieved at the cost of environmental degradation. The results suggest that these countries can reduce CO_2 emissions through utilizing energy protection policies, such as rationing energy consumption and controlling CO_2 emissions or increasing the share of clean energy of their total energy consumption.

Similarly, Y.-J. Zhang (2011) explored the effect of financial development on CO_2 emissions. There are several results like, first, China's financial development which constitutes an important driver for CO_2 emissions increase should be taken into account when CO_2 emissions demand is projected; second, the influence of financial intermediation scale on CO_2 emissions outweighs the effect of other financial development indicators though the influence of its efficiency appears weak but capable of causing a change of CO_2 emissions statistically; third, China's stock market scale has a relatively larger influence on carbon emissions but the influence of its efficiency is very limited. Finally, among financial development indicators, China's FDI exerts the least influence on the change of CO_2 emissions, due to its relatively smaller volume compared with its income.

On the other hand, several studies such as Boutabba (2014), Shahbaz, Kumar Tiwari, and Nasir (2013), Shahbaz, Solarin, Mahmood, and Arouri (2013), Tamazian, Chousa, and Vadlamannati (2009) and Yuxiang and Chen (2011) have argued that financial development helps to improve the environmental quality. Boutabba (2014) explored the impact of financial development on pollutant emissions in India for the period 1971-2008. To investigate the impact, this study adopts ARDL testing approach for cointegration and VECM to test the causal relationship between suggested variables. The results show that financial development helps to protect the environment through different channels. Similarly, Shahbaz, Hey, et al. (2013) examined the impact of financial development on the environmental quality in South Africa during the period 1965-2008 by applying ARDL testing approach. The findings of the study show that the increase in the financial development can improve the environment quality and these findings entail that financial development can be used as a policy to keep environment clean by introducing financial reforms. Similar results were found in the studies of Boutabba (2014) and Shahbaz, Hye, et al. (2013) in case of Indonesia for 1975-2011 and those of Shahbaz, Solarin, et al. (2013) in Malaysia for the period 1971-2011. These studies had also applied ARDL testing approach for cointegration and VECM to test the causal relationship between recommended variables. The results of Shahbaz, Hye, et al. (2013a) are slightly different from those of Boutabba (2014), Shahbaz, Hye, et al. (2013a) and Shahbaz, Solarin, et al. (2013). However, the results of all four studies agreed that financial development helps to mitigate the CO_2 emissions but Shahbaz, Hye, et al. (2013) find inverted U-shaped relationship between financial development and CO_2 emissions. This means that with the increase in financial development first CO_2 emissions increases and then it decreases.

2.3.3.1 Financial Development and CO_2 Emissions

In the past years numerous researchers such as Schumpeter (1934), Goldsmith (1959) and McKinnon (1993) have found a strong relationship between the financial development and economic growth. Those researchers have found that financial development can help to achieve stable economic growth, increase the country's saving, reduce the cost of information, and monitor costs. Beyond the factors of CO_2 emissions, financial development may also increase energy consumption. It may also stimulate technological progress in the energy sector aiming to reduce CO_2 emissions. Since, financial development contributes to CO_2 emissions through helping the manufacturing activities (Jensen, 1996). Financial development may also contribute to research and development activities and consecutively make better economic activities, and consequently, persuade environmental quality (J. A. Frankel & D. H. Romer, 1999), especially in developing countries (Frankel & Rose, 2002a). Accordingly, elimination of a nexus between financial development and CO_2 emissions may lead to omission of an important variable in the regression.

Numerous studies examine that financial development increases the demand of energy and consequently, contribute to the CO_2 emissions. In addition, Ziaei (2015) investigated the nexus between economic growth, energy consumption, financial development and CO_2 emissions in 12 East Asia and Oceania and 13 European countries during 1989-2011. The results of panel VECM suggested that financial development leads to higher energy consumption and ultimately causes CO_2 emissions in these regions. However, another study Shahbaz et al. (2015) explored the impact of economic growth, energy consumption and financial development on pollutant emissions in Malaysia. The ARDL bounds testing approach and VECM have been applied to confirm the long run, short run cointegration and causality among the said variables. The results suggest that there is long run cointegration among entire variable but as far as financial development and CO_2 emissions is concerned, financial development mitigate CO_2 emissions in Malaysia during the period 1971-2011. The study of Boutabba (2014) argued that since financial development increase the CO_2 emissions through an increase in energy consumption. The study suggested that, financial funding agencies including banks must invest in the installation of energy efficient heating and energy-efficient lighting and cooling apparatuses. While doing this, banks may give priorities, discount in interest rate and incentives to loans that are related to less emissions businesses.

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Furthermore, Yuxiang and Chen (2011) applied China's provincial panel data from 1999-2006 to explore the relationship between financial development and industrial pollutants. The results find improvement in the environmental quality with the increase in financial development in all 29 provinces of China. The results suggest that financial development can improve the environment quality in several channels such as, exploiting new technology, increase in income and capitalization and implementation of regulations regarding environment. Further, Jalil and Feridun (2011) also conducted a study on China to examine the impact of energy consumption, economic growth and financial development on pollutant emissions for the period 1953-2006. The findings of the study reveal that financial development in China has not taken place at the cost of environmental degradation even if it helps to improve the quality of environment. In the support of the above-mentioned studies, Tamazian and Rao (2010) have found comparable results. Their study addresses the issue of financial development and pollutant emissions in 24 transition economies for the period 1993-2004. The findings based on of the GMM testing approach reveal that financial development is a reliable source to protect the quality of environment in suggested countries. This means that the higher is the level of financial development, the greater will be the level of environmental quality. Further this study also suggests that financial development is a fundamental factor in reducing the CO_2 emissions. It hopes that the adoption of policies directed to financial development in order to attract higher level of research and development activities related to FDI might improve the environmental quality in respective countries. In addition, Tamazian et al. (2009) applied panel cointegration in case of BRIC countries for the period 1992-2004 and found similar results as those of Tamazian and Rao (2010).

Regardless to aforementioned, several studies such as Ozturk and Acaravci (2013), Omri, Nguyen, and Rault (2014a) and You, Zhu, Yu, and Peng (2015) argued that there is no evidence of empirical relationship between financial development and environmental quality. The study utilizes world panel and quantile regression method for the period 1985-2005. The results of the study reveal that financial development has no significant effect on CO_2 emissions in almost all quantiles. Similarly, another comprehensive study on the issue has been conducted by Omri et al. (2014a). This study utilizes one global panel of 54 countries and three different regional panels such as Latin America and the Caribbean, Europe and Central Asia, North Africa, Middle East and SSA countries. The results of this study which adopted GMM testing approach suggest that financial development and CO_2 emissions do not have any relationship during the period of study 1990-2011. In addition, Ozturk and Acaravci (2013) examined the relationship between energy consumption, economic growth, financial development and CO_2 emissions in Turkey for the period 1960-2007. The results of ARDL testing approach reveal that financial development has no significant effect on per capita CO_2 emissions in the long run and short run.

The above-mentioned studies show inconclusive results but by summarizing these results it can be concluded that financial development leads to increase in CO_2 emissions for the following reasons: First, stock market development helps listed enterprises to lower financing costs, increase financing channels, disperse operating risk and optimize asset/liability structure in order to buy new installations and invest in new projects and as a result increase energy consumption and CO_2 emissions. Second, financial development may attract FDI that will increase the economic development and contribute to CO_2 emissions. Third, wealthy and well-organized financial intermediation seems encouraging consumers' loan activities, which makes it easier for consumers to buy big label items like automobile, house, refrigerator, air conditioner, washing machine, and consequently emit more CO_2 emissions. On the other hand, financial development may also increase the enterprises' performance and energy efficiency and hence decrease energy consumption and condense CO_2 emissions.

2.3.3.2 International Trade and CO_2 Emissions

The impact of international trade on the pollutant emissions is a widely discussed issue among researchers. International trade causes the movement of final and intermediary goods from one country to another for either consumption or for further production process. A considerable growth has been recorded in international trade of goods, capital and services over the last three decades (World Bank, 2014). The share of international trade to the world GDP has increased from 39 percent in 1990 to 59 percent in 2011 (World Bank, 2014). This significant contribution of international trade to the world economic growth has made the world economy more dependent on it. This increase in international trade has boosted the use of energy especially in the transportation sector. Therefore, increase in consumption and production due to international trade is one of the sources of CO_2 emissions. Consequently, several studies such as Al-mulali (2012), Farhani et al. (2014), Kasman and Duman (2015), Omri et al. (2014a), Ozturk and Acaravci (2013) and Sbia, Shahbaz, and Hamdi (2014) explored the relationship between trade and environmental quality. Besides, there are several studies that explore the impact of international trade on pollutant emissions but findings of these studies are contrasted.

According to Antweiler, Copeland, and Taylor (1998) there are three channels namely scale, technique and composition effects through which international trade can result in either environmental improvement or its deterioration. Scale effect implies that trade liberalization causes emissions due to economic expansion which is detrimental to environment. The technique effect is believed to reduce emissions because of import of efficient and environmental friendly technologies. Finally, the composition effect signifies that international trade may reduce or increase CO_2 emissions depending upon the country's comparative advantage in cleaner or dirty industries. Hence, the composition effect can have both positive and negative impacts.

Furthermore, Kasman and Duman (2015) examined the impact of international trade on the pollutant emissions. The study utilized FMOLS to explore the cointegration and causality among proposed variables in 15 EU countries during 1992-2010. The results suggest that international trade has a positive significant impact on the CO_2 mission in 15 new EU countries. The findings of the study reveal that since international trade contributes to the economic growth of the host countries, a decrease in the international trade will directly hurt the economic growth. However, increase in international trade with the same pattern will affect the goal of sustainable development. Thus, government of these countries should control CO_2 emissions through energy efficiency and replace the fossil fuel energy with renewable energy. Additionally, Al-mulali and Sheau-Ting (2014) conducted an inclusive study covering 189 countries from the six different regions Asia Pacific, Eastern Europe, the Americas, MENA, SSA and Western Europe for the period 1990-2011 The results of FMOLS testing approach reveal that in all regions excluding Eastern Europe, international trade has a positive relationship with CO_2 emissions. Moreover, this study also suggests a reduction in tariffs barriers on products and technologies that can promote energy savings and efficiency and to put a restriction on the products that can cause environmental damage. Another panel study of Omri et al. (2014a) explored the impact of international trade on CO_2 emissions covering 54- countries from the three different regions namely, Latin America and the Caribbean, Europe and Central Asia, and MENA and SSA. The results of GMM testing approach suggest that there is a strong evidence of the impact of international trade on CO_2 emissions in world and in all the three regional panels for the period 1990-2011.

Olugbenga A Onafowora and Oluwole Owoye (2014) have also explored the determinants of CO_2 emissions in a panel study for the period 1970-2010. The panel of this study consists of countries such as Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea and South Africa and the study applied ARDL testing approach. The results of the study show that international trade significantly contributes to CO_2 emissions in all three regions during the period of study. Given these findings, it would be ill advised for the policy decision makers to adopt the EKC and assume it to be the conceptual basis for policies supporting economic growth unconditionally. In other words, owing to the probability of high environmental damage, costs to human health, nation's productivity and national output, high cost is incurred to improve the environment after the damage has occurred. It is also likely that irreversible environmental damage may have been caused even before the implied turning points are reached. It is therefore imperative that the governments enact conscious national policies for mitigating environmental degradation and resource depletion rather than rely on increasing economic growth to solve their environmental problems at later stages. A wide range of policy initiatives that would increase demand for better environment quality and its sustainability should be explored in tandem with measures to spur economic growth. Similar results have been found by Hossain (2011a) in case of newly industrialized countries for the period 1971-2007, Rahman, Rehman, and Abdul-Majeed (2012) in panel of low, upper and high-income countries during the period 1975-2000 and McCarney and Adamowicz (2005) during the period 1980-1995.

Furthermore, among single country studies, S. Ren, Yuan, Ma, and Chen (2014) investigated the relationship between international trade and pollutant emissions for the period 2000-2010. This study utilized two steps GMM estimation to test the impact of international trade on the pollutant emissions in China. The results of the study reveal that China's growing trade surplus is one of the important reasons for the rapid decrease in the environmental quality. Thus, to attain environmental friendly sustainable development of

China's economy, China should formulate exertions to transform its trade growth mode, support energy efficiency and probe the pollutant emissions. Additionally, Sbia et al. (2014) examined trade openness and CO_2 emissions in case of UAE by utilizing quarterly data for the period 1975-2011. Another study Clement et al. (1998) applies unit root for the stationarity test, VEC model for Granger causality and ARDL testing approach to test the long run relationship between the suggested variables. The results of the study indicate that trade openness significantly contributes to the pollutant emissions. Further, Shahbaz, Uddin, Rehman, and Imran (2014a) applied ARDL testing approach in case of Bangladesh covering the time period 1971-2010 to explore the impact of international trade on CO_2 emissions. The results suggest that due to dirty industries such as leather, shipbuilding and chemical which utilized massive amounts of toxic chemicals, the international trade of Bangladesh has continuously increasing CO_2 emissions.

Ozturk and Acaravci (2013) utilized bound testing approach during the time period 1960-2007 in case of Turkey. The results reveal that coefficient of international trade variable is positive at five percent level of significance which suggests that an increase in international trade causes an increase in CO_2 emissions in Turkey. Further, the results of Jalil and Feridun (2011) indicate that the sign of international trade coefficient is positive and significant which show that one percent increase in international trade will lead to increase in CO_2 emissions by 0.322 percent. Additionally, findings validate the existence of an EKC curve in case of China for the period 1953-2006. The study argues that the demand of crude oil has significantly increased and it is mostly refined domestically in China which finally hurts the quality of environment. The findings suggest that China should decrease the dependence on crude oil and adopt the policy of energy efficiency.

Another single country studies of Y.-J. Zhang (2011) in case of China for the period 1994-2009 and Feridun, Ayadi, and Balouga (2006) in case of Nigeria for the period 1992-1997 also found similar results.

On the contrary, several studies argue that international trade can play a fundamental role in 'greening' of the energy sector by facilitating the technology transfer for renewable energy and by responding to demand for sustainably energy sources. This demand has led to several trade opportunities, including exports of raw materials and components for renewable energy supply products and finished products, hence reducing pollutant emissions[1]. Numerous studies such as, Birdsall and Wheeler (1993), Ferrantino (1997), Shafik and Bandyopadhyay (1992) and Shahbaz et al. (2012) conclude that trade is beneficial for environment through technique effect. Further, international trade also enhances exports of the country which leads to an increase in economic growth. This means that economic growth boosts the income level, which helps the country to import advanced and environmental friendly technology (Birdsall & Wheeler, 1993). International trade also increases the competition with local producers, which persuades them to invest in more advanced technology to decrease per unit cost and consequently cause less CO_2 emissions during production process (Ferrantino, 1997). According to Antweiler et al. (1998), international trade may reduce pollutant emissions through technique effect which implies that international trade can help in the import of efficient and environmental friendly technologies. Brian R. Copeland and Taylor (2005) argued that international trade can help to improve the quality of environment through channels

[1]United Nations Environment Program. Green economy report: towards a green economy: pathways to sustainable development and poverty eradication. Nairobi, Kenya; 2011.

such as environmental regulations and capital-labor channels. Similarly, McCarney and Adamowicz (2005) examined that even policies of the government for international trade can reduce the CO_2 emissions. In another study Grether, Mathys, and de Melo (2007) also found that international trade has resulted in a decline of the CO_2 emissions worldwide for the period 1990-2000.

Shahbaz et al. (2012) explored the impact of economic growth, energy consumption and international trade on CO_2 emissions for the period 1971-2009 in case of Pakistan. The results reveal that there is a long run relationship among all variables included in the empirical study. The findings suggest that international trade is beneficial in curbing CO_2 emissions of the country. Evidently, Sebri and Ben-Salha (2014) investigated the impact of international trade on the CO_2 emissions for the period 1971-2010 in BRICS countries. The study utilizes multiple econometric techniques such as Zivot-Andrews for unit root, VECM for granger causality and ARDL testing approach to confirm cointegration among proposed variables. The results of the study indicate that BRICS countries are benefitted from the technological transfer to encourage the renewable energy sector through international trade and hence improve the quality of environment. This means that economic growth through international trade in BRICS countries does not depend on the cost of environmental degradation. Further, results indicate that one percent increase in international trade reduces CO_2 emissions by 0.110 percent. The current findings of the study can be validated through scale, technique and composition effects. Similar results have been found by Shahbaz, Kumar Tiwari, et al. (2013) for the period 1970-2010 and Köhler (2013) during the time period 1960-2009 in case of South Africa.

Besides abovementioned arguments, a few studies such as Sharma (2011) and You et al. (2015) explored that there is no evidence of relationship between international trade and environmental quality. The study of You et al. (2015) applied Quantile regression method and simple OLS for the world panel during the period 1985-2005. The results argue that international trade has no significant effect on CO_2 emissions at almost all quantiles. Similarly, Sharma (2011) explored the potential determinants of CO_2 emissions for a global panel covering 69 countries and three sub-panels based on the income level namely, low income, middle income and high income for the period 1985-2005. The results indicate that trade openness is statistically insignificant on CO_2 emissions for global and three sub-panels.

It is concluded that the impact of international trade on CO_2 emissions is inconsistent and complex. There are three main arguments that have been discussed in above mentioned studies. First the positive impact of international trade on CO_2 emissions, second a negative impact and third no impact or insignificant relationship between both variables. All the studies have strong justifications on their explored relationships. The studies that support the negative impact of international trade on CO_2 emissions generally explore that it is due to lack of implementation governmental policies, highly dependence on fossil fuels and due to dirty industries, such as leather, shipbuilding, chemical and utilizing huge quantity of toxic chemicals. The studies that have investigated whether international trade is beneficial for environmental quality mainly argue that countries with high international trade can benefit from the technological transfer that encourages the renewable energy sector and lead to the improvement in the quality of environment. Further, international trade also enhances exports of the country which leads to an increase in economic growth.

This means that economic growth boosts the income level, which helps the country to import advanced and environmental friendly technology and consequently reduces the pollutant emissions. Last but not the least, a few studies also could not find any evidence of relationship between international trade and CO_2 emissions. It may be due to less amount of international trade, absence of environmental issues or improper application of econometric techniques.

2.3.3.3 FDI and CO_2 Emissions

FDI is one of the key indicators of economic development. Based on the general perception, FDI promotes the economies of the host country in the developing world and the countries have granted FDI a high priority in their development agenda. These governments provide range of subsidies, incentives, relaxation in the taxes, local market access and duty exemptions to attract more FDI with the belief that it will contribute positively to their economies. The FDI can contribute to the economy through several channels, such as transfer of technology, management know-how, access to global market and competitiveness of industry (Blomström & Kokko, 1998; Javorcik, 2004).

Nevertheless, effects of FDI on the natural environment of the host country still stay a controversial subject. Under the ceteris paribus condition, environmental quality would decrease with an increase in economic growth due to FDI, and vice versa. This is called scale effect of FDI on quality of environment. This means that all other things holding the same, CO_2 emissions would change as a result of the structural changes in the economy specifically owing to FDI. This also means that a move toward pollution intensive production would generate more pollution and vice versa, called composition effect. This entails that if the scale and structure of economic growth remains the same, and if new technology is introduced due to FDI, it will alter the amount of pollutant emissions per unit of output, called technique effect of globalization. The decomposition analysis suggests that FDI and investment liberalization are double-edged swords, offering both disadvantages and advantages for a country. Since these factors interact simultaneously and can work in different directions, the net environmental effect of FDI can only be assessed empirically.

There are several studies that investigate the relationship between FDI and CO_2 emissions. For example, C. F. Tang and E. C. Tan (2015) investigated the impact of energy consumption, income and FDI on CO_2 emissions in Vietnam during the time period 1976-2009. The results of the study suggest that FDI contributes greatly to the nation's economy. This shows that the policy of Vietnam government to attract FDI for economic development is sustainable. On the contrary, the results argue that FDI not only contributes to the economic growth but also causes CO_2 emissions. The decrease in the CO_2 emissions can be at the cost of hurting economic growth. In this situation policy makers should make suitable policy that can probe CO_2 emissions without compromising the economic growth. Similarly, Kivyiro and Arminen (2014) utilized annual time series data from 1971-2009 in case of SSA countries. Their results of ARDL model show that three of SSA countries Kenya, Zimbabwe and South Africa have a positive relationship between FDI and CO_2 emissions. The causality running from FDI to CO_2 emissions means that MNCs increase the level of CO_2 emissions and these results support the pollution haven hypothesis.

In addition, Lau et al. (2014) conducted a study to explore the potential determinants of CO_2 emissions in Malaysia. The study uses ARDL model to examine the cointegration and finds that FDI is a factor of CO_2 emissions in case of Malaysia during the period 1970 - 2008. The study argues that Malaysia is a rapid growing economy in ASEAN region and FDI has a fundamental role in the economic growth. In this case policy makers should focus and make sure that cleaner and advance technology is used by the foreign investors. In addition, Omri et al. (2014a) also explored the relationship between FDI and CO_2 emissions in 54 countries for the period 1990-2011. In order to examine long run relationship, GMM model has been applied which has given vaguely different results from above studies. The results of the study suggest that negative causality runs from CO_2 emissions to FDI while positive causality runs reverse, that is, from FDI to CO_2 emissions. The results of the study argue that since FDI contributes to the economic growth of host countries, policymakers should focus on implementation of environmental regulation to probe the pollutant emissions to avert FDI out flow. On the other hand, Dincer and Rosen (2002) argued that it is also important to encourage foreign investors to transfer clean technology because a progress in green technology supplemented by FDI inflow may bring to a rapid improvement in the efficient use of energy and thus may result in a reduction of CO_2 emissions.

S. Ren et al. (2014) also investigated the impact of FDI on CO_2 emissions in the panel of industry in China for the period of 2000-2010. The results of GMM explore that large FDI inflows exaggerate China's CO_2 emissions when environmental regulation is relaxed. Comparable results have been found by Sbia et al. (2014) in case of UAE for the period

1975-2011, Al-mulali (2012) in 12 Middle East countries during 1990-2009 and Pao and Tsai (2011) in panel of BRIC countries from 1980-2007. Furthermore, He (2006) investigated the impact of FDI on pollutant emissions in 29 provinces of China from 1994-2000. The results of simultaneous equations show that although FDI in these provinces contributes to the CO_2 emissions but the impact is relatively weak.

On the contrary, several studies have founded negative relationship between FDI and CO_2 emissions in both single and panel countries studies. For example, Tamazian and Rao (2010) tested the role of financial and institutional development on CO_2 emissions in 24-transition countries for the period 1993-2004. This study utilizes different econometric techniques to highlight these relationships such as random effect specification to address possible country specific unobserved heterogeneity and GMM estimation to deal with potential endogeneity of the explanatory variables. The empirical results of GMM and other techniques show that financial and institution development helps to decrease the CO_2 emissions. In this regard, it is significant that the governments of transition countries can help to reduce the environmental degradation by formulating wide range policies that have long term benefits for reduction in GHG emissions. Correspondingly, Dean, Lovely, and Wang (2009) conducted study on 2886 industries in China from the period 1993-1996. The study argues that FDI's contribution of CO_2 emissions does not originate from guest countries, but it is the FDI that causes CO_2emissions. The study also argues that FDI from the high-income countries does not cause CO_2 emissions.

There are several other studies which explore that there is no relationship between foreign investment and environmental degradation. For example, Lee (2013) utilized the panel data of 19 nations of the G20 countries for the period 1971-2009 to investigate the contribution of FDI towards clean energy use, economic growth and CO_2 emissions. The results of fixed effect model claims that FDI leads to economic growth and green energy use whereas; there is no evidence of relationship with CO_2 emissions. Moreover, Gholipour Fereidouni and Ariffin Masron (2013) explored the impact of foreign investment in real estate sector on CO_2 emissions in 31-emerging economies during 2000-2008. This study applies fixed effect and GMM test to examine the relationship between the proposed variables. The results suggest that foreign investment in real estate sector does not have any relationship with CO_2 emissions. The study of Chandran and Tang (2013) accepted the impact of FDI and transport energy consumption on CO_2 emissions in ASEAN-5 countries namely Malaysia, Thailand, Indonesia, Singapore and Philippine. The study uses Johansen cointegration and Granger causality from the period 1971-2008 to examine the relationship. The results suggest that energy used in transport sector contributes to the CO_2 emissions but there is no evidence that FDI leads to increase CO_2 emissions in ASEAN-5 countries.

Similarly, Atici (2012) also conducted a study in ASEAN countries to explore the interaction between international trade and CO_2 emissions. The results suggest that exports of ASEAN countries are main contributors of CO_2 emissions in the whole ASEAN region. Besides, the study finds no evidence for the FDI deteriorating impact on CO_2 emissions during 1970-2006 in ASEAN region.

2.3.4 Population Growth and CO_2 Emissions

Three different measurement of population growth like population size, urbanization and population density are used to explore the impact of these activities on CO_2 emissions. In the following section, this study presented the previous studies on the relationship between population size, urbanization, population density and CO_2 emissions.

2.3.4.1 Population Size and CO_2 Emissions

Population size can stimulate environment both in negative and positive ways. According to Dietz and Rosa (1997), population size is one of the major driving forces behind the rapid increase of global CO_2 emissions. According to Malthus and Hollingsworth (1973),the impact of population size on environmental quality is evident. Each person creates some demands on energy for the necessities of life, food, shelter, clothing, water, and so on. Ceteris paribus, the higher is the number of people, the greater will be the energy demanded, is the Malthusian theory. The study of Bidsall (1992) specified two mechanisms through which population size could contribute to CO_2 emissions. First, a larger population could result in an increased demand for energy for power, industry, and transportation, consequently increasing fossil fuel emissions. Second, rapid population size can cause deforestation, as well as other changes in land use and burning of wood for fuel. These might contribute to the Pollutant emissions extensively (Fan et al., 2006; Hang & Yuan-sheng, 2011; Knapp & Mookerjee, 1996; Lantz & Feng, 2006; Brantley Liddle, 2013, 2015; van Ypersele & Bartiaux, 1995; You et al., 2015). On the contrary, Boserupian perspective (Boserup, 1965b, 1981) claimed that a population increase stimulates the appearance of technological innovations, which leads the protection of environment. Similarly, several studies argued that the higher is the population size, the more dynamic shall be the development of science and technological innovation, and the improved human's capability to present technological solutions to decrease environmental problems (P. Dasgupta, 2000; Ravallion, Heil, & Jalan, 2000; Urry, 2011).

Evidently, You et al. (2015) applied Quantile regression method and simple OLS to examine the relationship between population size and CO_2 emissions in the global panel. The results indicate that higher population size leads to higher level of CO_2 emissions all over the world during 1985 – 2005. In addition, Brantley Liddle (2013) investigated the impact of population size on the CO_2 emissions in different panels of low income countries, middle income countries and high income countries. The results of FMOLS testing approach suggested that population size hurting the quality of environment through high demand of transportation, housing, food and energy consumption. Similarly, Hang and Yuan-sheng (2011) attempted to identify the underlying driving forces which affect CO_2 emissions. Based on the known IPAT equation, population size is the main determinant of CO_2 emissions in China during 1980 – 2006. Additionally, Jorgenson and Clark (2010) investigated that one percent increase in population size increases CO_2 emissions by 1.52 percent and 1.62 percent in developed and less developed countries, respectively. Similar results have been found by Menz and Welsch (2012) in 26 OECD countries over the period 1960 – 2005.

Puliafito, Puliafito, and Grand (2008) explained that population size closely related to CO_2 emissions in global panel over the time period 1850 – 2150. In addition, Fan et al. (2006)

analyzed the impact factors of CO_2 emissions for the time period 1975 – 2000 in global, low income countries, middle income countries and high income countries panels. This study utilized Partial Least Squares (PLS) estimation method to estimate the STRIPAT model and confirm the contribution of population size on the environmental degradation. The results of the study support the Malthusian hypothesis, and explain that population size leads to CO_2 emissions. Lantz and Feng (2006) investigated that the driving macroeconomic and demographic forces stimulate CO_2 emissions in Canada. This study utilized provincial level panel data covering the time period 1970 – 2000. Besides other results, this study found that population size build pressure on CO_2 emissions in Canada. In another study A. Shi (2003) examined the impact of population size on global CO_2 emissions for the period 1975 – 1996. The study divided global panel into low income, lower middle income, upper middle income and high-income countries and applied GLS estimation approach to investigate the relationship between population size and CO_2 emissions. The estimation results also suggest that one percent raise in population size increases CO_2 emissions by 1.58 percent, 1.97 percent, 1.42 percent and 0.83 percent in low income, lower middle income, upper middle income and high-income countries, respectively.

In addition, Dietz and Rosa (1997) explored the effects of population and affluence on CO_2 emissions in 111 countries by applying linear, quadratic and cubic functions for the period 1990 -2025. The results indicate that one percent increase in population size will raise CO_2 emissions by 1.42 percent. This study argues that there is a need to decrease the level of population size to minimize the impact on environment and gain an increase in achieving the goal of sustainable development. Similarly, Knapp and Mookerjee (1996) investigated the relationship between population size and CO_2 emissions during 1980 – 1989. This study used Granger causality, error correction model (ECM) for cointegration and IPAT framework. The results of Granger causality and VECM indicate that population size causes CO_2 emissions and it can be controlled by slowing down population size. Further, van Ypersele and Bartiaux (1995) study the role of population size in global CO_2 emissions during time period 1950 – 1990. Similar to the previous studies this study also utilized classical equation I = P*A*T and explore that population size has a positive and significant impact on CO_2 emissions

On the other hand, there is a little evidence of having no relationship between population size and CO_2 emissions. Evidently, Brantley Liddle (2015) examined the CO_2 emissions elasticity for income and population size by using STRIPAT model. This study utilized panel data of 26-OECD and 54 non-OECD countries for the time period 1971 – 2011. The results of FMOLS testing approach indicate that the impact of population size on CO_2 emissions is not significant. This means that population size is not a determinant of pollutant emissions on most of OECD and non-OECD countries. Similarly, Begum, Sohag, Abdullah, and Jaafar (2015a) explored the impact of population size on CO_2 emissions in Malaysia during 1980 – 2009. The results of ARDL testing approach and DOLS indicate that population size does not have significant impact on CO_2 emissions. Furthermore, the study did not find any evidence of relationship between population size and CO_2 emissions in low income, middle income and high-income countries.

2.3.4.2 Urbanization and CO_2 Emissions

Urbanization is a phenomenon of economic and social modernization. It is not only the process of transforming rural labor from agricultural-based economy to urban areas where industrial and service sectors prevail, but also the process of the structural transformation of rural areas into urban areas. Additionally, numerous researchers such as Al-mulali, Fereidouni, Lee, and Sab (2013), Ghosh and Kanjilal (2014) and B. Li and Yao (2009) argued that demographic factors including urbanization, population size and population density also contribute to CO_2 emissions.

A rapid urbanization has been recorded in last two decades. The population in urban areas has increased from 746 million in 1950 to 3.9 billion in 2014 (UN, 2014). The growing urban population needs additional resources of consumption, thus building more pressure on the already fragile ecosystem. In 2014, more than 66 percent energy has been consumed and approximately 70 percent pollutants are emitted by urban cities (IEA, 2014). However, theories of ecological modernization and urban environmental transition both recognize that urbanization can have positive or negative impact on the environmental quality but it is difficult to conclude at so early stage (Sadorsky, 2014). On the basis of abovementioned arguments, if urbanization is found to be significantly hurting the environment then it can affect predicting models and climate change policies.

In addition, several studies have been conducted on the relationship between urbanization, energy consumption and CO_2 emissions (Al-mulali, Fereidouni, et al., 2013; Chikaraishi et al., 2015; Gholipour Fereidouni, 2013; Kasman & Duman, 2015; Parikh & Shukla, 1995; C. Zhang & Lin, 2012a). These previous studies have found different results by applying variety of econometric techniques. For example, Kasman and Duman (2015) explored the impact of urbanization on environmental degradation in case of 15 EU members and candidate countries for the period 1992-2010. The different panel unit root, cointegration and causality tests are utilized to explore the relationship. According to results of fully modified OLS, on the one side urbanization contributes to economic growth but on the other hand it increases the CO_2 emissions in these countries. The study of B. Yuan, Ren, and Chen (2015) argued that urbanization boost domestic demand of food, education, clothing, transportation and cultural entertainment in China. Evidently, with the change in structure and ratio of consumption demand of energy, the CO_2 emissions have also increased. Similarly, Chikaraishi et al. (2015) argue that growing urbanization is a burden for environment in 140 different countries. Sadorsky (2014) explored the impact of urbanization on CO_2 emissions for the panel of 16 emerging countries covering the period 1971 – 2009. The study utilized fixed effects model (FEM) and random effects model (REM) to investigate the relationship between both variables. The results of the study suggest that the increasing urbanization in emerging economies is one of the sources of CO_2 emissions.

In addition, Shahbaz, Sbia, et al. (2014) examined the relationship between urbanization and environmental degradation in United Arab Emirates (UAE) covering period 1975 – 2011. The study used VECM granger causality to confirm the direction of causality and ARDL testing approach to investigate the long run relationship between urbanization and CO_2 emissions. The empirical results confirm the existence of cointegration and long run positive relationship between urbanization and CO_2emissions. This means that urbanization should be re-planned otherwise urbanization will hurt the environmental quality by emitting CO_2 emissions. In another study, Shafiei and Salim (2014) investigated the impact of urbanization on CO_2 emissions in OECD countries for the period 1980 – 2011. The study applies VECM to confirm the relationship in the STRIPAT framework and results suggest that urbanization is the key indicator or a source of CO_2 emissions in OECD countries. In this regard, urban planners should take serious action on environmental changes during improving public transportation systems, improving the energy efficiency of buildings and increasing the share of renewable energy sources in energy supplies.

S. Wang, Fang, Guan, Pang, and Ma (2014) have conducted a study on 30 provinces of China to explore the determinants of CO_2 emissions during 1995 – 2011. The results of the study suggest that there is bidirectional positive relationship between urbanization and CO_2 emissions in 30 provinces of China. Al-mulali, Fereidouni, et al. (2013) also found positive and significant relationship between urbanization and CO_2 emissions in case of MENA region. The results of the study argue that the rapid increase in urbanization boost the energy demand which leads to increase CO_2 emissions in MENA countries. The findings of the study also suggest that there is a need to slow down the process of urbanization in order to reduce the CO_2 emissions and achieve ultimate goal of sustainable development. Gholipour Fereidouni (2013) also investigated the potential determinants of CO_2 emissions in 31 emerging economies during the period 2000 – 2008. The results of FEM and REM show that the urbanization is a key factor of CO_2 emissions in these 31 emerging economies.

Furthermore, the study of Al-mulali, Binti Che Sab, and Fereidouni (2012) have conducted a comprehensive study on this issue in seven different region for the time period 1980 – 2008. The study utilized ADF unit root test to confirm the stationarity level and FMOLS testing approach to explore the bidirectional relationship among proposed variables. The results from 184 countries show that there is a positive significant long run relationship in 84 percent countries and only 16 percent have mixed results. The findings of this study suggest that overall there is a need to initiate energy saving, efficiency and conservation projects to minimize their impact on environment. Similar results have been found by Sharma (2011) in case of 69 low, middle and high income countries during 1985 – 2005. Poumanyvong and Kaneko (2010a) also explored the impact of urbanization on CO_2 emissions in 99 different countries over the period 1975 – 2005. The study utilized balance panel data from the different income level countries such as low income, middle income and high income in STRIPAT framework. The results show that the impact of urbanization on CO_2 emissions is positive and significant especially in the middle-income countries. Alam, Fatima, and Butt (2007) aim to explore the impact of urbanization on CO_2 emissions during 1971 - 2005 in Pakistan. The ADF unit root test and VECM have been applied to confirm the stationarity and cointegration among the proposed variables. The results indicate that one percent increase in urbanization in the long run will lead to increase in CO_2 emissions by 0.81 percent. Additionally, Cole and Neumayer (2004) utilized STRIPAT model and argue that urbanization contributes to CO_2 emissions in 86 different countries from 1975 – 1998. Another study of Ehrhardt-Martinez, Crenshaw, and Jenkins (2002) utilized panel data of less developed countries for the period 1980 - 1995 and found similar results.

The abovementioned studies argue that the rapid urbanization is an important determinate of pollutant emissions and hurts the environment in different countries. On the other hand, a few studies such as Chikaraishi et al. (2015), Shafiei and Salim (2014), Sharma (2011) and Xu and Lin (2015c) investigated that urbanization helps to protect environment. These studies argue that urban cities generally have improved infrastructure that may assist the energy consumption as compared to rural areas, hence less CO_2 emissions. Furthermore, allocation of urban population is more contemplated than rural population, hence urban areas can obtain the benefits of increasing returns to scale in energy consumption, like centralized heating supply. Further, urban area household may also use cleaner energy fuels like natural gas, which emit less CO_2 emissions.

Chikaraishi et al. (2015) have explored to find out whether urbanization has positive or negative relationship with CO_2 emissions in 140 different countries covering period 1980 - 2008. By using STRIPAT framework, the study concluded that, the progress of urbanization could make countries more environmentally friendly when country's GDP per capita and percentage share of service industries in GDP are sufficiently high. Similarly, Xu and Lin (2015c) investigated the impact of urbanization on CO_2 emissions in different regions of China. This study used panel data covering time period 1990 – 2011 and shows that urbanization helps to reduce the CO_2 emissions in Central, Western and Eastern Regions of China.

Shafiei and Salim (2014) have used the STRIPAT framework to examine the impact of urbanization on CO_2 emissions in OECD countries during 1980 – 2011. The results of panel VECM show that the higher is the level of urbanization the lower is the impact on

CO_2 emissions. The findings of this study suggest that somehow CO_2 emissions can be controlled by increasing urbanization. Generally, congestion and spatial density reduce personal vehicle use and promote less mortised travel. If quality of public transport improves, it will help to decrease the dependency on own vehicle use and consequently it is a cause to energy efficiency and fewer CO_2 emissions. In another study, Sharma (2011) explores the determinants of CO_2 emissions in 69 different countries during 1985 – 2005 by applying GMM testing approach. The study divided 69 countries into different panels to make the panel data analysis more homogeneous. These panels are based on income levels such as low income, middle income and high-income countries. The results of the study indicate that urbanization have negative relationship with CO_2 emissions in global panel and all three sub-panels during the period of study. Fan et al. (2006) explored that urbanization has negative relationship with CO_2 emissions in global panel and high-income countries panel during 1975 – 2000.

Furthermore, studies investigated positive and negative relationship between urbanization and CO_2 emissions. However, a few studies like Du, Wei, and Cai (2012), Sharif Hossain (2011), Brant Liddle and Lung (2010) and H.-M. Zhu, You, and Zeng (2012a) argued that there is no or insignificant relationship between urbanization and CO_2 emissions. Du et al. (2012) also investigated the factors of CO_2 emissions in 30 provinces of China during the period 1995 – 2009. The results suggested that the impact of urbanization on the CO_2 emissions is insignificant in all provinces of China during the period of study. In another study, H.-M. Zhu et al. (2012a) applied semi-parametric FEM on the panel data of 20 most emerging countries for the time period 1992 – 2008. The results suggested that there is no evidence of relationship between urbanization and CO_2 emissions in panel of 20 different countries.

Sharif Hossain (2011) used panel data of newly industrialized countries for the period 1971 – 2007 to explore the impact of urbanization on CO_2 emissions. This study applies different econometric techniques like panel unit root to confirm stationarity level, Johansen Fisher panel cointegration test to examine cointegration and Granger causality to investigate the causality between urbanization and CO_2 emissions. Similar to H.-M. Zhu et al. (2012a), this study also found no evidence of relationship between urbanization and CO_2 emissions. Additionally, Brant Liddle and Lung (2010) used STRIPAT model to confirm the impact of urbanization on environmental degradation. This study applied OLS on the panel of 17 developed countries during the time period 1960 – 2005 and confirms that there is insignificant relationship between urbanization and CO_2 emissions.

It is concluded that all abovementioned studies explore different results such as urbanization contributes to CO_2 emissions (Al-mulali, Fereidouni, et al., 2013; Chikaraishi et al., 2015; Gholipour Fereidouni, 2013; Kasman & Duman, 2015; Parikh & Shukla, 1995; C. Zhang & Lin, 2012a), or urbanization helps to protect the environment (Chikaraishi et al., 2015; Fan et al., 2006; Shafiei & Salim, 2014; Xu & Lin, 2015c) and finally there is no evidence of the relationship between urbanization and environmental degradation (Du et al., 2012; Brant Liddle & Lung, 2010; Sharif Hossain, 2011; H.-M. Zhu et al., 2012a). This means that the impact of urbanization on CO_2 emissions is still not determined and there is a need to reinvestigate the relationship to formulate proper urban planning, protect environment and consequently sustainable development.

2.5 Underpinning Theories

Existing literature in this field has used several theories and econometric tools to study the role of energy consumption, economic growth, population on the CO_2 emissions. This study proposes several theories to achieve the established research objectives.

2.5.1 Economic Growth and CO_2 Emissions

This section presented the theories related to affluence and environmental degradation. The theories and hypothesis such as EKC, pollution halo and heaven hypothesis and scale effect, technique effect and composite effect are discussed in this section.

2.5.1.1 Environmental Kuznets Curve

Historically there have been different opinions about the economic and social cost of economic growth. Meadows, Meadows, Randers, and Behrens (1972) concluded that the economy of the world would reach to its physical limits of growth very soon due to ecological damages of economic growth. One year later to this report the first oil crises took place that led to the sense that world is going to face the dearth of natural and energy resources and this crisis also raised the issue of sustainability of economic growth. In literature, two conflicting views appeared that time. On one side, economists like Klaassen and Opschoor (1991) argued that substitution and technical progress can make up of the depleting of natural resources, so high level of consumption in future can be sustained.

Their key concern was to investigate the institutional arrangements for technical progress that will lead to sustainability of economic growth.

On the other side, environmental economists argued that substitution possibilities are constrained by physical laws even if there are continuous technological changes, the environmental degradation would limit the process of economic growth on both production and consumption side Tahvonen (2000). In the 1970s, the notion of sustainable development replaces the concept of "Limits to growth". Sustainability is a growth process that fulfills the desires of the current generation without compromising over the capabilities of upcoming generations to fulfill their requirements. Sustainability includes three components, the environmental, economic and sociopolitical sustainability (Ekins, 1993). But for the serious commentator of economics, pollution remained a consequence of market failures and they did not consider the scarcity of natural resources in economic growth model as pointed out by David I. Stern (2004). He stated that "there is still an inbuilt bias in mainstream production and growth theory to downplay the role of resources in the economy, though there is nothing inherent in economics that restricts the potential role of resources in the economy". World Development Report (1992) concluded that certain environmental problems are aggravated by economic growth and are linked with the deficiency of economic development. The Report recommended that accelerated equitable income growth as a mean to realize more world output and an improved environment. This suggestion placed the basis of the so-called EKC literature, which appears at the early 1990s.

Kuznets (1955b) postulated that income inequality first rises and then falls with economic growth. Named after him, the EKC is a hypothesized relationship between environmental degradation and income per capita. The basic idea is simple and intuitive. In the early stages of economic growth, environmental degradation and pollution tend to increase. After a certain level of income has been achieved, economic growth declines as well as the environmental degradation and pollution. Hence, the model is specified in quadratic form of income. Environmental degradation under this approach is a monotonically rising function in income with an "income elasticity" less than unity. The possibility to explain inverted U-shaped relationship between economic growth and environmental degradation is based on three different channels that have been explored by Stern (2004).

First, if there were no change in the structure or technology of the economy, pure growth in the scale of the economy would result in a proportional growth in pollution and other environmental impacts called Scale effect. It can be illustrated here that scale effect has a negatively impact on environment. At the second stage, composition of economy transformed from agriculture production to resource intensive heavy manufacturing industries. However, in the later stages of development, pollution decreases as the composition of the economy shifts towards service and light manufacturing industries. Finally, the channel of technique (or technology) effect suggests that with the economic growth having become outdated and obsolete, technologies are replaced by new and cleaner ones which have improved environmental quality. Based on EKC, the negative impacts of Scale effect on the environment tends to dominate in the initial stages of economic growth. However, the positive impacts of composition and technique effects tend to decrease emission levels that prevail at the declining stage. Through the understanding of EKC hypothesis, economic growth has direct relationship with the environmental degradation.

2.5.1.2 Pollution Halo and Haven Hypothesis

The complex relationship between FDI and the environment has been thoroughly investigated in recent years often with differing conclusions. No doubt, FDI promotes economic growth but also impacts environment negatively (He, 2006). Environmental regulations are essential means of internalizing the external environmental cost of firms' economic activity. Therefore, to attract FDI, the governments of developing countries have a tendency to undermine environment concerns through relaxed or non-enforced regulation which is termed as pollution haven hypothesis (PHH) in economic theory. As a result, companies like to shift thei0dr operations to these developing countries to take advantage of lower production cost which is known as industrial flight hypothesis. Both of these hypotheses lead to excessive pollution and degradation in environmental standard of the host countries. Due to the close correlation between a country's per capita income and environmental stringency (Somnath Dasgupta & Sengupta, 1995), the PHH argues that developing countries will become pollution havens whilst the developed world will specialize in clean production.

The PHH focuses on the cost effect of environmental regulations on firms, and presumes that production cost differentials are a sufficient stimulus for firms to relocate their production facilities. Rationalizations for this view generally come from the notion that stricter regulatory regime for environmental standards will add to the costs of production through requirements for new equipment, the need to find alternative methods for disposal of waste due to rules against landfill, and restrictions on inputs and outputs. In the absence of any other factors, it is in a firms' interest to relocate their production activities to countries with less stringent environmental regulations.

In contrast, it is also believed that foreign companies use better management practices and more advanced technologies that result in clean environment in host countries (Zarsky, 1999a). This is known as pollution haloes hypothesis. This implies that trends in environmental damage due to FDI are unsustainable. It is generally believed that FDI can have positive effect on host country's development efforts. In addition to be the main source of external capital, the inflow of foreign investment also helps in filling the resource gap between the targeted investment and locally mobilized savings as well as the gap between targeted foreign exchange requirements and those generated by net export earnings. FDI also helps to develop managerial and specialized technological skills, innovations in the techniques of production, by means of training programmes and the process of learning by doing in the host country. Furthermore, FDI inflows also encourage the local enterprises to increase invest in the development projects and provides employment opportunities for both skilled and unskilled labor in the recipient country.

Explanations as to why foreign owned firms might be cleaner than domestically owned firm generally fall into two categories. Firstly, this cleanliness may be driven by factors which are external to the firm. For example, it has been argued that developed countries' based multinationals will typically utilize cleaner technology and possess more sophisticated environmental management system than many domestic firms in developing countries, often due to the more stringent regulatory environment that exists in the developed countries (Zarsky, 1999). Pressure to continue to use such technologies in their affiliates in developing countries may arise because such multinationals may have large export markets in developed countries where they must meet the requirements of environmentally aware consumers. Such technologies may also be indirectly passed on to domestic firms, for example, via backward or forward linkages. Secondly, foreign owned firms may be cleaner than domestically owned firms for reasons that are internal to the firm, for example due to the firms' management practices.

2.5.1.3 Scale Effect, Technique Effect and Composite Effect

International trade entails movement of goods produced in one country for either consumption or further processing to other country. Production of those goods is not possible without effective use of energy. International trade affects energy demand via scale effect, technique effect and composite effect. Other things being same, international trade increases economic activities thus stimulating domestic production and hence economic growth. A surge in domestic production reshapes energy demand because of expansion in domestic production is commonly referred as scale effect. Such scale effect is caused by trade openness. Hence, due to international trade, the higher is the production, the greater shall be the energy consumption.

Similarly, another group of economists suggested that international trade enables developing economies to import advance technologies from developed economies. The adoption of advanced technology lowers energy intensity. The economic consequences of advance technologies implementations consume less energy and produce more output that is usually referred as technique effect (Arrow, 1962). Composite effect reveals that with the use energy intensive production as economic development for example, shift from agriculture to industry. In initial stages of economic development, since economy is based largely on agriculture sector, thus the use to energy consumption is relatively less. As economy starts shifting from agriculture to industry, the use of energy consumption increases. Arrow (1962) calls it positive composite effect. Finally, following maturity stage of economic development, shifts in industry to service sector consume less energy consumption which implies that energy intensity is lowered because of composite effect.

2.5.2 Population and CO_2 Emissions

This section provided the theoretical support to the relationship between population and CO_2 Emissions.

2.5.2.1 Malthus and Boserupian School of Thoughts

Generally, there are two different perceptions of the impact of population growth on the environmental quality like Malthus (1967) and Boserup (1965). First. Malthus (1967) argues that pressure of population on the resources cause environmental degradation. Malthus (1967) argued that the impact of population growth on environmental quality is evident. Each person creates some demands on energy for the necessities of life, food, shelter, clothing, water, and so on. Ceteris paribus, the higher is the number of people, the greater will be the energy demanded, is the Malthusian theory. The study of Bidsall

(1992) specified two mechanisms through which population growth could contribute to CO_2 emissions. First, a larger population could result in an increased demand for energy for power, industry, and transportation, consequently increasing fossil fuel emissions. Second, rapid population growth can cause deforestation, as well as other changes in land use and burning of wood for fuel. Hence, these all activities can increase the CO_2 emissions. Some recent studies like Begum, Sohag, Abdullah, and Jaafar (2015b) and M. M. Alam, Murad, Noman, and Ozturk (2016) have explained the relationship between population growth and CO_2 emissions.

The second perception is Boserup's claim that an increase in population encourages the emergence of technological innovations, which leads to a negative impact of population growth on the environment (Boserup, 1965b, 1981). Boserup deems a high population density to be a prerequisite for technological progress in agriculture. Accordingly, Malthusian scholars predict that the impact of population on greenhouse gases is more than proportional, while Boserupian academics state that this relationship does not exist or, if it does, it has a negative elasticity.

2.5.3 Energy Consumption and CO_2 Emissions

2.5.3.1 Neoclassical Growth Model

The energy consumption is a fundamental driver of output and plays a significant role in economic growth and development. It is a vital component in economic growth either directly or as a complement to other factors of production. The traditional neo-classical growth model, treats energy inputs as intermediate factors whereas land, labor and capital as basic factors and the role of energy in production as neutrality factor. On the other hand, the biophysical and ecological view is that energy plays a key role in income determination. Although, there are several factors of production, but the significant role of energy consumption cannot be ignored. Thus, the economies heavily dependent on energy use will be significantly affected by changes in energy consumption (J.-H. Yuan et al., 2008).

2.6 Conclusion

Nowadays many countries, especially developing ones are facing a major challenge of multi - directional links between economic, social and environmental aspects of development. The impact of energy consumption, economic growth, population on the environmental degradation are still controversial subjects of study. For example, the review of previous studies shows that the economic activities like GDP growth, international trade, financial development, FDI and industrial production help to protect the environment by emitting less CO_2 emissions and vice versa in other countries. The review of previous studies concludes that the effects of energy consumption, economic growth and population growth on environmental degradation are varying from one country to another. In this regard, it is not possible to generalize the results. Hence, this study creates four different panels such as high-income countries, upper middle-income countries, lower middle-income countries and low-income countries on the basis of income level.

Similarly, there are several studies that have investigated the STRIPAT model by incorporating population size, GDP per capita and technology as a factor of environment quality (I = P*A*T). According to York et al. (2003), additional factors can be entered the basic STRIPAT model as components of the technology. It can be disaggregated to study the impact per unit of consumption or production and the impact per unit of economic activity. However, there are several other factors also which can influence the environmental quality and which can be tested within the STRIPAT model.

For example, Shi (2003), Poumanyvong and Kaneko (2010) utilized the share of industry and services in GDP as proxy for influence (GDP per capita) in an investigation on pollution emissions. Furthermore, Martinex-Zarzoso et al. (2007) uses the share of industry in GDP and energy intensity as a proxy. In a study of national energy consumption, York (2007) employs urbanization to express population size. In addition, Shafiei and Salim (2014) added industrial production and population density as a proxy of GDP and population size in the basic STRIPAT model. To the best of knowledge of the researcher, this is one of the first studies that include renewable and non-renewable energy as a proxy of technology and international trade, FDI and financial development as proxy of affluence in the three different models for the selected countries over the time 1990 - 2015.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter commences with the elaboration of model specification based on STRIPAT model. The chapter continues further with the justification of all variables. Furthermore, method of data collection and data analysis technique are also a part of this chapter.

3.2 Model Specification

The core objective of this study is to explore the impact of population, affluence and technology on the environmental degradation. The different proxies of population such as population size, population density, urban population are selected. Similarly, GDP growth, international trade, financial development and FDI is selected as proxies of affluence and total energy consumption, renewable energy consumption and non-renewable energy consumption as proxies of technology. On the other side, CO_2 emissions is represented environmental degradation. To avoid any diagnostic issues such as heteroscedasticity, autocorrelation and serial correlation this study divide explanatory variables into three different models.

3.2.1 Selection of Variables

Selection of variables for each model is based on general - to - specific (GETS) modeling. According to Clark (2014) GETS provides a prescriptive and defendable way of selecting a few relevant variables from a large list of potentially important variables when fitting a regression model. GETS handle several issues in panel data, specifically, how such an algorithm can be applied to estimations based upon panel data. A command is presented, written in Stata and Mata, that implements this algorithm for various data types in a flexible way. This command is based on Stata's regress or xtreg command, so it is suitable for researchers in the broad range of field where regression analysis is used. Finally, the genspec command is illustrated using data from applied studies of GETS modeling with Monte Carlo simulation.

The formulation of three different models are basically based on STRIPAT framework introduced by Dietz and Rosa (1994, 1997). The STRIPAT model has the basic form as shown by Equation [3.1]

[3.1] $I_i = \alpha P_i^b A_i^c T_i^d e_i$

Taking the natural logarithm of both sides, Equation [3.2] is developed.

[3.2] $\ln I_{it} = \ln \alpha + b \ln(P_{it}) + c \ln(A_{it}) + d \ln(T_{it}) + \ln e_{it}$

where

I	=	Impact
P	=	Population
A	=	Affluence
T	=	Technology
α	=	Constant
b, c, d	=	Coefficients
e	=	Error term
t	=	1,2,3,.....,T
i	=	1,2,3,.....,N

Additional factors are included into basic STRIPAT framework followed by York et al. (2003). In Model I the impact of population growth, GDP per capita, international trade and total energy consumption on the CO_2 emissions are investigated. The Model I is represented by Equation [3.3].

$$[3.3] \quad \ln(CO_{2it}) = \ln\alpha_0 + \alpha_1 \ln(POP_{it}) + \alpha_2 \ln(Y_{it}) + \alpha_3 \ln(TR_{it}) + \alpha_4 \ln(TEC_{it}) + \ln\varepsilon_{1it}$$

where

CO_2	=	Carbon dioxide (MT)
POP	=	Total population (million)
Y	=	GDP growth (%)
TR	=	International trade ($billion)
TEC	=	Total energy consumption (Kg of oil equivalent per capita)
α_0	=	Constant
$\alpha_1, \alpha_2, \alpha_3, \alpha_4$	=	Coefficients

In Model II, the effects of the population density (used as a proxy of population growth), FDI, FD and renewable energy consumption are examined. Thus, Model II is given by Equation [3.4]:

$$[3.4] \quad \ln(CO_{2it}) = \ln b_0 + b_1 \ln(PD_{it}) + b_2 \ln(FDI_{it}) + b_3 \ln(FD_{it}) + b_4 \ln(NEC_{it}) + \ln\varepsilon_{2it}$$

where

PD	=	Population density (Persons/seq.km)
FDI	=	Foreign direct investment ($billions)
FD	=	Financial development (domestic credit to private sector, % of GDP)
NEC	=	Non-renewable energy consumption (Kg of oil equivalent per capita)
b_0	=	Constant
b_1, b_2, b_3, b_4	=	Coefficients

The purpose of Model III is to examine the relationship between CO_2 emissions, urbanization, industrial production and renewable energy consumption. The Model III is represented in Equation [3.5]:

$$[3.5] \quad \ln(CO_{2it}) = \ln c_0 + c_1 \ln(UB_{it}) + c_2 \ln(IND_{it}) + c_3 \ln(REC_{it}) + \varepsilon_{3it}$$

where

UB	=	Total population living in urban area (% of total population)
IND	=	Industrial Production (% of GDP)
REC	=	Renewable energy consumption (quadrillion British thermal units (Btu)
c_0	=	Constant
b_1, b_2, b_3, b_4	=	Coefficients

3.3 Definitions of Variables

3.3.1 Carbon Dioxide Emissions

CO_2 emissions are those elements that stem from the burning of fossil fuels and the manufacturing of cement. It includes CO_2 emissions during consumption of solid, liquid, and gas fuels and gas flaring (World Bank, 2016).

3.3.2 Total Energy Consumption

Total energy consumption (TEC) refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport (World Bank, 2016). It is measured in Kg of oil equivalent per capita.

3.3.3 Renewable Energy Consumption

Renewable energy (REC) is energy that is not depleted when used and naturally replenished on human timescale. It comes from various sources such as biomass, wood, tide, wave, solar and wind. The REC is environment friendly, safe and unlimited as compare to fossil fuels energy. It is measured in quadrillion Btu (World Bank, 2016)

3.3.4 Non-Renewable Energy Consumption

Non-renewable energy (NEC) comes from sources that will run out or will not be replenished in our life time. Energy comes from fossil fuels such as oil, coal and gas are commonly known as NEC. It measured in Kg of oil equivalent per capita (World Bank, 2016).

3.3.5 Economic Growth

Economic growth (Y) is an increase in the capacity of an economy to produce goods and services, compared from one period to another. Traditionally, aggregate economic growth is measured in terms of GNP or GDP, although alternative metrics are sometimes used. This study used GDP growth as proxy of economic growth and measured in percentage change from one year to another.

3.3.6 International Trade

International trade (TR) is the exchange of capital, goods, and services across international borders or territories, which could involve the activities of the government and individual. In most countries, such trade represents a significant share of GDP. TR is usually measured in local currency or USD (World Bank, 2016).

3.3.7 Foreign Direct Investment

FDI refers to direct investment equity flows in the reporting economy. It is the sum of equity capital, reinvestment of earnings, and other capital. FDI is a category of cross-border investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is resident in another economy. Ownership of 10 percent or more of the ordinary shares of voting stock is the criterion for determining the existence of a direct investment relationship (World Bank, 2016).

3.3.8 Financial Development

Financial development (FD) can be defined as the policies, factors, and the institutions that lead to the efficient intermediation and effective financial markets. A strong financial system offers risk diversification and effective capital allocation (Adnan, 2011). There are several measurements of FD; however, the study used domestic credit to private sector (% of GDP) as proxy of FD.

3.3.9 Industrial Production

Industry also comprises value added in sectors like mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. It is measured as an industry value added percentage of GDP (World Bank, 2016).

3.3.10 Population Size

Population size (POP) is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship (World Bank, 2016). In this study POP is measured in million.

3.3.12 Urbanization

Generally, urbanization (UB) is an interconnected development of environmental, demographic, economic, technological, cultural, economic and social changes, which entails the absorption of economic activities and population in urban areas along with land use change (McCarthy & Knox, 2005). In contrast, UB can also be narrowly defined as the physical growth of cities, urbanized territories and population size (Hutchison, 2009). The UB is calculated as the percentage of total population living in the urban area.

3.5 Data Source

Annual time series secondary data of all proposed variables are collected over the period 1980 – 2015 from different sources. TEC and NEC are calculated in kilo tons (KT) of oil equivalent per capita where REC is calculated in quadrillion Btu and data are collected from online database of International Energy Agency (IEA). FDI, TR are calculated in $ billion, FD is measured in domestic credit to private sector, percent of GDP. Furthermore, IND evaluates as the value of the GDP created in the industrial sector, GDP growth (Y) measured in percentage change and CO_2 measured in millions of metric tons (MT). The data of all these variables are collected from online database of World Development Indicators (WDI).

In addition, POP contracted as total population of a country PD is defined as a measurement of population per sq.km, UB quantified as a percentage of total population living in urban areas. The data of demographic variables are obtained from United Nation Statics Division (unstats.un.org).

3.5 Method of Analysis

The core objective of this research study is to test whether there is long run relationship between environmental degradation, population, affluence and technology. This study selected top ten highly CO_2 emitted countries from each income level including high income countries, upper middle income, lower middle income and low-income countries. Hence this study analyzed four different panels. The strategy of analysis mentioned in the following sections.

3.5.1 Panel Data Analysis

The panel data analysis consists of the four steps. First, the stationarity properties of the time series variables are examined using alternative panel unit root tests. If proposed variables are non-stationary, the second step is to test whether there is cointegration relationship between the series, using appropriate panel cointegration techniques. The presence of cointegration in first three models will lead to estimate the long run elasticities by utilizing FMOLS. Finally, causal effect between the proposed variables was investigated using Granger causality test approach.

3.5.1.1 Panel Unit Roots

Testing stationarity of time series variables is an important pre-requisite for traditional cointegration analysis. The unit root test is necessary in the FMOLS test to confirm that all the variables must remain either stationary at level I (0) or at first difference I(1).

A stationary time series variable is defined as one that comprises statistical properties like mean, median, variance, and autocorrelation constant and, does not depend over a time period. In other words, data in this time series fluctuate around a constant mean and it is independent of time; its variance of the fluctuation always remaining constant over time. The mean and variance of the data series during a year will be different from another year If the initial time series is not stationary, there is a need for some transformation to make it stationary. In order to determine the stationarity of the variables, traditional unit root tests were too limited, so new unit root tests were developed for the purpose (Martin et al. 2013; Shahbaz et al, 2013).

There are several panel unit root tests such as Im, K. S., Pesaran, M. H., and Shin, Y. (2003) test called IPS; Levin, Lin, and James Chu (2002) known as LLC and Maddala and Wu (1999) briefly called MW to check the stationarity properties of the variables. These tests apply to a balanced panel, but the LLC can be considered a pooled panel unit root test, IPS represents as a heterogeneous panel test and MW panel unit root test is non-parametric test. Although, there are several panel unit root tests, but this study applied IPS unit root test suggested by Im, K. S., Pesaran, M. H., and Shin, Y. (2003). This test explored a panel unit root test in the context of a heterogeneous panel. Since this study consists of four heterogeneous panels, hence, this study applied IPS unit root test.

The IPS test is not as restrictive as the LLC test. It allows for heterogeneous coefficient and proposed an alternative testing procedure based on averaging individual unit root test statistics. IPS suggested an average of the ADF tests when μ_{it} is serially correlated with different serial correlation properties across cross-sectional units. The null hypothesis (H_0) is that each series in the panel contains a unit root like $H_0 : \rho_i = 0$ for all i and the alternative hypothesis (H_1) allows for some (but not all) of the individual series to have unit root;

[3.6] $H_1 : \{\rho_i < for\ i = 1,2,......,N_1\ and\ \rho_i = 0\ for\ i = N1+1,....,N$

Formally, it requires the fraction of the individual time series that are stationary to be nonzero, like $\lim_{n\to\infty}(n1/n) = \delta\ where\ 0 < \delta \leq 1$. This condition is necessary for the consistency of the panel unit root test. The IPS t-bar statistic ($\bar{t}$) is defined as the average of the individual ADF statistics as mentioned in the Equation [3.7].

[3.7] $\bar{t} = \frac{1}{N}\sum_{i=1}^{N} t_{\rho i}.$

where t_{ρ_i} is the individual t-statistics for testing the null hypothesis: $\rho_i = 0$ for all i. IPS provides simulated critical values for $\bar{t}$ different number of cross-section n, series length T and Dickey-Fuller regressions containing intercepts only or intercepts and liner trends.

In the general case where the lag order ρ_i may be nonzero for some cross-sections, IPS shows that a properly standardized $\bar{t}$ has an asymptotic N (0, 1) distribution. Starting from well-known results in the time series that for a fixed n.

$$[3.8] \quad t_{\rho i} \Rightarrow \frac{\int_0^1 W_{iz} dW_{iz}}{[\int_0^1 W_{iz}^2]^{1/2}} = t_{iT}$$

as $T \to \infty$, where $\int W(r)\,dr$ denotes a Weiner integral with the argument r suppressed in Equation [3.8], IPS assumes that t_{iT} are IID and have finite mean and variance, represented in the Equation [3.9].

$$[3.9] \quad \frac{\sqrt{n}\left(\frac{1}{n}\sum_{i=1}^{n} t_{iT} - \frac{1}{n}\sum_{i=1}^{n} E\left[t_{iT} \middle| \rho_i = 0\right]\right)}{\sqrt{\frac{1}{n}\sum_{i}^{n} \mathrm{var}\left[t_{iT} \middle| \rho_i = 0\right]}} \Rightarrow N(0,1)$$

as $n \to \infty$ by the Lindeberg –Levy central limit theorem, Equation [3.9] converted into Equation [3.10].

$$[3.10] \quad t_{IPS} \frac{\sqrt{n}\left(\bar{t} - \frac{1}{n}\sum_{i=1}^{n} E\left[t_{iT} \middle| \rho_i = 0\right]\right)}{\sqrt{\frac{1}{n}\sum_{i}^{n} \mathrm{var}\left[t_{iT} \middle| \rho_i = 0\right]}} \Rightarrow N(0,1)$$

as $T \to \infty$ followed by $n \to \infty$ sequentially. The values of $E\left[t_{iT} \middle| \rho_i = 0\right]$ and $VAR\left[t_{iT} \middle| \rho_i = 0\right]$ have been computed by IPS via simulations for different values of Tand ρ_i's.

3.5.1.2 Panel Cointegration Tests

The cointegration approach tests the relationship between long-run equilibrium and the non-stationary economic variables. Let us consider, X_t be a vector of variables integrated of order one [$I(1)$]. Then the variables of X_t are deemed cointegrated if and only if, the linear combination $\beta'X_t$ (with $\beta \neq 0$) is stationary ($\beta'X_t \sim I(0)$) or the equilibrium error process is stationary ($U_t = Y_t - \beta'X_t$). The equilibrium is meaningful when the equilibrium error process is stationary (Engle & Granger, 1987). There are a variety of econometric methodologies that have been offered in the literature to evaluate long-run equilibrium relationship between non-stationary time series variables.

The residual-based cointegration test proposed by Engle-Granger (1987) and Johansen and Juselius (1995) cointegration methods have been frequently used to examine the long-run relationship between variables. Before running any estimation, it is a pre - requisite for all the variables to follow the same order of the above methods. In addition, traditional cointegration methods provide unreliable results for small sampling (Johansen, 2002). However, panel cointegration tests like Kao (1999), Maddala and Wu (1999), Pedroni (1999, 2004) and Westerlund (2007) are provided reliable results. Though, this study applied Kao (1999) and Pedroni (1999, 2004) cointegration tests because of various advantages.

Kao (1999) presented two types of cointegration tests in panel data, the DF and ADF types tests. Consider the following panel regression model which shows by Equation [3.11].

[3.11] $y_{it} = x'_{it}\beta + z'_{it}\gamma + \varepsilon_{it}$

where y_{it} and x_{it} are I (1) and non-cointegrated. For, $z_{it} = \{\mu_i\}$ Kao (1999) proposed DF and ADF-type unit root tests for ε_{it} as a test for the null of no cointegration. The DF-type tests can be calculated from the fixed effects residuals which shows by Equation [3.12]

[3.12] $e'_{it} = \rho\,\hat{e}_{i,t-1} + v_{it}$

where $e'_{it} = \widetilde{y}_{it} - \widetilde{x}'_{it}\hat{\beta}$ and $\widetilde{y}_{it} = y_{it} - \overline{y}i$, $\widetilde{x}_{it} = x_{it} - \overline{x}i$. To test the null hypothesis of no cointegration, the null hypothesis can be written as $H_0 : \rho = 1$. The OLS estimate of ρ and the t-statistic are given as

[3.13] $\hat{\rho} = \dfrac{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{e}_{it}\hat{e}_{i,t-1}}{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{e}^2_{it}}$

and

[3.14] $t_\rho = \dfrac{(\hat{\rho}-1)\sqrt{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{e}_{it}\hat{e}_{i,t-1}}}{S_e}$

Where

[3.15] $s_e^2 = \dfrac{1}{NT}\sum_{i=1}^{N}\sum_{t=2}^{T}(\hat{e}_{it} - \hat{\rho}\hat{e}_{i,t-1})^2$

Kao proposed the following four types of ADF tests which are shown by Equation [3.16] to Equation [3.19]

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

[3.17] $$DF_{t} = \sqrt{1.25}\cdot t_{\rho} + \sqrt{1.875N}$$

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

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

where $\hat{\sigma}_{v}^{2} = \hat{\Sigma}_{yy} - \hat{\Sigma}_{yx}\hat{\Sigma}_{xx}^{-1}$ and $\hat{\sigma}_{0v}^{2} = \hat{\Omega}_{yy} - \hat{\Omega}_{yx}\hat{\Omega}_{xx}^{-1}$ and $\hat{\Sigma}$ is estimator of long run covariance of $\zeta_{it} = (\Delta y_{it}, \Delta x_{it}')'$, $\hat{\Omega}$ is the estimator of contemporaneous covariance $\zeta_{it} = (\Delta y_{it}, \Delta x_{it}')'$. While DF_{ρ} and DF_{t} are based on the strong exogenity of the regressors and disturbances. For the ADF test, it can run the following regression which are mentioned in Equation [3.20]

[3.20] $$e_{it} = \rho\hat{e}_{i,t-1} + \sum_{j=1}^{p}\delta_{j}\Delta\hat{e}_{i,t-j} + v_{it}$$

with the null hypothesis of no cointegration, the ADF test statistics can be constructed as:

[3.21] $$ADF = \frac{t_{ADF}+\frac{\sqrt{6N}\hat{\sigma}_{v}}{2\hat{\sigma}_{0v}}}{\sqrt{\frac{\hat{\sigma}_{0v}^{2}}{2\hat{\sigma}_{v}^{2}}+\frac{3\hat{\sigma}_{v}^{2}}{10\hat{\sigma}_{0v}^{2}}}}$$

where t_{ADF} is the t-statistic of ρ Equation [3.21]. The asymptotic distribution of $DF_{\rho}, DF_{t}, DF_{\rho}^{*}$ and ADF converge to a standard normal distribution N (0, 1) by sequential limit theory.

Pedroni (1999, 2004) also proposed several tests for the null hypothesis of cointegration in a panel data model that allows for considerable heterogeneity. Pedroni considered the following type of regression:

[3.22] $$y_{it} = \alpha_i + \delta_i t + X_{it}'\beta_i + e_{it}$$

for a time series panel of observables y_{it} and X_{it} for members i=1..., N over time periods t = 1... T, where X_{it} is an m-dimensional column vector for each member i and β_i is an m-dimensional column vector for each member i. The variables y_{it} and X_{it} are assumed to be I (1). for each member i of the panel, and under the null of no cointegration the residual e_{it} will also be I (1). The parameters α_i and δ_i allow for possibility of member specific fixed effects and deterministic trends, respectively. The slope coefficients β_i are also permitted to vary by individual, so that in general the cointegration vectors may be heterogeneous across members of the panel. The DF-type tests and ADF- type tests can be calculated from the fixed effects residuals

[3.23] $$\hat{e}_{it} = \rho_i \hat{e}_{i,t-1} + v_{it}$$

[3.24] $$\hat{e}_{it} = \rho_i \hat{e}_{i,t-1} + \sum_{j=1}^{p} \varphi_{ij} \Delta \hat{e}_{i,t-j} + v_{it}$$

The null hypothesis for cointegration tests are: $H_0 : \rho_i = 1; H_1 : \rho_i = \rho < 1 \ (i = 1,2,..., N)$ and $H_0 : \rho_i = 1; H_1 : \rho_i < 1 \ (i = 1,2,...; N)$.

To study the distribution properties of above tests, Pedroni described the DGP in terms of the partitioned vector $Z'_{it} = (Y_{it}; X'_{it})$ such that the true process Z_{it} is generated as

$Z_{it} = Z_{i,t-1} + \xi_{it}$ for $\xi'_{it} = (\xi^{Y}_{it}, \xi^{x}_{it})$.

Pedroni's tests can be classified into two categories. The first set (within dimension) is similar to the tests discussed above, and involves averaging test statistics for cointegration in the time series across cross-section. For the second set (between dimension), the averaging is done in pieces so that the limiting distributions are based on limits of piecewise numerator and denominator terms. The basic approach in both cases is to first estimate the hypothesized cointegration relationship separately for each member of the panel and then pool the resulting residuals when constructing the panel tests for the null of no cointegration. Specifically, in the first step, one can estimate the proposed cointegration regression for each individual member of the panel in the form of Equation [3.11], including idiosyncratic intercepts or trends as the particular model warrants, to obtain the corresponding residual $\hat{e}_{it}$. In the second step, the way in which the estimated residuals are pooled will differ among the various statistics, which are defined as follows. Panel variance ratio statistics:

[3.25] $$Z_{\hat{\nu}_{NT}} = \hat{L}_{11}^{2}\left(\sum_{i=1}^{N} A_{22i}\right)^{-1} = \hat{L}_{11}^{2}\left(\sum_{i=1}^{N}\sum_{t=1}^{T} e_{i,t-1}^{2}\right)^{-1}$$

Panel- rho statistic:

[3.26] $$\begin{aligned} Z_{\hat{\rho}_{NT}-1} &= \left(\sum_{i=1}^{N} A_{22i}\right)^{-1}\left(\sum_{i=1}^{N}\left(A_{21i} - T\hat{\lambda}_i\right)\right) \\ &= \left(\sum_{i=1}^{N}\sum_{t=1}^{T} e_{i,t-1}^{2}\right)^{-1}\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\left(\Delta\hat{e}_{it}\hat{e}_{i,t-1} - \hat{\lambda}_i\right)\right] \end{aligned}$$

Panel-t statistic:

[3.27] $$\begin{aligned} Z_{t_{NT}} &= \left(\tilde{\sigma}_{NT}^{2}\sum_{i=1}^{N} A_{22i}\right)^{-1/2}\left[\sum_{i=1}^{N}\left(A_{21i} - T\hat{\lambda}_i\right)\right] \\ &= \left(\tilde{\sigma}_{NT}^{2}\sum_{i=1}^{N}\sum_{t=1}^{T} e_{i,t-1}^{2}\right)^{-1/2}\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\left(\Delta\hat{e}_{it}\hat{e}_{i,t-1} - \hat{\lambda}_i\right)\right] \end{aligned}$$

Group-rho Statistic:

[3.28] $$\tilde{Z}_{\hat{\rho}_{NT}-1} = \sum_{i=1}^{N} A_{22i}^{-1}\left(A_{21i} - T\hat{\lambda}_i\right) = \sum_{i=1}^{N}\left[\left(\sum_{t=1}^{T} e_{i,t-1}^{2}\right)^{-1}\sum_{t=1}^{T}\left(\Delta\hat{e}_{it}\hat{e}_{i,t-1} - \hat{\lambda}_i\right)\right]$$

Group-t statistic:

[3.29] $$\tilde{Z}_{t_{NT}} = \sum_{i=1}^{N}\left[\left(\hat{\sigma}_i^{2}\sum_{t=1}^{T} e_{i,t-1}^{2}\right)^{-1/2}\left[\sum_{t=1}^{T}\left(\Delta\hat{e}_{it}\hat{e}_{i,t-1} - \hat{\lambda}_i\right)\right]\right]$$

where $\hat{\mu}_{it} = \hat{e}_{it} - \hat{\rho}_i\hat{e}_{i,t-1}$, $\hat{\lambda}_i = \frac{1}{T}\sum_{s=1}^{K_i} w_{sKi}\sum_{t=s+1}^{T}\hat{\mu}_{it}\hat{\mu}_{i,t-s}$ for some choice of lag window

$w_{sKi} = 1 - \frac{s}{1+K_i}$, $\hat{S}_i^2 = \frac{1}{T}\sum_{t=1}^{K_i}\hat{\mu}_{it}^2$, $\tilde{\sigma}_i^2 = \hat{S}_i^2 + 2\hat{\lambda}_i^2$, $\tilde{\sigma}_{NT}^2 = \frac{1}{N}\sum_{i=1}^{N}\hat{\sigma}_i^2$, and $\hat{L}_{11}^2 = \frac{1}{N}\sum_{i=1}^{N}\hat{\sigma}_i^2$,

where $\hat{L}_{1li}^2 = (\hat{\Omega}_{1li} - \hat{\Omega}_{2li}\hat{\Omega}_{22i}^{-1}\hat{\Omega}_{2li}$ such that $\hat{\Omega}_i$ is consistent.

The first three statistics are based on pooling the data across the within group of the panel; the next two statistics are constructed by pooling the data along the between group of the panel. Pedroni (1999) derived asymptotic distributions and critical values for several residual-based tests of the null of no cointegration in panels where there are multiple regressors. Let consider Equation [3.30].

$$\frac{\chi_K - \mu_K\sqrt{N}}{\sqrt{V_K}} \Rightarrow N(0,1) \quad (as\ T.N \rightarrow \infty)_{seq} \qquad [3.30]$$

where

$$\chi = \left(T^2N^{3/2}Z_{\hat{v}_{NT}}, T\sqrt{N}Z_{\hat{\rho}_{NT}-1}, Z_{\hat{t}_{NT}}, TN^{-1/2}\tilde{Z}_{\hat{\rho}_{NT}-1}, N^{-1/2}\tilde{Z}_{\hat{t}_{NT}}\right)'$$

for each of the K=1…,5 statistics of X, the values of μ_k and V_k can be found from the table in Pedroni (1999), which depends on whether the model includes estimates fixed effects estimated fixed effects and estimated trends. Thus, to test the null hypothesis of no cointegration, one simple computes the values of the statistic so that it is in the form of Equation [3.11] above based on the value of μ_k and V_k from the Table II in Pedroni (1999) and compares these to the appropriate tails of the normal distribution. Under the alternative hypothesis, the panel variance statistic diverges to positive infinity, and consequently the right tail of the normal distribution is used to reject the null hypothesis. Consequently, for the panel variance statistic, large positive values imply that the null hypothesis of no cointegration is rejected. For each of the other four test statistics, these diverge to negative infinity under the alternative hypothesis, and consequently the left tail of the normal distribution is used to reject the null hypothesis. Thus, for any of these latter tests, large negative values imply the null of no cointegration is rejected.

3.5.1.3 Panel Fully Modify Ordinary Least Square Estimation

Having established the existence of cointegrating relationship among the time series variables, this study continues to estimate Model I, Model II, and Model III using FMOLS method proposed by Pedroni (2001) which allows for estimating heterogeneous cointegrated vector for panels members. The main advantage of this method is that it corrects for both serial correlation and simultaneity bias. Another reason why OLS is not appropriate is that its estimation produces biased results since the repressors are endogenously determined in the I(1) case. Pedroni (2001) considers the following cointegrated system for panel data:

[3.31] $Y_{it} = \alpha_i + \beta X_{it} + \varepsilon_{it}$

where Y and X are cointegrated. Pedroni (2001) proposed another equation that augments the cointegration regression with lead and lagged differences of the repressors to control the endogenous feedback effect. Hence, Equation [3.31] is specified as:

[3.32] $Y_{it} = \alpha_i + \beta X_{it} + \sum_{k=-ki}^{Ki} \gamma_{ik} \Delta X_{it-k} + \varepsilon_{it}$

Pedroni (2001) also defines $\varsigma_{it} = (\varepsilon_{it}, \Delta X_{it})$ and let $\Omega_{it} = \lim E[1/T(\sum_{t=1}^{T} \varsigma_{it})(\sum_{t=1}^{T} \varsigma_{it})']$ be the long run covariance for this process. This long run covariance matrix can be decomposed as $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i'$ where Ω_i^0 is the contemporaneous covariance and Γ_i is a weighted sum of auto covariance. Hence, the panel FMOLS estimator is specified as follows:

$$[3.33]\quad \beta^{*}_{FMOLS} = \frac{1}{N}\sum_{i=1}^{N} [(\sum_{t=1}^{T}(X_{it} - \overline{X}_i)^2)^{-1}(\sum_{t=1}^{T} (X_{it} - \overline{X}_i)Y^{*}_{it} - T\gamma_i)]$$

where $Y^{*}_{it} = Y_{it} - \overline{Y}(\hat{\Omega}_{2,1,i} / \hat{\Omega}_{2,2,i})\Delta X_{it} and \hat{\gamma}_i = \hat{\Gamma}_{2,1,i} + \hat{\Omega}^{0}_{2,1,i} - (\hat{\Omega}_{2,1,i} / \hat{\Omega}_{2,2,i})(\hat{\Gamma}_{2,2,i} + \hat{\Omega}_{2,2,i})$

3.5.1.4 Panel Granger Causality

The cointegration relationship indicates the existence of causal relationship among the variables, at least in one direction. However, it does not provide information on the direction of causality. To investigate the direction of short-run and long-run causal relationship among the variables, this study will specify a panel-based ECM with a dynamic error correction representation. Basically, this study will follow the Engle and Granger (1987) two step approach. In the first step, the long-run parameters presented in Model I, Model II and Model III (Equation 3, Equation 4 and Equation 5) are estimated, using the FMOLS procedure, to obtain the residuals. Incorporating the residuals as a right-hand side variable, the short-run error correction model is estimated in the second step. The Granger causality test involving error correction term (ECT) is specified as follows:

Model 1:

$$[3.34]\quad \Delta CO_{2it} = \alpha_{1i} + \sum_{P}\alpha_{11ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{12ip}\Delta POP_{it-p} + \sum_{P}\alpha_{13ip}\Delta Y_{it-p} + \sum_{P}\alpha_{14ip}\Delta TR_{it-p} + \sum_{P}\alpha_{15ip}\Delta TEC_{it-p} + \phi_{1i}ECT_{it-p} + \varepsilon_{1it}$$

$$[3.35]\quad \Delta POP_{it} = \alpha_{2i} + \sum_{P}\alpha_{21ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{22ip}\Delta POP_{it-p} + \sum_{P}\alpha_{23ip}\Delta Y_{it-p} + \sum_{P}\alpha_{24ip}\Delta TR_{it-p} + \sum_{P}\alpha_{25ip}\Delta TEC_{it-p} + \phi_{2i}ECT_{it-p} + \varepsilon_{2it}$$

$$[3.36]\quad \Delta Y_{it} = \alpha_{3i} + \sum_{P}\alpha_{31ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{32ip}\Delta POP_{it-p} + \sum_{P}\alpha_{33ip}\Delta Y_{it-p} + \sum_{P}\alpha_{34ip}\Delta TR_{it-p} + \sum_{P}\alpha_{35ip}\Delta TEC_{it-p} + \phi_{3i}ECT_{it-p} + \varepsilon_{3it}$$

$$[3.37]\quad \Delta TR_{it} = \alpha_{4i} + \sum_{P}\alpha_{41ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{42ip}\Delta POP_{it-p} + \sum_{P}\alpha_{43ip}\Delta Y_{it-p} + \sum_{P}\alpha_{44ip}TR_{it-p} + \sum_{P}\alpha_{45ip}\Delta TEC_{it-p} + \phi_{4i}ECT_{it-p} + \varepsilon_{4it}$$

$$[3.38]\quad \Delta TEC_{it} = \alpha_{5i} + \sum_{P}\alpha_{51ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{52ip}\Delta POP_{it-p} + \sum_{P}\alpha_{53ip}\Delta Y_{it-p} + \sum_{P}\alpha_{54ip}\Delta TR_{it-p} + \sum_{P}\alpha_{55ip}\Delta TEC_{it-p} + \phi_{5i}ECT_{it-p} + \varepsilon_{5it}$$

Model II:

$$[3.39]\quad \Delta CO_{2it} = \alpha_{1i} + \sum_{P}\alpha_{11ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{12ip}\Delta PD_{it-p} + \sum_{P}\alpha_{13ip}\Delta FDI_{it-p} + \sum_{P}\alpha_{14ip}\Delta FD_{it-p} + \sum_{P}\alpha_{15ip}\Delta NEC_{it-p} + \phi_{1i}ECT_{it-1} + \varepsilon_{1it}$$

$$[3.40]\quad \Delta PD_{it} = \alpha_{2i} + \sum_{P}\alpha_{21ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{22ip}\Delta PD_{it-p} + \sum_{P}\alpha_{23ip}\Delta FDI_{it-p} + \sum_{P}\alpha_{24ip}\Delta FD_{it-p} + \sum_{P}\alpha_{25ip}\Delta NEC_{it-p} + \phi_{2i}ECT_{it-1} + \varepsilon_{2it}$$

$$[3.41]\quad \Delta FDI_{it} = \alpha_{3i} + \sum_{P}\alpha_{31ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{32ip}\Delta PD_{it-p} + \sum_{P}\alpha_{33ip}\Delta FDI_{it-p} + \sum_{P}\alpha_{34ip}\Delta FD_{it-p} + \sum_{P}\alpha_{35ip}\Delta NEC_{it-p} + \phi_{3i}ECT_{it-1} + \varepsilon_{3it}$$

$$[3.42]\quad \Delta FD_{it} = \alpha_{4i} + \sum_{P}\alpha_{41ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{42ip}\Delta PD_{it-p} + \sum_{P}\alpha_{43ip}\Delta FDI_{it-p} + \sum_{P}\alpha_{44ip}\Delta FD_{it-p} + \sum_{P}\alpha_{45ip}\Delta NEC_{it-p} + \phi_{4i}ECT_{it-1} + \varepsilon_{4it}$$

$$[3.43]\quad \Delta FDI_{it} = \alpha_{5i} + \sum_{P}\alpha_{51ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{52ip}\Delta PD_{it-p} + \sum_{P}\alpha_{53ip}\Delta FDI_{it-p} + \sum_{P}\alpha_{54ip}\Delta FD_{it-p} + \sum_{P}\alpha_{55ip}\Delta NEC_{it-p} + \phi_{5i}ECT_{it-1}$$

$$[3.44]\quad \Delta NEC_{it} = \alpha_{6i} + \sum_{P}\alpha_{61ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{62ip}\Delta PD_{it-p} + \sum_{P}\alpha_{63ip}\Delta FDI_{it-p} + \sum_{P}\alpha_{64ip}\Delta FD_{it-p} + \sum_{P}\alpha_{65ip}\Delta NEC_{it-p} + \theta_{6i}ECT_{it-1}$$

ModelII:

$$[3.45]\quad \Delta CO_{2it} = \alpha_{1i} + \sum_{P}\alpha_{11ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{12ip}\Delta UR_{it-p} + \sum_{P}\alpha_{13ip}\Delta IND_{it-p} + \sum_{P}\alpha_{14ip}\Delta REC_{it-p} + \phi_{1i}ECT_{it-1}$$

$$[3.46]\quad \Delta UR_{it} = \alpha_{2i} + \sum_{P}\alpha_{21ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{22ip}\Delta UR_{it-p} + \sum_{P}\alpha_{23ip}\Delta IND_{it-p} + \sum_{P}\alpha_{24ip}\Delta REC_{it-p} + \phi_{21i}ECT_{it-1}$$

$$[3.47]\quad \Delta IND_{it} = \alpha_{3i} + \sum_{P}\alpha_{31ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{32ip}\Delta UR_{it-p} + \sum_{P}\alpha_{33ip}\Delta IND_{it-p} + \sum_{P}\alpha_{34ip}\Delta REC_{it-p} + \phi_{31i}ECT_{it-1}$$

$$[3.48]\quad \Delta REC_{it} = \alpha_{4i} + \sum_{P}\alpha_{41ip}\Delta CO_{2it-p} + \sum_{P}\alpha_{42ip}\Delta UR_{it-p} + \sum_{P}\alpha_{43ip}\Delta IND_{it-p} + \sum_{P}\alpha_{44ip}\Delta REC_{it-p} + \phi_{4ii}ECT_{it-1}$$

where Δ, ECT, and p denote the first difference of the variable, the error-correction term, and the lag length, respectively. The optimal lag length was determined using Akaike's information criterion (AIC). In the above models, the causality runs from ΔGDP toΔCO_2 (ΔEC) if the joint null hypothesis $\alpha_{13}ip = \alpha_{14}ip = 0 \;\forall\; ip$ ($\alpha_{23}ip = \alpha_{24}ip = 0 \;\forall\; ip$) is rejected. The presence of two variables measuring real national income in the system requires cross-equation restrictions to determine causality from emissions, energy consumption, trade openness and urbanization to real income using a likelihood ratio test. For instance, causality from ΔCO_2 to ΔGDP is supported if the null hypothesis $\alpha_{31}ip = 0 \;\forall\; ip$ and$\alpha_{41}ip = 0 \;\forall\; ip$ is rejected.

3.6 Conclusion

This chapter details the research methodology that is applied in this study. The STRIPAT model has been discussed in the section of theoretical framework. In the next section three different models are elaborated to explore the impact of technology, affluence and population on the environmental degradation. In addition, all the variables are justified with respect to research framework and previous literature along with expected similarities. Similarly, time duration, collection, sources and types of data are mentioned in the next section. Finally, in the section of method of analysis, justification and details of panel unit root tests, panel cointegration tests and panel long run relationship test likes FMOLS and panel Granger causality test are discussed.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This section presents and discusses the empirical results, thereby answering the research questions of the study in a comprehensive way. Three different models are tested to investigate the relationship between energy consumption, economic growth and CO_2 emissions. The three models are investigated on four diverse groups of countries namely, high income, upper middle income, lower middle income and low-income countries. First, the study explains the descriptive statistics of each variable. To confirm the level of stationarity, this study applied IPS unit root test suggested by Im, K. S., Pesaran, M. H., and Shin, Y. (2003). Furthermore, panel cointegration tests like Pedroni cointegration test and Kao cointegration test was applied to confirm the cointegration relationship. After using relevant and suitable tests for checking data properties, this study has applied FMOLS to test the long run relationship among proposed variables. Finally, study applied the Granger causality test to examine the causal effects among the variables.

4.2 Descriptive Statistics

The descriptive statistics such as, minimum, maximum, mean and standard deviation are tabulated in Table 4.1. The reported results show that high income countries are the biggest contributors of the CO_2emissions with average rate of 1035.42MT and low-income countries have least contribution in CO_2 emissions on average during 1980-2015. In term of average total energy consumption, group of high income countries is ranked the first, followed by upper middle, lower middle and low-income countries. Similarly, in term of renewable and non-renewable energy consumption, high income countries are leading contributors followed by upper middle, lower middle and low-income countries. The reported statistics shows that the CO_2 emissions, energy consumptions, financial development, international trade, FDI, industrial production are simultaneously increasing with the similar pattern.

When look at the demographic character, upper middle-income countries are the largest with an average 287.34 million population. On the contrary, lower middle-income countries and high-income countries stand second and third largest population with an average of 178.56 million and 78.44 million, respectively. However, low income countries have fairly low population with an average of 17.48 million. On the other hand, an average 75.63 percent population of high income countries is living in urban area. Similarly, an average 56.61 percent population of upper middle-income countries, 37.07 percent of lower middle-income countries and only 26.25 percent of low income countries are living in urban area. However, with an average of 178.56 persons per sq.km lower middle-income countries are leading, followed by high income countries with an average of 176.46 person per sq.km, upper middle-income countries with an average of 65.33 person per sq.km and low-income countries 52.58 person per sq.km.

Large values of standard deviation specify higher dispersion in time series data. The patterns of average total energy consumption, non-renewable energy consumption, renewable energy consumption and CO_2 emissions are similar. For example, high income countries are largest consumers of total energy consumption, non-renewable energy consumption and renewable energy consumption and also emit highest amount of CO_2 emissions with an average of 1035.42 MT. Similarly, upper middle income is the second largest in all three types of energy consumption and also the second largest in CO_2 emissions with an average of 640.96 MT. Finally, low income countries are least in total, non-renewable and renewable energy consumption and aggravate minimum CO_2 emissions.

The reported statistics presented in Table 4.1 show that lower middle-income countries have highest GDP growth rate with an average of 4.95 percent, followed by upper middle-income countries, low income countries and low-income countries with average growth rates of 4.61 percent, 3.78 percent and 2.59 percent respectively. In case of all other selected economic variables such as financial development, international trade, FDI and industrial production, high income countries are leading, followed by upper middle-income countries, lower middle-income countries and low-income countries, respectively.

Table4.1
Summary of Descriptive Statistics

	High Income Countries				Upper Middle-Income Countries			
Variable	Mini	Maxi	Mean	SD	Mini	Maxi	Mean	SD
CO_2	134.76	6116.44	1035.42	1475.35	27.97	9679.82	640.96	1462.20
TEC	1046.41	8365.20	4449.85	1834.54	411.70	3033.68	1641.97	685.93
NEC	263.23	7261.29	3247.34	1751.96	.00	2926.78	1409.35	716.69
REC	25.51	5627.46	1202.51	1392.34	.00	622.64	222.25	130.59
FD	12.89	227.75	99.12	49.33	7.09	166.50	58.91	43.24
TR	.00	5194.73	841.61	884.00	11.00	4786.00	233.27	549.47
FDI	-25.09	350.07	31.81	58.58	-1.00	291.00	13.26	37.35
IND	20.00	39.00	29.74	4.73	23.82	60.56	36.77	8.08
GDP	-10.00	13.24	2.59	2.88	-21.60	23.17	4.61	5.40
POP	14.80	319.13	78.44	71.25	13.89	1367.82	287.34	466.97
POD	1.91	517.35	176.46	144.40	14.62	145.32	65.33	37.79
UR	56.72	93.02	75.63	7.68	19.36	88.94	56.61	19.98
	Lower Middle-Income Countries				Low Income Countries			
Variable	Mini	Maxi	Mean	SD	Mini	Maxi	Mean	SD
CO_2	7.63	2596.71	193.87	380.40	.41	17.63	3.46	3.58
TEC	102.56	1165.51	507.83	225.33	114.21	923.49	393.42	160.65
NEC	.00	1148.02	331.00	246.01	5.22	437.20	70.82	85.96
REC	.00	645.67	175.34	155.22	86.58	583.88	322.59	112.34
FD	5.30	114.72	28.02	17.53	.20	103.63	17.74	12.46
TR	3.28	1027.77	77.62	134.42	.56	28.42	4.82	4.81
FDI	-4.55	43.41	2.56	5.76	-.42	6.70	.21	.64
IND	18.84	53.00	30.75	6.91	6.30	40.86	20.39	6.44
GDP	-13.13	13.25	4.95	21.13	-16.80	26.80	3.78	5.39
POP	9.13	1275.92	178.56	279.02	1.60	88.35	17.48	17.66
POD	43.57	1222.08	236.93	258.40	4.71	196.54	52.58	43.06
UR	14.85	59.70	37.07	11.23	6.09	43.51	26.2595	10.15

The descriptive statistics shows that the low-income countries are on the bottom in all variables. They have least contribution in CO_2 emissions with least energy consumption, financial development, international trade, FDI, GDP growth and total population. Whereas, high income countries remain leading in most of the cases, such as CO_2 emissions, energy consumption, FDI, financial development and urban population.

4.3 Panel Unit Root Test Results

The results of panel unit root test are reported in Table 4.2 indicate that the null hypothesis of the existence of a unit root cannot be rejected for all the variables at the five percent and 10 percent level of significance. However, the unit root null hypothesis for the variables at the first difference can almost be completely rejected at the five percent level. The study concludes that all selected variables are cointegrated of order I (1).

Table4.2
Panel Unit Root Test Results

Variables	High Income Countries				Upper Middle Countries			
	Level		First Difference		Level		First Difference	
	Stat	p-value	Stat	p-value	Stat	p-value	Stat	p-value
CO_2	1.875	0.969	-12.150	0.000**	5.971	1.000	-15.044	0.000**
POP	0.610	0.729	-2.442	0.007**	1.145	0.873	-3.641	0.001**
Y	-1.605	1.000	-14.924	0.000**	26.245	0.159	-18.136	0.000**
TR	5.430	1.000	-13.805	0.000**	6.474	1.000	-8.327	0.000**
TEC	2.221	0.986	-12.590	0.000**	3.923	1.000	-11.548	0.000**
PD	3.339	0.999	-1.594	0.055**	-1.694	0.451	-1.913	0.027**
FDI	-0.333	0.369	-15.386	0.000**	4.274	1.000	-11.257	0.000**
FD	0.773	0.780	-12.425	0.000**	2.002	0.977	-10.749	0.000**
NEC	1.707	0.956	-11.550	0.000**	2.135	0.983	-10.008	0.000**
UR	3.208	0.999	-1.284	0.099***	1.239	0.892	0.652	0.074***
IND	0.792	0.785	-15.221	0.000**	-0.629	0.264	-11.431	0.000**
REC	-0.195	0.422	-7.986	0.000**	0.275	0.608	-4.754	0.000**
Variables	**Lower Middle-Income Countries**				**Low Income Countries**			
	Stat	p-value	Stat	p-value	Stat	p-Value	Stat	p-value
CO_2	10.371	1.000	-6.763	0.000**	6.710	1.000	-14.805	0.000**
POP	7.796	1.000	-1.834	0.033**	1.145	0.873	-6.401	0.000**
Y	26.543	0.148	-5.328	0.000**	-4.827	0.973	-10.450	0.000**
TR	5.125	1.000	11.547	0.000**	13.732	1.000	-1.624	0.052***
TEC	0.433	0.667	-3.971	0.000**	0.589	0.722	-8.341	0.000**
PD	2.919	0.998	-1.418	0.078***	12.144	1.000	-3.818	0.001**
FDI	4.132	1.000	-8.100	0.000**	2.503	0.993	-15.425	0.000**
FD	1.726	0.957	-5.736	0.000**	0.935	0.825	-10.992	0.000**
NEC	1.877	0.969	-2.848	0.002**	0.621	0.732	-9.263	0.000**
UR	4.805	1.000	2.465	0.099***	17.563	1.000	-6.193	0.000**
IND	-0.273	0.392	-17.408	0.000**	-0.709	0.239	-16.373	0.000**
REC	4.007	1.000	-4.823	0.000**	0.420	0.663	-2.848	0.002**

Note: **, *** denote significance at the 5 percent and 10 percent level, respectivel

4.4 Panel Cointegration Test

In the next step, this study examines a long-run equilibrium relationship between the variables. The results are presented in Table 4.3 for high income, Table 4.4 for upper middle income, Table 4.5 for lower middle income and Table 4.6 for low income countries. Out of seven test statistics, most of them confirm the presence of cointegration among the variables. Therefore, following the Pedroni (1999) test in the series, this study concludes that all three models in high income panel, upper middle income panel, lower middle income panel and low income panel series have a long-run equilibrium relationship.

Table 4.3
Pedroni Residual Cointegration Test Results (High Income Countries)

Model I ($CO_2 = f(POP, Y, TR, TEC)$)				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	1.424	0.077***	0.202	0.419
Panel rho-Statistic	-1.117	0.131	0.107	0.542
Panel PP-Statistic	-3.080	0.001**	-1.552	0.060***
Panel ADF-Statistic	-3.834	0.001**	-2.474	0.006**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	1.176	0.880		
Group PP-Statistic	-1.357	0.087		
Group ADF-Statistic	-2.031	0.021**		
Model II ($CO_2 = f(PD, FDI, FD, NEC)$)				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.291	0.614	-2.556	0.994
Panel rho-Statistic	0.954	0.830	2.192	0.098***
Panel PP-Statistic	-2.051	0.020**	0.423	0.663
Panel ADF-Statistic	-3.161	0.008**	-2.001	0.022**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	1.930	0.973		
Group PP-Statistic	-1.499	0.066***		
Group ADF-Statistic	-3.643	0.001**		
Model III ($CO_2 = f(UR, IND, REC)$)				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	2.087	0.018**	1.693	0.045**
Panel rho-Statistic	0.111	0.054***	0.184	0.573
Panel PP-Statistic	-1.313	0.094***	-1.168	0.121
Panel ADF-Statistic	-1.326	0.092***	-1.094	0.136
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	0.924	0.822		
Group PP-Statistic	-1.082	0.139		
Group ADF-Statistic	-1.643	0.050**		

Note: **, *** denote significance at the 5 percent and 10 percent level, respective

Table 4.4
Pedroni Residual Cointegration Test Results (Upper Middle-Income Countries)

Model I ($CO_2 = f(POP, Y, TR, TEC)$				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	5.611	0.000**	-0.960	0.831
Panel rho-Statistic	-0.193	0.423	-2.649	0.004**
Panel PP-Statistic	-3.394	0.003**	-4.809	0.000**
Panel ADF-Statistic	-4.487	0.000**	-5.197	0.000**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	-0.379	0.352		
Group PP-Statistic	-2.033	0.021**		
Group ADF-Statistic	-3.098	0.001**		
Model II ($CO_2 = f(PD, FDI, FD, NEC)$				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	5.745	0.000**	-1.326	0.907
Panel rho-Statistic	-4.568	0.000**	-2.037	0.020**
Panel PP-Statistic	-7.082	0.000**	-5.051	0.000**
Panel ADF-Statistic	-6.819	0.000**	-5.499	0.000**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	-0.487	0.313		
Group PP-Statistic	-3.213	0.007**		
Group ADF-Statistic	-3.705	0.001**		
Model III ($CO_2 = f(UR, IND, REC))$				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	2.396	0.008***	-1.753	0.096***
Panel rho-Statistic	1.241	0.892	-0.523	0.300
Panel PP-Statistic	-0.284	0.388	-3.713	0.000**
Panel ADF-Statistic	-1.523	0.063***	-4.694	0.000**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	0.916	0.820		
Group PP-Statistic	-1.887	0.029**		
Group ADF-Statistic	-2.689	0.003**		

Note: **, *** denote significance at the 5 percent and 10 percent level, respectively

Table 4.5
Pedroni Residual Cointegration Test Results (Lower Middle-Income Countries)

Test	Statistic	Prob.	Weighted Statistic	Prob.
Model I ($CO_2 = f(POP, Y, TR, TEC)$)				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	6.411	0.000**	-0.901	0.816
Panel rho-Statistic	-0.981	0.163	-1.481	0.069**
Panel PP-Statistic	-0.916	0.179	-4.079	0.000**
Panel ADF-Statistic	-1.386	0.082***	-5.092	0.000**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	-0.122	0.451		
Group PP-Statistic	-2.630	0.004**		
Group ADF-Statistic	-4.784	0.000**		
Model II ($CO_2 = f(PD, FDI, FD, NEC)$)				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.358	0.640	-1.074	0.858
Panel rho-Statistic	-1.306	0.095***	-2.521	0.005**
Panel PP-Statistic	-3.402	0.000**	-6.088	0.000**
Panel ADF-Statistic	-3.137	0.000**	-5.949	0.000**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	-0.485	0.313		
Group PP-Statistic	-3.835	0.000**		
Group ADF-Statistic	-2.669	0.003**		
Model III ($CO_2 = f(UR, IND, REC)$)				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	1.368	0.085	0.179	0.428
Panel rho-Statistic	-0.414	0.339	-0.236	0.406
Panel PP-Statistic	-1.662	0.048**	-1.676	0.046**
Panel ADF-Statistic	-2.591	0.004**	-1.852	0.031**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	0.947	0.828		
Group PP-Statistic	-1.290	0.098***		
Group ADF-Statistic	-0.767	0.021**		

Note: **, *** denote significance at the 5 percent and 10 percent level, respectively

Table 4.6
Pedroni Residual Cointegration Test Results (Low Income Countries)

Model I ($CO_2 = f(POP, Y, TR, TEC)$)				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.441	0.329	0.221	0.412
Panel rho-Statistic	-0.532	0.029**	0.010	0.504
Panel PP-Statistic	-3.427	0.000**	-1.449	0.073***
Panel ADF-Statistic	-1.592	0.055***	-0.984	0.001**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	1.397	0.918		
Group PP-Statistic	-2.645	0.004**		
Group ADF-Statistic	-1.086	0.138		
Model II ($CO_2 = f(PD, FDI, FD, NEC)$)				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	2.238	0.012**	-0.358	0.639
Panel rho-Statistic	-0.423	0.335	0.161	0.564
Panel PP-Statistic	-3.447	0.000**	-2.228	0.012**
Panel ADF-Statistic	-4.871	0.000**	-2.913	0.001**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	0.898	0.815		
Group PP-Statistic	-3.467	0.000**		
Group ADF-Statistic	-3.722	0.000**		
Model III ($CO_2 = f(UR, IND, REC)$)				
Alternative hypothesis: common AR coefficients (within-dimension)				
Test	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	1.642	0.050**	-1.260	0.896
Panel rho-Statistic	-0.962	0.168	-0.462	0.322
Panel PP-Statistic	-3.168	0.000**	-3.541	0.000**
Panel ADF-Statistic	-3.330	0.000**	-4.151	0.000**
Alternative hypothesis: individual AR coefficients (between-dimension)				
Group rho-Statistic	0.570	0.715		
Group PP-Statistic	-2.377	0.008*		
Group ADF-Statistic	-2.393	0.008*		

Note: **, *** denote significance at the 5 percent and 10 percent level, respectively

For robustness, this study also applied cointegration relationships among the variables using another panel cointegration technique proposed by Kao (1999). The results of Kao's cointegration test presented in Table 4.7 also confirmed the existence of long-run equilibrium relationship among the variables. Therefore, the study continued towards panel long-run relationship between the variables by using panel FMOLS.

Table 4.7
Kao Residual Cointegration Test

Model Test	High Income Countries		ADF
		t-statistic	Probability
I	$CO_2 = f(POP, Y, TR, TEC)$	-2.318	0.012**
II	$CO_2 = f(PD, FDI, FD, NEC)$	-2.249	0.012**
III	$CO_2 = f(UR, IND, REC))$	-3.138	0.008**
Upper Middle Countries			
I	$CO_2 = f(POP, Y, TR, TEC)$	-2.824	0.002**
II	$CO_2 = f(PD, FDI, FD, NEC)$	-1.540	0.061***
III	$CO_2 = f(UR, IND, REC))$	-0.722	0.023**
Lower Middle Countries			
I	$CO_2 = f(POP, Y, TR, TEC)$	-2.5127	0.006**
II	$CO_2 = f(PD, FDI, FD, NEC)$	-1.374	0.084**
III	$CO_2 = f(UR, IND, REC))$	2.390	0.008**
Low Income Countries			
I	$CO_2 = f(POP, Y, TR, TEC)$	-2.318	0.012**
II	$CO_2 = f(PD, FDI, FD, NEC)$	-3.454	0.003**
III	$CO_2 = f(UR, IND, REC))$	-0.093	0.046**

Note: **, *** denote significance at the 5 percent and 10 percent level, respectively

4.5 Long Run Relationship Results

The long run estimation results of high income, upper middle, lower middle and low-income countries are reported in Table 4.8, Table 4.9, Table 4.10 and Table 4.11, respectively.

4.5.1 High Income Countries

The long run estimation results of the selected variables are reported in Table 4.8. The estimated coefficients of population size are positive and statistically significance at 5 percent level in the panel of high income countries and single countries such as US, Canada, Poland and Australia. It is found that, one million increases in the population of group of high income countries, US, Canada, Poland and Australia leads to increase in CO_2 emissions by 23.48 MT, 25.27 MT, 13.95 MT, 16.28 MT and 18.08 MT, respectively. The results are in line with Dietz and Rosa (1997). This study argued that population growth is one of the major driving forces behind the rapid increase of global CO_2 emissions. According to Malthus and Hollingsworth (1973) the impact of population growth on environmental quality is evident. Each person creates some demands on energy for the necessities of life like food, shelter, clothing, water, and so on. According to Malthusian tradition, the higher is the number of people, the greater is the energy demanded. The study of Bidsall (1992) suggested two mechanisms through which population growth could contribute to CO_2 emissions. First, a larger population could result in increased the energy demand for power, industry, and transportation, which consequently increase GHGs emissions. Second, rapid population growth can cause the deforestation, other changes in land use, and burning of wood for fuel. This might contribute to the pollutant emissions extensively (Fan et aL, 2006; Hang & Yuan-sheng, 2011; Knapp & Mookerjee, 1996; Lantz & Feng, 2006; Brantley Liddle, 2013, 2015; van Ypersele & Bartiaux, 1995; You et al., 2015).

Table 4.8
Estimation Results (High Income Countries)

	Model 1					Model 2					Model 3			
	POP	Y	TR	TEC	R^2	FD	FDI	POD	NEC	R^2	IND	UR	REC	R^2
Group β	0.000*	0.608	0.000*	0.000*	0.96	0.008*	0.003*	0.000*	0.000*	0.99	0.003*	0.007*	0.873	0.98
	[23.489]	[1.733]	[-0.140]	[0.111]		[0.070]	[0.012]	[0.166]	[0.847]		[-19.52]	[17.013]	[0.014]	
Individual β														
US	0.000*	0.712	0.033**	0.000*	0.98	0.213	0.536	0.004*	0.004*	0.94	0.076***	0.455	0.026**	0.79
	[25.274]	[-2.783]	[-0.109]	[0.953]		[0.187]	[-0.01]	[0.150]	[0.002]		[-101.54]	[-90.30]	[-2.517]	
Japan	0.253	0.043**	0.002*	0.000*	0.96	0.04**	0.565	0.495	0.000*	0.96	0.024**	0.528	0.140	0.71
	[-1.366]	[-0.019]	[0.170]	[1.090]		[0.052]	[-0.09]	[0.146]	[1.172]		[-0.970]	[-0.565]	[0.088]	
Germany	0.000*	0.237	0.000*	0.003*	0.95	0.879	0.372	0.694	0.000*	0.97	0.198	0.001*	0.002*	0.83
	[-10.714]	[2.357]	[-0.041]	[0.110]		[-0.05]	[-0.03]	[0.005]	[0.908]		[0.193]	[-5.487]	[-0.18]	
UK	0.002*	0.127	0.034**	0.002*	0.90	0.007*	0.614	0.056**	0.018*	0.92	0.016**	0.000*	0.724	0.78
	[-19.840]	[-2.480]	[0.056]	[0.057]		[0.341]	[0.028]	[-2.68]	[0.077]		[-7.742]	[-48.21]	[-0.07]	
Canada	0.013**	0.885	0.750	0.000*	0.95	0.254	0.02**	0.000*	0.000*	0.94	0.035**	0.000*	0.622	0.88
	[13.958]	[0.280]	[0.015]	[0.074]		[0.058]	[0.121]	[153.4]	[0.078]		[18.658]	[28.826]	[0.021]	
Italy	0.000*	0.351	0.002*	0.000*	0.97	0.250	0.908	0.100	0.000*	0.98	0.000*	0.048**	0.015**	0.58
	[-34.720]	[-0.979]	[0.072]	[0.112]		[0.074]	[-0.04]	[-1.26]	[0.831]		[-52.801]	[-90.34]	[-0.54]	
France	0.004*	0.452	0.171	0.038**	0.48	0.215	0.193	0.034**	0.000*	0.91	0.023**	0.012**	0.013**	0.80
	[-10.909]	[-2.638]	[0.022]	[0.042]		[0.315]	[0.145]	[1.609]	[0.174]		[-1.515]	[-7.529]	[-0.24]	
South Korea	0.430	0.244	0.009*	0.000*	0.95	0.06**	0.380	0.001*	0.000*	0.95	0.005*	0.003*	0.892	0.93
	[-4.668]	[0.834]	[0.027]	[0.111]		[-0.06]	[0.008]	[2.927]	[0.525]		[-3.051]	[5.024]	[-0.08]	
Poland	0.006*	0.277	0.000*	0.000*	0.98	0.896	0.005*	0.030**	0.000*	0.97	0.386	0.113	0.071***	0.53
	[16.280]	[-0.527]	[-0.072]	[0.124]		[0.025]	[-1.03]	[5.751]	[0.124]		[-3.907]	[-17.07]	[-0.29]	
Australia	0.000*	0.827	0.082***	0.000*	0.98	0.000*	0.750	0.048**	0.03**	0.98	0.001*	0.000*	0.002*	0.98
	[18.008]	[0.230]	[-0.061]	[0.066]		[2.567]	[-0.04]	[-79.1]	[0.182]		[-3.007]	[23.662]	[-0.052]	

Note:*, **, *** denote significance at the 1 percent, 5 percent and 10 percent level, respectively. In parentheses t-statistics are mentioned.

On the contrary, the estimated coefficients of population size are negative and statistically significant at five percent level in Germany, UK, Italy and France. The results reported in Table 4.8 shows that if there are one million increases in the population size the CO_2 emissions will decrease by 10.71 MT, 19.84 MT, 34.30 MT and 10.90 MT in Germany, UK, Italy and France, respectively. It is due to population growth can encourage the manifestation and development of technological innovations, and improve human capability to present technological solutions to decrease environmental problems. The results are inconsistent with You et al. (2015). However, the total population of Japan and South Korea is statistically insignificant even at 10 percent. Hence, there is no long run relationship between population and CO_2 emissions in the case of South Korea.

The coefficient of GDP growth of Japan is negative and statistically significant at five percent level. The reported results show that one percent increase in the GDP growth leads to decrease in CO_2 emissions by 0.019MT. These results are in line with C. F. Tang and B. W. Tan (2015) and Al-mulali (2012) who also found negative relationship between GDP growth and CO_2 emissions. Similarly, results contradict with Alshehry and Belloumi (2015) and Zeb et al. (2014) who found positive relationship. The studies of Alshehry and Belloumi (2015) and Zeb et al. (2014) suggested that GDP growth have significant positive and negative impact on energy consumption and CO_2 emissions depends on the stages of development. At the first stage, pure growth in the economy scale would result in a proportional growth in pollution and other negative environmental impacts. The second stage shows that the transformation of the economy change composition from agriculture production to more resource intensive heavy manufacturing industries leads to more pollutant emissions. In the later stages of development, pollution decreases as the composition of the economy shifts towards service and light manufacturing industries. Japan is a high-income country and its economy has already shifted towards service and light manufacturing industries. Hence, GDP growth of Japan helps to reduce the level of CO_2 emissions. The coefficients of GDP growth are statistically insignificant even at 10 percent level of significance in most of the selected high-income countries. The coefficients of GDP growth are insignificant in the panel of high income countries and individual countries such as US, Germany, Canada, Italy, France, South Korea, Poland and Australia. These results are in line with studies by Wendy N Cowan, Tsangyao Chang, Roula Inglesi-Lotz, and Rangan Gupta (2014).

The coefficients of international trade are positive and statistically significant at five percent level in Japan, Italy, South Korea and at 10 percent level in UK. The results suggest that $1 billion increase in international trade of these countries will leads to increase in CO_2 emissions by 0.170MT, 0.072MT, 0.027MT and 0.056MT in Japan, Italy, South Korea and UK respectively. These positive results are supported by the studies like Faiz-Ur-Rehman, Ali, and Nasir (2007) and Farhani, Chaibi, and Rault (2014), where results are contrary with the studies like B. Lin and Sun (2010) who found negative relationship. It is argued that the rapid increase in international trade can boost the energy use especially through transportation, which is the main source of CO_2 emissions. On the contrary, international trade coefficients are negative and statistically significance in group of high income countries like the US, Germany, Poland and Australia at 10 percent significance level. The results are consistent with Kohler (2013b) and inconsistent with Farhani et al. (2014) who are also found similar results. These results support the argument that international trade can play a fundamental role in the 'greening' of the energy sector, in particular, by facilitating the technology transfer for renewable energy and by responding to demand for sustainably energy sources. This demand has led to several trade opportunities, including exports of raw materials and components for renewable energy supply products and finished products, hence reduction in pollutant emissions. Finally, international trade coefficients of Canada and France are statistically insignificant even at 10 percent level. The results are consistent with the study of Sharma (2011) in 69 countries and Kohler (2013b) in case of South African perspective who also found insignificant relationship.

The coefficients of energy consumption are positive and statistically significant at one percent level in all countries. The reported results show that if there is 1KT increase in energy consumption will lead to increase in CO_2 emissions by 0.111MT 0.953MT, 1.090MT, 0.110MT, 0.057MT, 0.074MT, 0.112MT, 0.042MT, 0.111MT, 0.124MT and 0.066MT in the panel of high income countries, the US, Japan, Germany, UK, Canada, Italy, France, South Korea, Poland and Australia, respectively. These results are in line with many recent studies like Alshehry and Belloumi (2015) in the Saudi Arabia, C. F. Tang and B. W. Tan (2015) in the Vietnam and Dogan and Turkekul (2016) in the case of the US who also found positive relationship between energy consumption and CO_2 emissions. Whereas, results are inconsistent with Ozturk and Acaravci (2010b) in case of Turkey. It is suggested that energy is a key factor of production and used in commercial and non-commercial activities, which leads to economic growth of a country. Most of the energy comes from fossil fuels and non-renewable sources such as oil, coal and gas, which consequently leads to increase in CO_2 emissions.

The coefficients of financial development are positive and significant at one percent level in the panel of high income countries, Japan, UK and Australia. The reported results show that one percent increase in financial development will lead to increase CO_2 emissions by 0.070MT, 0.052MT, 0.341MT and 2.567MT in the panel of high income countries, Japan, UK and Australia, respectively. These positive relationship results are supported by the studies such as M. M. Alam et al. (2016) and Shahbaz, Hye, et al. (2013b). It is argued that financial development contributes to CO_2 emissions through the aiding manufacturing activities. Due to financial development, it is easy to borrow funds to purchase energy consumable products, get access to financial capital in order to develop existing business or start a new one which increase the energy consumption and consequently increase CO_2 emissions.

In contrast, coefficients of financial development are negative and statistically significant in Australia and South Korea at five percent significance level. If there is one percent increase in financial development, it will help to decrease CO_2 emissions by 0.05 MT in Australia and 0.06 MT in South Africa. These studies argue that financial development provides with the motive and opportunity to use new technologies with clean and environment friendly production processes. Consequently, such technologies also improve the global environment by lowering the CO_2. It is also suggested that financial development may also play a significant role in improving the environment. Greater financial sector development can facilitate financing at lower costs investment in environmental projects. Since much of environmental protection will be a public-sector activity, the ability to raise such financing is especially important for governments at the local, state, and national levels. At last, coefficient of financial development in the US, Germany, Canada, Italy, France and Poland are found statistically insignificant.

The effect of FDI on the natural environment of the host country is controversial subject. The coefficients of FDI are positive and significant at one percent level in the panel of high income countries and in Canada at five percent level. The results show that $1 billion increase in the FDI of selected panel of high income countries and Canada will increase the CO_2 emissions by 0.012MT and 0.121MT, respectively. These results support the hypothesis of scale effect and composition effect. The scale effect suggested that the environmental quality would decrease with the increase in economic growth due to FDI, and vice versa. Similarly, in composition effect pollution emissions would change as a result of the structural changes in the economy specifically owing to FDI. This means a move toward pollution intensive production would generate more pollution and vice versa.

The coefficient of FDI is negative and statistically significant at the five percent level in Poland. The reported results show that $1 billion increase in the FDI of Poland will lead to decrease in CO_2 emissions by 1.03MT. These results support the hypothesis of technique effect of globalization. The technique effect of globalization entails that if scale and structure of economic growth remains the same, innovative technology introduced due to FDI will alter the amount of pollutant emissions per unit of output and consequently, reduce the total emissions. However, coefficients of FDI are insignificant even at 10 percent level of significance in most of the countries like the US, Japan, Germany, UK, Italy, France, South Korea and Australia. The results are in line with Atici (2012) and contrary to Dean et al. (2009).

In addition, in majority of cases, coefficients of population density are positive and statically significant at five percent level such as panel of high income countries, US, Canada, South Korea, France and Poland. The results argue that one percent increase in the population density of these countries will lead to increase in the CO_2 emissions by 0.166MT, 0.150MT, 153.4MT, 2.927MT, 1.609MT and 5.751MT, respectively. These positive relationship results are in line with Q. Zhu and Peng (2012) and contrary to S. Alam et al. (2007) who found insignificant relationship between population density and CO_2 emissions. It is argued that the more is the population density, the higher is the demand of energy which may cause increase in the pollution emissions.

Meanwhile, the coefficients of population density are negative and statistically significance at five percent only in UK and Australia. The results reveal that one percent increase in the population density of UK and Australia can help to reduce the CO_2 emissions by 2.68MT and 79.1MT in both countries. It is suggested that the population density may reduce the CO_2 emissions, since energy demand depends on per capita energy consumption and population density has a negative impact on the per capita road transportation energy consumption. This implies that populous and highly urban cities have less demand for personal transport, therefore, it lowers the amount of CO_2 emissions. Finally, coefficients of population density are insignificant even at 10 percent level in case of Japan and Italy. Therefore, there is no relationship between population density of Japan and Italy and CO_2 emissions. The results are in line with Begum et al. (2015b) and contrary with the studies like Fan et al. (2006).

All coefficients of non-renewable energy consumption are positive and statistically significant at five percent significance level. The results are evident that 1KT increase in the non-renewable energy can increase the CO_2 emissions by 0.847MT, 0.002MT, 1.172MT, 0.908MT, 0.077MT, 0.078MT, 0.831MT, 0.174MT, 0.525MT, 0.124MT and 0.182MT in the panel of high countries, the US, Japan, Germany, UK, Canada, Italy, France, South Korea, Poland and Australia, respectively. These positive results are supported by the studies such as Bölük and Mert (2014) and Farhani and Shahbaz (2014) but are inconsistent with Apergis and Payne (2012) who found insignificant relationship. The results are very much logical since 80 percent energy comes from the fossil fuels which are consumed for production, transportation and construction purpose. It is reported in Table 4.1 that high-income countries are one of the highest consumers of non-renewable energy consumption and emitting highest amount of CO_2 emissions.

The coefficient of industrial production (IND) is positive and statistically significant at five percent level only in Canada. It is suggested that one percent increase in the IND will leads to increase in CO_2 emissions by 18.658MT. The results are consistent with Du et al. (2012) who also found positive relationship between IND and CO_2 emissions and inconsistent with Gregg, Andres, and Marland (2008) who found negative relationship. Canada is one of the high-income countries that have massive IND and which are using non-renewable energy. Hence, Canada's industrial production hurts the environment by emitting high CO_2 emissions. On the other side, coefficient of IND is negative and statistically significant at five percent level in the panel of high income countries such as, the US, Japan, UK, Italy, France, South Korea and Australia. The results suggest that one percent increase in the IND of these countries will lead to decrease of CO_2 emissions by

19.51MT, 101.54MT, 0.97MT, 7.742MT, 52.80MT, 1.51MT, 3.05MT, 3.07MT, respectively. The study suggests that while IND is at initial stage, pollution emissions increase due to lack of environmental policies and old machinery. At a later stage pollution relatively decreases due to improvement in polices and replacement of old machinery with the latest. Since, US, Japan, UK, Italy, France, South Africa and Australia are high income countries and using latest technology. Hence, there is less pollution emissions during the industrial production in these countries. Finally, coefficients of IND are insignificant in case of Germany and Poland even at 10 percent significance level. Therefore, there is no relationship found between industrial production of Germany and Poland with the CO_2 emissions. The results are in line with the studies like Heede (2014) who also found insignificant relationship.

Population living in the urban area is another suspected culprit of CO_2 emissions. The reported results in Table 4.8 show that the coefficients of urbanization are positive and statistically significant at five percent level in the panel of high income countries, South Korea and Australia and Canada. The reported results argue that if there is one percent increase in the urbanization, it will lead to increase in CO_2 emissions by 17.01MT, 5.02MT and 23.71MT in the panel of high income countries, South Korea and Australia, respeetively. These are surprising result because it is expected that greater urbanization leads to more public transport use and thus to lower emissions. In different studies, it can be observed that the relationship between urbanization and emissions is complex, even in countries with the same levels of income and development. However, developed and largely urbanized countries are in a better position to achieve low carbon intensity by adopting new energy technologies. Hence, it seems that the relationship between urbanization and emissions can be better explained by the EKC hypothesis in developed countries.

It is argued that urbanization and environment are the interconnected processes between the physical growth of cities and human activities, which increase the use of motor vehicle, production and consumption of other goods. These activities required energy, which consequently increase the pollutant emissions like CO_2 emissions.

The coefficients of urbanization (UB) are negative and significant in the US, Germany and UK, Italy and France at five percent significance level. The results recommended that one percent increase in the urbanization of the US, Germany, UK, Italy and France consequently will decrease in the CO_2 emissions by 90.30MT, 5.48MT and 48.21MT, 0.048MT and 0.012MT, respectively. These results indicate that at a higher level of urbanization, CO_2 emissions decrease. In other words, when a certain level of urbanization is achieved, emissions tend to decline in these high-income countries. This finding confirms the ecological modernization theory, which argues that if the environment and the economy are properly managed through structural changes or modernization, emissions can be curbed. Therefore, as urbanization is a key indicator of modernization, it is expected that at higher levels of urbanization, the environmental impact decreases. In addition, Ehrhardt-Martinez (1998) explains this phenomenon by stating that the urbanization process in its initial stages depends more on resource extraction. However, advanced urbanization is accompanied by largely complete urban infrastructure as well as increased use of less-polluting fuels.

The similar results are found by Sharma (2011) and different results found by Sadorsky (2014). It is investigated that urbanization can increase in the efficiency of public transportation that will decrease the negative impact on the environment. On the other side, coefficients of urbanization are insignificant in the US, Japan and Poland even at 10 percent level of significance.

The coefficients of renewable energy are negative and statistically significant at one percent level in Germany and Australia, at five percent level in the US, Italy and France, and at 10 percent level of significance in Poland. These results argue that 1KT increase in the renewable energy consumption of the US, Germany, Italy, France, Poland and Australia can decrease the CO_2 emissions by 0.028MT, 0.002MT, 0.015MT, 0.013MT, 0.071MT, respectively. The similar results are found by Bölük and Mert (2014) and Robalino-López et al. (2014) and different results by Farhani and Shahbaz (2014). It is argued that the renewable energy consumption positively affects the economic growth but also helps to reduce pollutant emissions in the host countries. On the other side, coefficients of renewable energy consumption are insignificant even at 10 percent level of significance in case of high income countries panel, Japan, UK, Canada and South Korea.

According to results reported in Table 4.8, it is summarized that both total energy consumption and non-renewable energy consumption are the main culprit of CO_2 emissions in the high-income countries. The coefficients of both variables are positive and statistically significant at different level of significance. Similarly, population density followed by population growth, financial development and urbanization are a few other major reasons of high CO_2 emissions in these countries.

However, industrial production, renewable energy consumption and international trade are found to be environmental friendly and mainly help to reduce the CO_2 emissions in these high-income countries. It might be due to an increase in the trends of renewable energy consumption and improved technology used for transportation in international trade and in industrial production by high income countries. Finally, results show that GDP growth does not have any contribution in the CO_2 emissions of selected high-income countries. Similarly, financial development and FDI are also insignificant with respect to CO_2 emissions in the most of countries.

4.5.2 Upper Middle Income Countries

The results of long run estimates are reported in the Table 4.9. The results show that the coefficients of population growth are positive and statistically significant at one percent level in the panel of upper middle-income countries and individual countries like China, Mexico, South Africa, Iran, Brazil, Venezuela and Romania. It is evident that, if there is an increase of one million population in these countries, it will lead to increase in the CO_2 emissions by 0.95MT, 4.26MT, 0.282MT, 5.857MT, 4.502MT, 2.866MT, 8.898MT and 9.895MT, respectively. These results support the arguments of Malthus and Hollingsworth (1973), which reveal that each person creates some demand on energy for the necessities of life, food, shelter, clothing, water, and so on. Hence, the greater is the population growth, the higher is the demand of energy and consequently, it increases the

CO_2 emissions. The world population 7238.18 million was recorded in 2014 and cumulative population of selected upper middle-income countries was 2078.69 million which is the one fourth (28.72 percent) of the world's total population. Therefore, this 2078.69 million population creates the higher demand of energy, which consequently causes a high level of CO_2 emissions.

On the other hand, coefficients of population growth are insignificant in Turkey, Thailand and Romania even at 10 percent level of significance. It means that there is no long run relationship found between population growth and CO_2 emissions in these countries. These results are consistent with the results of Begum et al. (2015b) and inconsistent with Brantley Liddle (2013).

The coefficient of GDP growth is positive and significant at 10 percent level only in China. The reported results in Table 4.9 show that if there is one percent increase in the GDP growth of China, it will lead to the increase of CO_2 emissions by 26.93MT. According to results among selected upper middle-income courtiers, only China's GDP growth contributes to the CO_2 emissions. The results are consistent with Wendy N. Cowan, Tsangyao Chang, Roula Inglesi-Lotz, and Rangan Gupta (2014) and Lotfalipour, Falahi, and Ashena (2010a) who also found positive relationship between GDP growth and CO_2 emissions, whereas inconsistent with Kasman and Duman (2015) who found negative relationship. It is investigated that GDP growth have significant positive and negative impact on energy consumption and CO_2 emissions depends on the stages of development.

Table 4.9
Estimation Results (Upper Middle-Income Countries)

	Model 1					Model 2					Model 3			
	POP	Y	TR	TEC	R^2	FD	FDI	POD	NEC	R^2	IND	UR	REC	R^2
Group β	0.000*	0.359	0.001*	0.000*	0.95	0.070*	0.000*	0.145	0.050*	0.96	0.012*	0.000*	0.010*	0.95
	[0.953]	[-0.008]	[0.035]	[1.097]		[2.501]	[24.24]	[-6.33]	[0.154]		[0.467]	[2.834]	[-0.22]	
Individual β														
China	0.000*	0.052***	0.000*	0.000*	0.96	0.414	0.093***	0.453	0.000*	0.90	0.894	0.000*	0.001*	0.86
	[4.261]	[26.938]	[0.773]	[2.264]		[-0.09]	[0.035]	[0.473]	[0.971]		[0.077]	[1.527]	[-1.209]	
Mexico	0.000*	0.424	0.004*	0.004*	0.96	0.006*	0.928	0.000*	0.000*	0.97	0.349	0.000*	0.039*	0.93
	[0.282]	[-0.716]	[0.074]	[0.265]		[-1.31]	[-0.04]	[6.784]	[0.238]		[1.727]	[18.162]	[-0.53]	
South Africa	0.000*	0.049**	0.004*	0.002*	0.94	0.635	0.733	0.001*	0.000*	0.92	0.019**	0.000*	0.183	0.95
	[5.857]	[-2.746]	[0.331]	[0.066]		[0.047]	[-0.06]	[0.752]	[0.883]		[4.636]	[29.267]	[0.085]	
Iran	0.008*	0.388	0.202	0.000*	0.95	0.001*	0.877	0.000*	0.019*	0.98	0.019**	0.000*	0.348	0.92
	[4.502]	[-1.081]	[1.759]	[0.156]		[3.797]	[-1.09]	[11.83]	[0.064]		[0.154]	[4.458]	[-0.01]	
Brazil	0.000*	0.745	0.003*	0.693	0.85	0.836	0.000*	0.000*	0.001*	0.90	0.163	0.027**	0.007*	0.90
	[2.866]	[-0.531]	[0.187]	[-0.03]		[-0.01]	[0.870]	[16.67]	[0.255]		[-3.154]	[8.128]	[0.350]	
Turkey	0.412	0.828	0.009*	0.008*	0.97	0.000*	0.000*	0.000*	0.007*	0.99	0.000*	0.000*	0.005*	0.95
	[1.706]	[-0.180]	[77.40]	[-84.5]		[0.886]	[1.175]	[5.074]	[0.031]		[-10.08]	[11.091]	[-0.542]	
Thailand	0.252	0.072***	0.007*	0.000*	0.97	0.804	0.035**	0.016*	0.000*	0.97	0.047**	0.651	0.000*	0.89
	[1.126]	[-0.567]	[-0.075]	[0.203]		[0.012]	[0.959]	[0.951]	[0.178]		[0.196]	[-0.040]	[-1.085]	
Venezuela	0.000*	0.001*	0.605	0.783	0.95	0.005*	0.163	0.000*	0.760	0.76	0.427	0.000*	0.001*	0.87
	[8.898]	[-1.044]	[-0.040]	[-0.04]		[-0.14]	[0.044]	[1.565]	[0.156]		[-0.542]	[16.650]	[-0.32]	
Romania	0.005*	0.405	0.182	0.000*	0.98	0.139	0.007*	0.841	0.000*	0.93	0.009*	0.434	0.001*	0.86
	[9.895]	[0.164]	[0.091]	[0.079]		[-0.07]	[0.042]	[0.137]	[0.676]		[8.520]	[3.213]	[-0.16]	
Malaysia	0.846	0.918	0.004*	0.127	0.89	0.113	0.018**	0.01**	0.03**	0.97	0.001*	0.000*	0.109	0.97
	[-0.09]	[-0.003]	[0.527]	[0.529]		[-0.15]	[2.111]	[2.483]	[0.045]		[-4.064]	[7.391]	[-0.60]	

Note:*, **, *** denote significance at the 1 percent, 5 percent and 10 percent level, respectively. In parentheses t-statistics are mentioned.

At the first stage pure growth in the scale of the economy would result in a proportional growth in pollution and other negative environmental impacts. The second stage shows that composition of the economy has mainly been transformed from agriculture production to more resource intensive heavy manufacturing industries which lead to more pollutant emissions. In the later stages of development, pollution decreases as the composition of the economy shifts towards service and light manufacturing industries. Hence, China is still in the first stage of production where her heavy manufacturing industries lead to more CO_2 emissions.

Furthermore, coefficients of GDP growth are negative and statistically significant at one percent level in Venezuela, at five percent in South Africa and at 10 percent in Thailand. The results show that, one percent increase in the GDP growth of Venezuela, South Africa and Thailand will lead to decrease in the CO_2 emissions by 1.044MT, 2.745MT and 0.567MT, respectively. The countries like Venezuela, South Africa and Thailand are upper middle-income countries and the composition of the economy shifted towards service and light manufacturing industries. Hence, GDP growth of these countries helps decrease the level of CO_2 emissions. On the other hand, coefficients of GDP growth are insignificant in group of upper middle-income countries, Mexico, Iran, Brazil, Turkey, Romania and Malaysia even at 10 percent level of significance.

Similarly, coefficients of international trade are positive and statistically significant at one percent level in group of upper middle-income countries, Mexico, South Africa, Brazil, Turkey and Malaysia. The obtained results suggest that $1 billion increase in the international trade of these countries will lead to increase in the CO_2 emissions by

0.773MT, 0.074MT, 0.331MT, 0.187MT, 77.40MT and 0.527MT, respectively. The results are in line with the studies like McCarney and Adamowicz (2005) and Al-mulali and Sheau-Ting (2014) who also found positive relationship between international trade and CO_2 emissions but different results found in Kohler (2013a). There are two schools of thought about the impact of international trade on CO_2 emissions. The first school of thought argues that trade openness provides an offer to each country to have access to international markets which enhances the market share among countries (Shahbaz et al., 2012). This leads to competition between countries and increases the efficiency of using scarce resources and encourages importing cleaner technologies in order to lower the CO_2 emissions (Ford Runge & Davis, 1995; Helpman, 1998). Another group proposes that natural resources are depleted due to international trade. This depletion of natural resources increases CO_2 emissions and causes a decrease in environmental quality (Brian R Copeland & Taylor, 2001; Schmalensee, Stoker, & Judson, 1998). The results of this study support the arguments of second group where they argue that the 'natural resources are depleted due to international trade.

On the other side, the coefficients of international trade are negative and statistically significant at one percent level in China and Thailand. It is due to the governments of China and Thailand has undertaken many measures to curb pollution in China and improve the country's environmental situation. Those measures included cleaner energy, green technology, carbon taxing and so on. The results suggest that $1billion increase in the international trade of China and Thailand cause a decrease in the CO_2 emissions by 0.035MT and 0.075MT. It is argued that the international trade is beneficial to environmental quality through environmental regulations and capital-labor channels. It is argued that the impact of international trade on environmental quality. They introduced composition, scale and technological effects by decomposing the international trade model. Their study concluded that international trade is beneficial to the environment if the technological effect is greater than the composition effect and scale effect. The international trade will improve the income level of developing nations and induce them to import less polluted techniques to enhance production. The authors documented that free trade decreases CO_2 emissions because international trade will shift the production of pollution-intensive goods from developing countries to the developed nations. Furthermore, quality of the environment is improved if the environmental regulatory effect is stronger than the capital-labor effect. It is suggested that the international trade improves environmental quality depending on government policies. The local government can reduce CO_2 emissions through their environmental policies.

Finally, coefficients of international trade are insignificant in Iran, Venezuela and Romania even at 10 percent level of significance. Hence, international trade of these countries doesn't have any relationship with CO_2 emissions in the long run. The results are in line with B. Lin and Sun (2010) in case of China who also found insignificant relationship between international trade and CO_2 emissions.

The coefficients of total energy consumption are positive and statistically significant at one percent level in group of upper middle-income countries, China, Mexico, South Africa, Iran, Turkey, Thailand and Romania. The results suggest that 1 KT increase in the consumption of total energy by these countries can increase CO_2 emissions by 1.097MT, 2.264MT, 0.265MT, 0.066MT, 0.156MT, 8.005MT, 0.203MT and 0.077MT, respectively. The results are consistent with many studies like Halicioglu (2009b), Chang (2010) and Menyah and Wolde-Rufael (2010b) who also found positive relationship between energy consumption and CO_2 emissions and inconsistent with the studies like Odhiambo (2012) who found different results. On the contrary, the coefficients of total energy consumption are insignificant in Brazil, Venezuela, Romania and Malaysia. It means that there is no long run relationship between energy consumption of these countries and CO_2 emissions. The results are similar to the study of Odhiambo (2012) and different from the results of Soytas et al. (2007b).

According to the results reported in the Table 4.9 the coefficients of financial development are positive and statistically significant at one percent level in the panel of upper middle-income countries, Iran and Turkey. The results suggest that if there is one percent increase in the financial development of these countries, it will lead to an increase in CO_2 emissions by 2.501MT, 3.797MT and 0.886MT, respectively. It is argued that the financial development causes the environmental degradation by emitting CO_2 emissions due to inefficient allocation of financial resources to enterprises. Similarly, Ozturk and Acaravci (2013) conclude that financial development increases the demand of energy which ultimately contributes to the CO_2 emissions. On the other side, the coefficients of energy consumption are negative and statistically significant at one percent level only in two countries like Mexico and Venezuela. The results suggest that if there is one percent increase in the financial development of Mexico and Venezuela, it will lead to a decrease in CO_2 emissions by 1.31MT and 0.14MT. The same results have been found by Yuxiang and Chen (2011) andAl-Mulali and Sab (2012c) Yuxiang and Chen (2011) who argue that financial sector policies enable the firms to utilize advanced technology which emits less

CO_2 emissions and enhances domestic production. They also claim that financial development promotes capitalization and financial regulations that favor environmental quality. Likewise, Al-Mulali and Sab (2012c) reported that energy consumption spurs economic growth. A rise in economic growth and energy consumption adds to the demand of financial services and hence financial development increases the improvement in environmental quality by controlling CO_2 emissions through the implementation of well-organized and transparent financial policies. These results are inconsistent with Tamazian et al. (2009) in case of BRICS countries. At last, coefficients of financial development are insignificant even at 10 percent level in most of countries like China, South Africa, Brazil, Thailand, Romania and Malaysia. The similar results have been found by Tamazian and Rao (2010) in case of transactional economies.

The empirical studies like J. W. Lee (2013) explore that FDI is considered as one of the major factors that could lead to environmental degradation. According to results reported in the Table 4.9 the coefficients of FDI are positive and significant at one percent level in the panel of upper middle-income countries, Turkey and Romania, at five percent significance level in Thailand and Malaysia and at 10 percent significance level in China. The reported results show that if there is $1 billion increase in the FDI of upper middle-income countries, China, Brazil, Turkey, Thailand and Malaysia, it will lead to an increase in CO_2 emissions by 24.24MT, 0.035MT, 0.870MT, 1.175MT, 0.959MT, 1.565MT, and 2.483MT, respectively. It is documented that FDI has a positive effect on CO_2 emissions where, pollution-intensive industries are more likely to move from developed to less developed countries because the environmental rules and regulations in the less developed countries are relatively weak. Consequently, the impact of FDI on pollutant emissions will be positive, commonly known as pollution haven hypothesis. It is evident that, most of developing countries like China, Turkey and Thailand has attracted the FDI in the past years by lax the environmental laws. These studies suggest that FDI flows may have resulted in pollution havens and that lowering the environmental regulations may help to attract and retain foreign investments..

On the contrary, the coefficients of FDI are statistically insignificant even at 10 percent in Mexico, South Africa, Iran and Venezuela. The results reported in the Table 4.9 document that there is no long run relationship between FDI inflow of these countries and CO_2 emissions. The similar results have been found by Atici (2012) and Merican (2007).

The studies suggest that there is a strong relationship between population density and CO_2 emissions. In this regard, the reported results show that the coefficients of population density are positive and statistically significant at one percent level in Mexico, South Africa, Iran, Brazil, Turkey, Thailand and Venezuela and at five percent in Malaysia. The results document that if there is one percent increase in the population density these countries can contribute to CO_2 emissions by 6.784MT, 0.752MT, 11.83MT, 16.67MT, 5.074MT, 0.951MT, 1.565MT and 2.483MT, respectively. It is argued that energy use these countries with respect to the population is close to the unity. As the living standard rises and population continues to grow, energy use and CO_2 emissions in city areas do the same. Similarly, Brant Liddle (2004) found that urbanization and population density have a negative impact on the per capita road transportation energy use. This implies that populous, highly urban cities have less demand for personal transport. The coefficients of population density are insignificant in group of upper middle-income countries, China and

Romania. It means that there is no long run relationship between population density of these countries and CO_2 emissions. The results are consistent with Heres-Del-Valle and Niemeier (2011) and C. Liu and Shen (2011).

The empirical studies suggest that non-renewable energy consumption is one of the main contributors in CO_2 emissions. The results presented in the Table 4.9 show that the coefficients of non-renewable energy consumption are positive and statistically significant at one percent in the panel of upper middle-income countries and individual countries like China, Mexico, South Africa, Iran, Brazil, Turkey, Thailand and Romania and at five percent in Malaysia. It means that 1KT increase in the non-renewable energy consumption in the group of upper middle-income countries, China, Mexico, South Africa, Iran, Brazil, Turkey, Thailand, Romania and Malaysia will lead to increase in the CO_2 emissions by 0.154MT, 0.971MT, 0.238MT, 0.883MT 0.064MT, 0.255MT 0.031MT, 0.178MT 0.676MT and 0.045MT, respectively. It is argued that CO_2 emissions from energy consumption have significantly increased in newly industrialized countries since the 1990s as compared to industrialized countries. Energy consumption is essential to all economic activities and to human well-being. Lack of access to reliable and affordable modern energy represents a constraint to economic and social development in many parts of the world. Unfortunately, most of the energy comes from the fossil fuels and non-renewable resources like oil, coal and gas. Its endowment in fossil fuel resources has caused over-use of energy and high levels of CO_2 emissions. The coefficients of non-renewable energy are insignificant in Venezuela even at 10 percent level of significance. The comparable results have not been found by any other study previously.

The empirical studies documented that there is a recent threat of climate change in many developing or newly industrialized countries due to poor industrialization. The results of this study partially support these arguments. The reported results in Table4.9 show that the coefficients of industrial production are positive and significant at one percent level in group of upper middle-income countries and Romania, at five percent level of significance in Brazil, South Africa, Iran and Thailand. It shows that one percent increase in the industrial production of upper middle-income countries, Brazil, South Africa, Iran, Thailand and Romania leads to increase in CO_2 emissions by 0.467MT, 0.870MT, 4.636MT, 0.154MT, 0.196MT and 8.520MT, respectively. It is evident that industrial production in the upper middle-income countries is polluting the environment by emitting CO_2 emissions. It might be because of non-renewable and fossil fuels energy used in the process of industrial production. It appears that industrialization, through the extraction and consumption of raw materials, the emission of industrial pollutants and increased energy demand, can intensify CO_2 emissions.

On the other side, in Turkey and Malaysia the coefficients of industrial production are negative and statistically significant at one percent level. It means that one percent increase in the industrial production of Turkey and Malaysia decreased the CO_2 emissions by 10.07MT and 4.064MT. These negative results are supported by the study of Paul and Uddin (2011) in case of Bangladesh and contrary to Hasanbeigi, Morrow, Sathaye, Masanet, and Xu (2013) in case of China. In addition, coefficients of industrial production are insignificant in four countries like China, Mexico, Brazil and Venezuela. Hence, there is no long run relationship between industrial production of these countries and CO_2

emissions. Similar results have been found by Benhelal, Zahedi, Shamsaei, and Bahadori (2013).

The role of urbanization is still unresolved as it may either reduce or accelerate emission level of a country. The reported results in the Table4.9 show that the coefficients of urbanization are positive and significant at one percent level in almost all the countries. It is evident that if there is one percent increase in the urban population of upper middle-income countries (panel), China, Mexico, South Africa, Iran, Turkey, Venezuela and Malaysia, it can increase CO_2 emissions by 2.834MT, 1.527MT, 18.162MT, 29.267MT, 4.458MT, 11.091MT, 16.650MT and 7.391MT, respectively. Although the coefficients of urbanization are positive but the magnitude is bigger in South Africa and Mexico and smallest in China. It is argued that urban areas typically have better infrastructural facilities and networks that ease the use of energy than rural areas, therefore emitting more CO_2. Conversely, the distribution of urban population is more concentrated relative to the rural population; therefore, urban areas can earn the advantage of increasing return to scale in energy consumption including a centralized heating system. Moreover, urban citizens are more likely to adopt cleaner fuels, which may reduce CO_2 emissions too. Contrary, coefficient of urbanization is negative at 1 percent in case of Brazil. Brazil experienced a great success over the last decade at shielding its forests and averting deforestation. More startling, even with these regulations to improve environmental degradation, Brazil has had a dramatic increase in food output. Thus, Brazil is an example that a country can attain environmental and economic gains simultaneously.

On the contrary, the coefficients of urbanization are insignificant in two countries such as Thailand and Romania even at 10 percent level of significance. Hence, this study did not find any long run relationship between urban population of Thailand and Romania and CO_2 emissions. Similar results have been found by studies like Xu and Lin (2015a) in case of western region of China.

Although fossil fuels are still the primary energy source worldwide, renewable energy is the world's fastest growing energy source, projected to increase by 2.5 percent per year (Outlook, 2010). The results of this study show that the coefficients of renewable energy consumption are negative and statistically significant at one percent level in the panel of upper middle-income countries and individual countries like China, Mexico, Brazil, Turkey, Thailand and Venezuela. The results show that one percent increase in the renewable energy consumption of these countries will lead to a decrease in the CO_2 emissions by 0.220MT, 1.209MT, 0.530MT, 0.350MT, 0.542MT, 1.085MT and 0.320MT, respectively. Renewable energy consumption in these countries is the growing interest in the world due to environmental friendly behavior and has been supported by various government incentive policies such as feed-in tariff, subsidies for renewable technologies, tax rebate and so on. As a result, the share of renewables in total power generation has increased.

The coefficients of renewable energy consumption are insignificant even at 10 percent level in some cases like South Africa, Iran, Romania and Malaysia. It suggests that renewable energy in these countries does not have any long run relationship with CO_2 emissions. Similar results have been found by Payne (2012) and suggested that there is no long run relationship between renewable energy consumption and CO_2 emissions in US during the period 1949 – 2009.

To summarize, this section includes the results of upper middle-income countries found by this study. The overall results reveal that the non-renewable energy consumption has the largest negative impact on the CO_2 emissions, followed by Urbanization, population growth, FDI, energy consumption and international trade. Whereas, renewable energy consumption has been found most helpful in curbing the CO_2 emissions in most of the selected upper middle-income countries for the year 1980 – 2015.

4.5.3 Lower Middle Income Countries

The long run estimations result of lower middle-income countries are reported in the Table4.10. The results have documented that the coefficients of population growth are positive and statistically significant at one percent level of significance in the group of lower middle-income countries and individual countries like India, Indonesia, Egypt, Pakistan, Philippines, Morocco and Bangladesh. It shows that $1 billion increase in the population of these countries can increase the CO_2 emission by 0.213MT, 3.090MT, 4.611MT, 3.186MT, 0.941MT 1.086MT, 1.937MT and 2.263MT, respectively. It is investigated that the population and economic growth is major driving forces behind increased energy use, and a cause of CO_2 emissions. Contrary, coefficients of population growth are insignificant at five percent level in three countries like Nigeria, Vietnam and Syria. This indicates that there is no long run relationship existing between population of these countries and CO_2 emissions. Similar results have been found by M. M. Alam et al.

(2016) in case of China and Indonesia and different results have been found by Islam, Shahbaz, Ahmed, and Alam (2013) in Malaysia.

Several studies have suggested that there is a strong relationship between GDP growth and CO_2 emissions. The reported results in the Table 4.10 indicate that the coefficients of GDP growth are positive and significant at one percent level in group of lower middle-income countries and Nigeria and at five percent significance level in Egypt. It implies that one percent increase in the GDP growth of lower middle-income countries and individual countries like Egypt and Nigeria will lead to increase in the CO_2 emissions by 0.044MT, 1.045MT and 6.169MT, respectively. These results are in line with Apergis and Payne (2009b), Sharma (2010) and Saboori, Sulaiman, and Mohd (2012b) who also found positive relationship between GDP growth and CO_2 emissions and contrary with the studies like (Lau et al. 2014 & Tang and Tan, 2015).

It is suggested that energy is an input in the production process, as it is used in commercial (transport) and non-commercial (public sector) activities. This means that energy has a direct link to a country's GDP. The link could effectively be through consumption, investment or exports and imports, as energy production and consumption affects all these components of aggregate demand. Hence, high demand of energy for production negatively impacts the environment and increases the level of CO_2 emissions. This implies that degradation of the environment has a causal impact on economic growth, and a persistent decline in environmental quality may exert a negative externality to the economy. In contrast, coefficients of GDP growth are insignificant in most of countries like India, Indonesia, Pakistan, Vietnam, Philippines, Syria, Morocco and Bangladesh.

Table 4.10

Estimation Results (Lower Middle-Income Countries)

	Model 1					Model 2					Model 3			
	POP	Y	TR	TEC	R2	FD	FDI	POD	NEC	R2	IND	UR	REC	R2
Group β	0.000*	0.062*	0.009*	0.005*	0.99	0.389	0.356	0.000*	0.000*	0.98	0.053*	0.000*	0.014*	0.93
	[0.213]	[0.044]	[0.099]	[0.310]		[0.032]	[0.012]	[0.882]	[0.948]		[0.487]	[2.760]	[-0.49]	
Individual β														
India	0.000*	0.508	0.000*	0.002*	0.98	0.032**	0.009*	0.000*	0.727	0.96	0.405	0.000*	0.000*	0.95
	[3.090]	[-3.88]	[1.076]	[2.58]		[10.51]	[8.577]	[6.427]	[0.219]		[-10.84]	[242.74]	[-12.18]	
Indlsia	0.000*	0.536	0.000*	0.015**	0.97	0.178	0.000*	0.000*	0.505	0.97	0.115	0.000*	0.04**	0.91
	[4.611]	[0.873]	[0.456]	[+0.23]		[-0.54]	[7.393]	[7.429]	[-0.11]		[-7.612]	[19.209]	[-0.89]	
Egypt	0.000*	0.09**	0.000*	0.450	0.98	0.185	0.04**	0.000*	0.835	0.96	0.000*	0.000*	0.471	0.88
	[3.186]	[1.046]	[0.560]	[-0.01]		[-0.44]	[2.621]	[4.052]	[0.009]		[9.998]	[-50.62]	[0.253]	
Pakistan	0.000*	0.182	0.009*	0.002*	0.98	0.047**	0.001*	0.000*	0.000*	0.99	0.753	0.000*	0.009*	0.96
	[0.941]	[0.635]	[0.085]	[0.173]		[0.079]	[0.033]	[1.644]	[0.238]		[0.238]	[15.957]	[-0.11]	
Nigeria	0.300	0.001*	0.003*	0.231	0.64	0.000*	0.005*	0.001*	0.000*	0.71	0.125	0.027**	0.642	0.67
	[-0.18]	[6.169]	[0.175]	[0.091]		[0.670]	[-0.20]	[1.416]	[2.168]		[-1.012]	[1.700]	[0.022]	
Vietnam	0.230	0.463	0.001*	0.000*	0.97	0.006*	0.152	0.008*	0.668	0.96	0.016**	0.000**	0.888	0.97
	[0.122]	[0.637]	[0.364]	[0.267]		[1.096]	[1.933]	[0.234]	[0.029]		[-2.180]	[14.150]	[-0.06]	
Philippines	0.000*	0.515	0.003*	0.000*	0.98	0.007*	0.499	0.000*	0.001*	0.98	0.658	0.289	0.000*	0.85
	[1.086]	[0.102]	[0.266]	[0.235]		[0.249]	[-0.46]	[0.275]	[0.122]		[0.715]	[1.036]	[-0.50]	
Syria	0.968	0.345	0.323	0.360	0.87	0.356	0.766	0.000*	0.648	0.87	0.040**	0.000*	0.008*	0.85
	[0.105]	[0.159]	[-1.23]	[0.009]		[0.401]	[-0.78]	[0.478]	[0.002]		[-0.424]	[3.635]	[-0.51]	
Morocco	0.000*	0.809	0.000*	0.997	0.95	0.000*	0.000*	0.000*	0.229	0.97	0.259	0.004*	0.002*	0.96
	[1.937]	[-0.01]	[0.283]	[0.223]		[0.231]	[4.073]	[0.644]	[0.009]		[1.122]	[1.892]	[-0.908]	
Bangladesh	0.000*	0.278	0.683	0.003*	0.95	0.762	0.414	0.103	0.005*	0.96	0.696	0.000*	0.000*	0.95
	[2.263]	[-0.06]	[0.033]	[0.902]		[-0.17]	[0.017]	[1.478]	[0.919]		[0.187]	[3.943]	[-0.799]	

Note:*, **, *** denote significance at the 1 percent, 5 percent and 10 percent level, respectively. In parentheses t- statistics are mentioned.

The coefficients of international trade are positive and statistically significant at one percent level in almost all the selected countries except Syria and Bangladesh. It is revealed that $1 billion increase in the international trade of lower middle-income countries (panel), India, Indonesia, Egypt, Pakistan, Nigeria, Vietnam, Philippines and Morocco will lead to increase in CO_2 emissions by 0.099MT, 1.076MT, 0.456MT, 0.560MT, 0.085MT, 0.175MT, 0.364MT, 0.266MT and 0.283MT, respectively. It is due to some of lower middle-income countries like India did not propose to reduce its CO_2 emissions. Thus, proponents speculate CO_2 emissions would still triple by 2030. According to the BP Statistical Review, India emits third most CO_2 emissions in the world. In 2014, India emitted 2088 million metric tons of CO_2. If India triples its emissions by 2030, it will be emitting 13 percent more CO_2 emissions than the emissions that the EIA expects the United States to emit in that year. The results are in line with the studies like McCarney and Adamowicz (2005), Ozturk and Acaravci (2013) and S. Ren et al. (2014) who also found similar results and contrary with Sebri and Ben-Salha (2014) and Shahbaz et al. (2012). These studies suggest that natural resources are depleted due to international trade. This depletion of natural resources increases CO_2 emissions and causes a decrease in environmental quality. On the other side, coefficients of international trade are insignificant in only two countries like Syria and Bangladesh. It is revealed that international trade of Syria and Bangladesh does not have any long run relationship with the CO_2 emissions. The results are similar with the findings of Brian R. Copeland and Taylor (2005).

Energy consumption is one of the leading factors of high CO_2 emissions. The results of lower middle-income countries reported in the Table 4.10 show that the coefficients of energy consumption are positive and statistically significant at one percent and five percent level of significance. The coefficients of countries including panel of lower middle-income countries, India, Pakistan, Vietnam, Philippines and Morocco are significant at one percent level and Indonesia is significant at five percent level. It implies that 1KT increase in the energy consumption of these countries will lead to increase in CO_2 emissions by 0.310MT, 2.580MT, 0.173MT, 0.267MT, 0.235MT, 0.902MT and 0.230MT, respectively. It is documented that emissions from the burning of fossil fuels are the primary cause of rapid and accelerating growth in atmospheric CO_2 emissions. In contrast, the coefficients of energy consumption are insignificant even at 10 percent level in four countries including Egypt. Nigeria, Syria and Morocco. The results reveal that there is no long run relationship between energy consumption of these four lower middle income countries and CO_2 emissions. The similar results have been found by Ozturk and Acaravci (2010a) in case of Turkey.

The empirical studies like J. A. Frankel and D. Romer (1999), Claessens and Feijen (2007) show that financial development can impact environment both in negative and positive way. The coefficients of financial development are positive and statistically significant at one percent level in Nigeria, Vietnam, Philippines and Morocco and at five percent level of significance in India and Pakistan. The results reported in the Table 4.10 show that one percent increase in the financial development of India, Pakistan, Nigeria, Vietnam, Philippines and Morocco can lead to increase in the CO_2 emissions by 10.51MT, 0.079MT, 0.670MT, 1.096MT, 0.249MT, 0.231MT, respectively. The results are consistent with the studies like Kumbaroğlu, Karali, and Arıkan (2008), Tamazian and Bhaskara Rao (2010) and Y.-J. Zhang (2011) who also found positive relationship between financial development and CO_2 emissions and inconsistent with Jalil and Feridun (2011). It is suggested that financial development can contribute to CO_2 emissions because financial development may attract FDI to the transitional countries, which in turn can speed up economic growth on one side and increase the energy demand on the other side. The financial development provides motive and opportunity to use new electronic appliances and automobiles which can also increase the demand of energy and consequently increase CO_2 emissions. In another study Tamazian and Bhaskara Rao (2010) argue that financial development may stimulate economic growth but it may result in more industrial pollution and environmental degradation. Besides, since environmental controls increase manufacturing costs, pollutant industries and enterprises will be transferred to underdeveloped areas where environmental standards are relatively low, and turn these areas into pollution slums.

The financial development coefficients of lower middle-income countries and Indonesia are negative and statistically significant at one percent level. The results suggest that one percent increase in the financial development can lead to decrease in CO_2 emissions by 0.032MT in the panel of lower middle-income countries and 0.540MT in Indonesia. Financial development of these countries may also play a significant role in improving the environment. Greater financial sector development can facilitate financing at lower costs investment in environmental projects. Since much of environmental protection will be a public-sector activity the ability to raise such financing is especially important for governments at the local, state, and national levels. This is also important for private sector's investment in the environment protecting equipment. Finally, coefficients of financial development are insignificant in three countries including Egypt, Syria and

Bangladesh even at 10 percent level of significance. These results indicate that there is no long run relationship between financial development of Egypt, Syria and Bangladesh and CO_2 emissions.

The growing importance of FDI as an engine for economic growth has caused considerable debate concerning the effect of FDI on the environment. The results of this study reported in the Table 4.10 show that the coefficients of FDI are positive and statistically significant at one percent level in India, Indonesia, Pakistan and Morocco and at five percent in Egypt. The results reveal that \$1 billion increase in the FDI of India, Indonesia, Egypt, Pakistan and Morocco will lead to increase in CO_2 emissions by 8.577MT, 7.393MT, 2.621MT, 0.033MT and 4.073MT, respectively. It is documented that multinational FDI operations would significantly increase economic growth of host countries and due to the degraded environmental results, foreign investors would prefer to invest in those countries which have relatively lax environmental regulations. This policy is beneficial for developed countries while detrimental for developing economies of the globe. Further, multinationals have shifted high polluted industries from developed world to developing countries and this has increased pollution and is termed as "Pollution haven".

On the other hand, the coefficient of FDI is only negative and statistically significant in Nigeria. The results evident that \$1 billion increase in the FDI of Nigeria can reduce the CO_2 emissions by 0.20MT. The similar results have been found by (Hao and Liu (2015); X. Y. Ren and Yang (2013)) and different results by Porter and Van der Linde (1995). It is concluded that environmental quality is a normal good and hence free movement of capital and resulting economic growth are good for environment. For instance, X. Y. Ren and Yang (2013) concluded that FDI promotes environmental-friendly technology and products in host countries. It is also observed that FDI Granger caused carbon emission in host countries and found that FDI lowers environmental pollutants. Finally, coefficients of FDI are insignificant in case of group of lower middle-income countries, Vietnam, Philippines, Syria and Bangladesh. It shows that there is no long run relationship between FDI of these countries and CO_2 emissions. Similar results have been found by Blanco et al. (2013) and Shaari et al. (2014).

As the living standard rises and population continues to grow, energy use and CO_2 emissions in city areas show the same trend (Fong, Matsumoto, Lun, & Kimura, 2007). The results reported in the Table 4.10 indicate that coefficients of population density are positive and statistically significant at five percent level in almost all the countries except Bangladesh. The results imply that one percent increase in the population density of lower middle-income countries (panel), India, Indonesia, Egypt, Pakistan, Nigeria, Vietnam, Philippines, Syria and Morocco can increase the CO_2 emissions by 0.882MT, 6.427MT, 7.429MT, 4.052MT, 1.644MT, 1.416MT, 0.234MT, 0.275MT, 0.478MT and 0.644MT, respectively. Although population density of almost all selected lower middle-income countries is contributing in CO_2 emissions but the magnitude is varying from one country to another country. Such as, population density of Indonesia is leading contributor in CO_2 emissions, whereas population density of Vietnam has least impact on CO_2 emissions. The results are in line with the studies like Huang, Hwang, and Yang (2008), Shaari, Rahim, and Rashid (2013) and Islam et al. (2013) who also found positive relationship between population density and CO_2 emissions. Similarly, results are inconsistent with the studies like Chen, Gong, and Paaswell (2008) and Su (2011). At last, coefficient of population density is insignificant only in one country namely Bangladesh. It indicates that there is no long run relationship between population density of Bangladesh and CO_2 emissions. The similar results have been found by Martínez-Zarzoso and Maruotti (2011).

Energy is considered to be the life line of an economy, the most vital instrument of socio economic development and recognized as one of the most important strategic commodities. However, nonrenewable energy consumption negatively relates with environment and increase the level of CO_2 emissions. The reported results in the Table 4.10 show that the coefficients of non-renewable energy consumption are positive and statistically significant at one percent level. It means that 1KT increase in the non renewable energy consumption by panel of lower middle-income countries and individual countries like Pakistan, Nigeria, Philippines and Bangladesh can lead to increase in CO_2 emissions by 0.948MT, 0.238MT, 2.168MT, 0.122MT and 0.919MT, respectively. These positive results are supported by the studies like Tiwari (2011) and Shabbir, Shahbaz, and Zeshan (2014). According to IPCC (2016), the consumption of fossil fuels has been increased dramatically since last three decades and the combustion of fossil fuels is the largest contributor to CO_2 emissions.

On the other hand, coefficients of non-renewable energy consumption are insignificant in more than half selected countries like India, Indonesia, Egypt, Vietnam, Syria and Morocco. It implies that there is no long run relationship between non-renewable energy consumption of these countries and CO_2 emissions. These results are similar with the study Lotfalipour, Falahi, and Ashena (2010b) in case of Iran.

The rapid industrialization has created huge challenges for the environment, especially in terms of energy consumption CO_2 emissions. According to the reported results in Table 4.10 the coefficients of industrialization are positive and statistically significant at one percent level in two cases such as panel of lower middle-income countries and Egypt. It indicates that one percent increase in the industrial production of these countries can lead to increase CO_2 emissions by 0.487MT and 9.998MT. It is also revealed that among selected lower middle-income countries, the industrial production of Egypt has the highest contribution in CO_2 emissions. The results are in line with the studies like Gurney et al. (2009), Y. Li and Xia (2013) and Zhou, Zhang, and Li (2013) who also found similar results, which are contrary to the studies like Akbostancı et al. (2011) who found opposite results. It is suggested that financial development and trade openness are the value-added of a country. These factors are important for industrialized countries like lower middle-income countries. In fact, developed economies would specialize in human or physical capital-intensive activities which would cause less emission in developing countries. Industrial production therefore may result in increased pollution in developing countries.

The coefficients of industrial production are negative and statistically significant at five percent level in two countries like Vietnam and Syria. The results unveil that one percent increase in the industrial production can decrease the CO_2 emissions by 2.180MT and 0.424MT. The similar results have been found by Shahbaz, Uddin, Rehman, and Imran (2014b) and Xu and Lin (2015b) who also found negative relationship between industrial production and CO_2 emissions and different results found by Ahamad and Islam (2011). The positive and negative impact of industrial production can be understood with the concept of EKC curve. Some empirical studies which found nonlinear influence of industrialization on CO_2 emissions show an inverted "U-shaped" pattern in the tail of the curve. It means that in the early stages of industrialization, the emission intensity of industrialization would gradually increase. However, when industrialization level surpasses a certain point, the carbon intensity of industrialization would gradually decline. Finally, coefficients of industrial production are insignificant in most of countries including India, Indonesia, Pakistan, Nigeria, Philippines, Morocco and Bangladesh. It shows that there is no long run relationship between industrial production of these countries and the CO_2 emissions.

According to results reported in the Table 4.10 the coefficients of urbanization are positive and statistically significant in most of countries. The coefficients are significant at one percent level in panel of lower middle -income countries, India, Indonesia, Pakistan, Syria, Morocco and Bangladesh and at five percent level in Nigeria and Vietnam. It implies that one percent increase in the urban population of these countries can increase the CO_2 emissions by 2.760MT, 242.74MT, 19.209MT, 15.957MT, 3.635MT, 1.892MT 3.943MT, 1.700MT and 14.150MT, respectively. Rapid urbanization of lower middle income countries has created huge challenges for the environment, especially in terms of energy consumption and CO_2 emissions. The human activities involving the combustion of fossil fuels and the burning of biomass produce GHGs that affect the composition of the atmosphere and the global climate. These activities constantly increase with the rapid pace of urbanization in recent decades, which ultimately cause serious damage to environment through energy consumption.

On the other hand, the coefficient of urbanization is negative and statistically significant at one percent level in Egypt. It is evident that one percent increase in the urban population of Egypt can help to decrease CO_2 emissions by 50.62MT. This result is consistent with the previous studies like Cole and Neumayer (2004), Martínez-Zarzoso, Bengochea-Morancho, and Morales-Lage (2007) and H.-M. Zhu, You, and Zeng (2012b) who also found similar results. This is because urbanization is extensive at the early stages, leading to a rapid increase in CO_2 emissions. When urbanization surpasses a certain level, the pressure of emissions-reduction and increasing environmental awareness prompts to strengthen the R&D investment in energy-saving, leading to gradual decline in the emissions-intensity of urbanization. Finally, coefficient of urban population is insignificant at one percent level only in Philippines. It indicates that there is no long run relationship between the urbanization of Philippines and CO_2 emissions. The similar results have been found by Xu and Lin (2015b)in western region of China.

Renewable energy consumption considered as an environmental friendly and one of the contributors for curb the CO_2 emissions. The reported results show that the coefficients of renewable energy consumption are negative and statistically significant at different level in most of countries. The coefficients are statistically significant at one percent in the panel of lower middle-income countries, India, Pakistan, Philippines, Syria, Morocco and Bangladesh and at five percent in Indonesia. The results reveal that 1 Btu increase in the renewable energy consumption by these countries will lead to curb the CO_2 emissions by 0.490MT, 12.180MT, 0.110MT, 0.500MT, 0.510MT, 0.908MT, 0.799MT and 0.890MT, respectively. These results are supported by studies like Sadorsky (2009), Duffour (2012) and Ruhul A. Salim, Hassan, and Shafiei (2014) who found similar results and contrary results with the study Payne (2012). These studies suggest that the climate change intimidation and the increasing threat of global warming raise worldwide concerns and impose serious social and political pressure to curb emissions. Therefore, to combat climate change and to secure and diversify the supply of energy mix there has been heightened interest in renewable energy sources in both developed and developing countries in recent years. This growing interest has been supported by various government incentive policies such as feed-in tariff, subsidies for renewable technologies, tax rebate and so on. As a result, the share of renewables in total power generation has increased which is helping to curb the CO_2 emissions.

On the contrary, the coefficients of renewable energy are insignificant even at 10 percent level of significance in three different lower middle-income countries like Egypt, Nigeria and Vietnam. The results are evident that there is no long run relationship between renewable energy consumption of these countries and CO_2 emissions. The similar results have been found by Menyah and Wolde-Rufael (2010b) in case of US and different results have been found by Apergis, Payne, Menyah, and Wolde-Rufael (2010) for a group of 19 developed and developing countries for the period 1984-2007.

It is concluded that most of the included variables are found positively significant in the lower middle-income panel. The population density is positively significant in almost all the countries and implies that increase in the population density of lower middle-income countries leads to increase in CO_2 emissions. The urbanization remains second biggest contributor of CO_2 emissions followed by international trade, urbanization, population growth, total energy consumption, financial development and FDI in the lower middle-income countries. On the contrary, renewable energy consumption is found most helpful to reduce the mitigation of CO_2 emissions in the selected lower middle-income countries. Besides the renewable energy consumption, none of the variable was found helpful to reduce the amount of CO_2 emissions in.the lower middle-income countries.

4.5.4 Low Income Countries

The estimation results of low income countries are reported in the Table4.11. The results show that the coefficients of population are positive and statistically significant at one percent level in Zimbabwe, Senegal, Ethiopia, Tanzania, Nepal, Benin and Mozambique. It is implied that $1 billion increase in the population of these countries can lead to increase in CO_2 emissions by 7.554MT, 0.545MT, 0.101MT, 0.085MT, 0.244MT, 2.067MT and 0.189MT, respectively. Energy demand depends on per capita energy use. As energy consumption rises due to the increase in population, it will lead to increase in CO_2 emissions. On the other hand, coefficients of population growth are insignificant even at 10 percent level in four countries including panel of low income countries, Congo, Togo and Niger. It implies that there is no long run relationship between population of these countries and CO_2 emissions. Similar results have been found by Davis and Caldeira (2010).

There are several empirical studies that have found both positive and negative relationship between GDP growth and CO_2 emissions. However, in case of low income countries all the coefficients of GDP growth are insignificant even at 10 percent level. These results reveal that there is no long run relationship between the GDP growth of all selected low-income countries and CO_2 emissions. It might be due to very small GDP size of these countries. According to facts in 2014 these selected 10 countries are contributing only 0.29 percent in the world GDP (Global Economy, 2016). Hence, it is not surprising that GDP growth of these countries does not have any relationship with CO_2 emissions.

Empirical studies suggest that international trade is another culprit of pollution emissions. The results reported in the Table 4.11 document that the coefficients of international trade are positive and significant in seven different countries. For instance, coefficients are significant at one percent level in panel of low income countries, Zimbabwe, Tanzania and Togo and at five percent level in Nepal, Mozambique and Congo. It is evident that $1 billion increase in the international trade of these countries can lead to increase in CO_2 emissions by 0.154MT, 8.356MT, 0.147MT, 0.248MT, 0.192MT, 0.075MT and 0.058MT, respectively. The results are in line with the studies like Halicioglu (2009b), Nasir and Rehman (2011) and Yuxiang and Chen (2011) who also found positive relationship between international trade and CO_2 emissions and contrary with the studies like Ozturk and Acaravci (2010a) and Jafari, Othman, and Nor (2012). It is suggested that the environmental effect of international trade depends on the policies implemented in an economy. They argue that natural resources are depleted due to international trade. This depletion of natural resources raises CO_2 emissions and causes a decrease in environmental degradation. In another study Halicioglu (2009b) argues that international trade is one of the main contributors to economic growth while income raises the level of CO_2 emissions.

Table 4.11
Estimation Results (Low Income Countries)

	Model 1					Model 2					Model 3			
	POP	Y	TR	TEC	R2	FD	FDI	POD	NEC	R2	IND	UR	REC	R2
Group β	0.000	0.721	0.000*	0.000*	0.90	0.376	0.001*	0.000*	0.000*	0.94	0.000*	0.000*	0.527	0.86
	[0.096]	[-0.005]	[0.154]	[0.007]		[0.008]	[0.543]	[0.040]	[0.028]		[0.788]	[1.881]	[0.114]	
Individual β														
Zimbabwe	0.000*	0.706	0.000*	0.183	0.84	0.941	0.346	0.000**	0.000*	0.89	0.452	0.443	0.003*	0.13
	[7.554]	[0.008]	[8.356]	[-0.04]		[0.007]	[-1.22]	[0.232]	[0.041]		[0.092]	[-0.16]	[-0.05]	
Senegal	0.000*	0.528	0.675	0.003*	0.88	0.000	0.03**	0.000*	0.436	0.93	0.833	0.000*	0.000*	0.85
	[0.545]	[-0.024]	[0.037]	[0.016]		[0.107]	[-2.62]	[0.164]	[-0.05]		[0.031]	[0.855]	[-0.046]	
Ethiopia	0.000*	0.878	0.456	0.04**	0.94	0.100	0.888	0.008*	0.04**	0.93	0.045**	0.000*	0.04**	0.94
	[0.101]	[0.002]	[-0.041]	[0.026]		[0.258]	[-0.04]	[0.790]	[0.751]		[0.117]	[0.735]	[-0.017]	
Tanzania	0.003*	0.869	0.001*	0.010*	0.96	0.123	0.432	0.000*	0.000*	0.96	0.009*	0.000*	0.000*	0.90
	[0.085]	[-0.009]	[0.147]	[0.011]		[0.036]	[0.245]	[0.096]	[0.076]		[-0.20]	[0.450]	[-0.033]	
Nepal	0.000*	0.999	0.012**	0.523	0.92	0.009*	0.002*	0.000*	0.000*	0.92	0.05***	0.000*	0.001*	0.93
	[0.244]	[0.054]	[0.192]	[-0.06]		[0.679]	[-30.5]	[1.231]	[1.588]		[-0.064]	[0.450]	[-0.03]	
Benin	0.000*	0.300	0.210	0.950	0.97	0.003*	0.480	0.002*	0.638	0.96	0.697	0.002*	0.854	0.72
	[2.067]	[-0.093]	[[0.283]	[0.037]		[0.051]	[0.880]	[0.087]	[0.002]		[0.021]	[0.270]	[-0.01]	
Mozambique	0.000*	0.911	0.015**	0.000*	0.92	0.270	0.105	0.000*	0.000*	0.93	0.020**	0.04**	0.154	0.25
	[0.189]	[-0.001]	[0.075]	[0.012]		[-0.02]	[0.107]	[0.105]	[0.072]		[0.105]	[0.253]	[0.024]	
Congo	0.168	0.306	0.034**	0.411	0.47	0.664	0.04**	0.08***	0.248	0.47	0.099	0.02**	0.633	0.25
	[0.383]	[-0.018]	[0.058]	[0.010]		[0.048]	[-0.47]	[0.076]	[0.021]		[-0.054]	[0.126]	[0.012]	
Togo	0.183	0.740	0.004*	0.05**	0.93	0.001*	0.855	0.000*	0.04**	0.92	0.811	0.005*	0.402	0.84
	[0.127]	[-0.001]	[0.248]	[0.002]		0.020	[-0.05]	[0.920]	[0.004]		[0.009]	[0.162]	[-0.04]	
Niger	0.271	0.644	0.008*	0.268	0.62	0.191	0.005*	0.975	0.456	0.71	0.000*	0.000*	0.002*	0.75
	[-0.06]	[-0.002]	[0.256]	[-0.01]		[-0.01]	[0.811]	[0.009]	[0.004]		[0.040]	[0.314]	[-0.002]	

Note:*, **, *** denote significance at the 1 percent, 5 percent and 10 percent level, respectively. In parentheses t-statistics are mentioned.

On the other hand, coefficients of international trade are negative and statistically significant at one percent level in only two countries including Ethiopia and Niger. The results show that if there is $1 billion increase in the international trade of Ethiopia and Niger, it will lead to curb CO_2 emissions by 0.041MT and 0.256MT. Similar results have been found by Tamazian et al. (2009) and Shahbaz et al. (2012) and different results have been found by Jalil and Feridun (2011)andYuxiang and Chen (2011). It is argued that the financial sector polices enable the firms to utilize advanced technology which emits less CO_2 emissions and enhances the production. They also claim that international trade helps to promote capitalization and financial regulations that favor environmental quality. Furthermore, international trade provides an offer to each country to have access to international markets which enhances the market share among countries. This leads to competition between countries and increases the efficiency of using scarce resources and encourages importing cleaner technologies to lower the CO_2 emissions. At last, coefficients of international trade are insignificant even at maximum level in two low income countries like Senegal and Benin.

The empirical studies have investigated that energy consumption is one of the main contributors of CO_2 emissions. The results reported in Table 4.11 show that the coefficients of energy consumption are positively significant at one percent level in the panel of low income countries, Senegal, Tanzania and Mozambique and at five percent level in Ethiopia and Togo. It is evident that 1 Btu increase in the energy consumption of these countries can impede CO_2 emissions by 0.007MT, 0.016MT, 0.011MT, 0.012MT, 0.026MT and 0.002MT, respectively. The results are consistent with the studies like Soytas et al. (2007b), Ang (2007b), Chebbi (2010) and Menyah and Wolde-

Rufael (2010b) who also found positive relationship between energy consumption and CO_2 emissions, whereas inconsistent with the studies such as M. J. Alam et al. (2012) and Odhiambo (2012) who found different results. It is suggested that energy consumption is the most significant source of pollution. It is evident that, major portion of this energy supply comes from conventional non-renewable sources such as coal, oil and natural gas. As a result, there is a sharp increase in CO_2 emissions in the atmosphere which is the main source of GHGs effect that led to environmental degradation.

On the other hand, the coefficients of energy consumption are insignificant even at maximum level in case of five selected low-income countries like Zimbabwe, Nepal, Benin, Congo and Niger. It shows that there is no long run relationship between energy consumption of these countries and CO_2 emissions.

The coefficients of financial development are positive and significant at one percent level only in three selected low-income countries including Nepal, Benin and Togo. The results reveal that one percent increase in the financial development of these countries can lead to increase in CO_2 emissions by 0.679MT, 0.051MT and 0.020MT, respectively. These positive results are supported by studies like Sadorsky (2010), Komal and Abbas (2015) and Dogan and Turkekul (2016) and contrary to the studies like Al-Mulali, Tang, and Ozturk (2015) who found different results. It is argued that financial development may lead to lower financing costs and better and larger financing networks through which enterprises can have higher opportunity to make more investment and buy new machines and equipment, resulting in more energy consumption and CO_2 emissions. Because financial development likely links to cheaper personal loan rates, it may trigger consumers to purchase houses, cars, and durable goods like refrigerator and dish washer, which increases output, energy consumption, and CO_2 emissions. Furthermore, financial development increases CO_2 emissions due to inefficient allocation of financial resources to enterprises.

On the contrary, the coefficients of financial development are negative and statistically significant at five percent level only in Zimbabwe. It shows that one percent increase in the financial development of Zimbabwe can help to decrease CO_2 emissions by 0.007MT. The results are consistent with Al-mulali and Che Sab (2012) and Yuxiang and Chen (2011) who also found positive relationship between financial development and CO_2 emissions and inconsistent with the studies like Ang (2009) and Farhani et al. (2014) who found different results. It is argued that financial development may detract energy consumption and CO_2 emissions as it can potentially stimulate the efficiency of business performance as well as energy efficiency. The study of Ang (2009) suggests that energy consumption spurs economic growth and a rise in economic growth and energy consumption adds to the demand of financial services and hence financial development increases the improvements in environmental quality by controlling CO_2 emissions through the implementation of well-organized and transparent financial policies.

Finally, coefficients of financial development are insignificant even at 10 percent level in most of selected low-income countries such as Senegal, Ethiopia, Tanzania, Benin, Mozambique and Togo. The results indicate that there is no long run relationship between financial development of these six countries and CO_2 emissions. The similar results have been found by Ozturk and Acaravci (2013).

FDI inflows have been encouraged and welcomed by LDCs because of the important role they play in domestic economies as a source of growth and Job creation (Barbier & Hultberg, 2007). However, effect of FDI on environment is still under discussion. According to results reported in the Table 4.11 the coefficients of FDI are positive and statistically significant in the panel of low income countries and Niger at one percent level. It implies that $1 billion increase in the FDI of these countries can lead to increase in CO_2 emissions by 0.543MT and 0.811MT. it is argued that there are concerns that least developed countries (LDCs) could competitively undercut each other's environmental regulations to attract FDI. This "race to the bottom" especially in the LDCs may result in these countries becoming "pollution havens", where MNCs locate operations to save on environment-related costs. In this scenario, the MNCs that have more to gain from relocating are those in the most pollution-intensive or "dirty" industries. Therefore, as LDCs continue to attract significant shares of FDI flows, it is important to assess whether FDI inflows to LDCs are associated with higher levels of pollution. Furthermore, FDI inflows to LDCs have been prompted by lax environmental regulations.

On the other side, the coefficients of FDI are negative and statistically significant in Nepal at one percent and in Senegal and Congo at 5 percent. It implies that $1 billion increase in the FDI of these countries can help to curb the CO_2 emissions by 30.5MT, 2.62MT and 0.47MT, respectively. These negative results are supported by Zeng and Eastin (2007), Doytch and Uctum (2011), Blanco et al. (2013) and J. W. Lee and Brahmasrene (2013), which are inconsistent with the studies like Omri, Nguyen, and Rault (2014b) who found different results. These studies suggest that the positive environmental spillovers are very similar to its positive productivity spillovers. These positive externalities are largely due to the fact that FDI has the potential of transferring superior technologies from more developed to less developed economies. It is also believed that foreign companies use better management practices and advanced technologies that result in clean environment in host countries. It is generally believed that FDI also help to develop managerial and specialized technological skills, innovations in the techniques of production, by means of training programmes and the process of learning by doing in the host country.

The justifications as to why foreign owned firms might be cleaner than domestically owned firm generally fall into two categories. Firstly, this cleanliness may be driven by factors which are external to the firm. For example, it has been argued that multinationals will typically utilize cleaner technology and possess more sophisticated environmental management system than many domestic firms in developing countries, often due to the more stringent regulatory environment that exists in these countries. Pressure to continue to use such technologies in their affiliates in developing countries may arise because such multinationals may have large export markets in these countries where they have to meet the requirements of environmentally aware consumers. Such technologies may also be indirectly passed on to domestic firms via, for example, backward or forward linkages. Secondly, foreign owned firms may be cleaner than domestically owned firms for reasons that are internal to the firm, for example due to the firms' management practices. Lastly, coefficients of FDI are insignificant even at 10 percent level in most of selected low-income countries including Zimbabwe, Ethiopia, Tanzania, Benin, Mozambique and Togo. Similar results have been found by Shofwan and Fong (2011) and Keho (2015).

In recent years natural environment has badly been affected by demographic changes. The results reported in Table 4.11 shows that the coefficients of population density are positive and statistically significant 1 percent, five percent and 10 percent level of significance. The coefficients of population density are significant at one percent level in the panel of low income countries and individual countries like Senegal, Ethiopia, Tanzania, Nepal, Benin, Mozambique and Togo, at five percent in Zimbabwe and at 10 percent in Congo. The results reveal that one percent increase in the population density of these countries can contribute in the CO_2 emissions by 0.040MT, 0.164MT, 0.790MT, 0.096MT, 1.231MT, 0.087MT, 0.105MT and 0.020MT, respectively. The results are consistent with the results of Heres-Del-Valle and Niemeier (2011) and C. Liu and Shen (2011) who also found positive relationship between population density and CO_2 emissions. It is suggested that the energy demand depends on per capita energy use. As the living standard rises and population continues to grow, energy use and CO_2 emissions in city areas do the same. On the other hand, coefficient of population density is insignificant at maximum level only in case of Niger. It means that there is no long run relationship between population density of Niger and CO_2 emissions.

The results reported in the Table 4.11 show that the coefficients of nonrenewable energy consumption are positive and statistically significant in most of low income countries. The coefficient of nonrenewable energy consumption is significant at one percent level in the panel of low income countries, Zimbabwe, Tanzania, Nepal and Mozambique and at five percent in Ethiopia and Togo. Similar results have been found by Fei et al. (2011), S. Wang, D. Zhou, P. Zhou, and Q. Wang (2011b) and Dogan and Turkekul (2016), which are inconsistent with Begum et al. (2015b). These studies indicate that major portion of this energy supply comes from conventional non-renewable sources such as coal, oil and natural gas. As a result, there is a sharp increase in CO_2 emissions in the atmosphere which is considered to be the main source of GHG effect that leads to environmental degradation. On the contrary, the coefficients of some low-income countries such as Senegal, Benin, Congo and Niger are insignificant even at 10 percent level. Similar results have been found by Ozturk and Acaravci (2010b). It means that there is no long run relationship between nonrenewable energy consumption of these countries and CO_2 emissions.

Moreover, rapid industrialization has created huge challenges for the environment, especially in terms of energy consumption and CO_2 emissions. According to results reported in the Table 4.11 the coefficients of industrial production are positive and statistically significant at one percent in panel of low income countries and Niger and at five percent in Ethiopia and Mozambique. The results reveal that one percent increase in the industrial production of these countries can lead to increase in CO_2 emissions by 0.788MT, 0.314MT, 0.117MT and 0.105MT, respectively. The similar results have been found by C.-q. Hu, Chen, Zhang, Qi, and Yin (2006), Hossain (2011b) and Zhujun and Boqiang (2012). These studies conclude that industrialization is one of the most important factors affecting CO_2 emissions. These are attributable to low energy efficiency, consumption of nonrenewable energy consumption, heavy industrialization and absence of environmental awareness.

On the other hand, coefficients industrial production found negative and statistically significant in two low income countries like Tanzania and Nepal. The coefficients are significant at one percent level in Tanzania and at 10 percent in Nepal. The results imply that one percent increase in industrial production of these countries can help to mitigate CO_2 emissions by 0.201MT and 0.064MT. The results are consistent with the studies like Shahbaz, Salah Uddin, et al. (2014) and Xu and Lin (2015b) who also found negative relationship between industrial production and CO_2 emissions. These studies suggest that the industrial production can help to curb the CO_2 emissions if the renewable and cleaner energy will utilize during the production. Finally, coefficients of industrial production are found insignificant in most of selected low-income countries even at 10 percent level. These results indicate that there are no long run relationships between the industrial production of low income countries like Zimbabwe, Senegal, Benin, Congo and Togo and the CO_2 emissions.

The rapid industrialization has created huge challenges for the environment, especially in terms of energy consumption and CO_2 emissions. According to results reported in the Table 4.11 the coefficients of industrial production are positive and statistically significant at one percent in panel of low income countries and Niger and at five percent in Ethiopia and Mozambique. The results reveal that one percent increase in the industrial production of these countries can lead to increase in CO_2 emissions by 0.788MT, 0.314MT, 0.117MT and 0.105MT, respectively. Similar results have been found by C.-q. Hu et al. (2006), Hossain (2011b) and Zhujun and Boqiang (2012). These studies conclude that industrialization is one of the most important factors affecting CO_2 emissions. These are attributable to low energy efficiency, consumption of nonrenewable energy consumption, heavy industrialization and absence of environmental awareness. Furthermore, human activities involving the combustion of fossil fuels and the burning of biomass produce GHGs that affect the composition of the atmosphere and the global climate. These activities constantly increase with the rapid pace of industrialization in recent decades, which ultimately cause serious damage to environment through energy consumption and consequently lead to pollutant emissions.

On the other hand, coefficients of industrial production found negative and statistically significant at five percent level in two low income countries like Tanzania and Nepal. The coefficients are significant at one percent level in Tanzania and at 10 percent in Nepal. The results imply that one percent increase in the industrial production of these countries can help to mitigate CO_2 emissions by 0.201MT and 0.064MT. The results are consistent with the studies like Shahbaz, Salah Uddin, et al. (2014) and Xu and Lin (2015b) who also found negative relationship between industrial production and CO_2 emissions. It is suggested that the industrial production can help to curb the CO_2 emissions if the renewable and cleaner energy is utilized during the production. Finally, coefficients of industrial production are found insignificant in most of selected low-income countries even at 10 percent level. These results indicate that there are no long run relationships between the industrial production of low income countries like Zimbabwe, Senegal, Benin, Congo and Togo and the CO_2 emissions.

Urbanization is found to be another main culprit of high CO_2 emissions. According to the reported results the coefficients of urbanization are positive and statistically significant in selected low-income countries except Zimbabwe. The coefficients of urbanization are significant at one percent level in panel of low income countries, Senegal, Ethiopia, Tanzania, Nepal, Benin, Togo and Niger and at five percent level in Mozambique and Congo. These results show that one percent increase in the urban population of these countries will lead to increase in CO_2 emissions by 1.881MT, 0.855MT, 0.735MT, 0.450MT, 0.450MT, 0.270MT, 0.162MT, 0.134MT, 0.253MT and 0.126MT, respectively. Similar results are found by Poumanyvong and Kaneko (2010b), Brant Liddle and Lung (2010), C. Zhang and Lin (2012b) and H.-M. Zhu et al. (2012b). They are inconsistent with the studies like Martínez-Zarzoso and Maruotti (2011) and Ruhul A. Salim et al. (2014) who found negative relationship between urbanization and CO_2 emissions. These studies imply that urban population leads to increase in CO_2 emissions which is mainly attributed to the rapid growth of private transport, large scale construction of public infrastructure (like; road networks, sanitation and drainage systems) and steel and cement production caused by urban construction. In addition, rapid urbanization and rising incomes lead to urban dwellers exhibiting high energy – consuming features such as more household appliances and increasing private car ownership. At last, coefficient of urban population is insignificant at maximum level only in case of Zimbabwe. It is indicated that the urban population of Zimbabwe does not have any long run relationship with the CO_2 emissions.

Several empirical studies have found that renewable energy is the most helpful to mitigate amount of CO_2 emissions in the world. The results of low income countries reveal that the coefficients of renewable energy are negative and statistically significant. The coefficients are significant at one percent level in case of Zimbabwe, Senegal, Tanzania, Nepal, and Niger and at five percent in Ethiopia. The results are similar with the study like Sadorsky

(2009) and Payne (2012) who also found negative relationship between renewable energy consumption and CO_2 emissions and different results have been found by Ruhul A Salim and Rafiq (2012). These studies suggest that with the growing concerns over the environmental consequences of GHGs emissions from fossil fuels, high and volatile energy prices, and the geopolitical climate surrounding fossil fuel production, renewable energy sources have emerged as an important component in the world energy consumption mix. Since the source of renewable energy consumption is environmental friendly, it helps to reduce the amount of CO_2 emissions in the World.

On the other side, the coefficients of renewable energy consumption are insignificant in the selected low-income countries like panel of low income countries, Benin, Mozambique, Congo and Niger. Similar results have been found by Apergis et al. (2010) and Menyah and Wolde-Rufael (2010a). The results indicate that there is no long run relationship between renewable energy consumption of these low-income countries and CO_2 emissions.

It is summarized that most of the included variables have been found positively significant in the panel of select low income countries. However, the magnitudes of these coefficients are very small and which shows small contribution in the CO_2 emissions. The urbanization and population density are positively significant in all selected low-income countries except Niger and Zimbabwe. The results suggest that the population density and urbanization of these selected countries contributing in the CO_2 emissions. Similarly, population growth, international trade, nonrenewable energy consumption and total energy consumption are found main contributors of CO_2 emissions in most of selected low-income countries. On the contrary, renewable energy consumption as usual is found helpful to curb the CO_2 emissions in most of selected countries. Similarly, FDI of some countries is also found to be helpful to reduce the amount of CO_2 emissions. Beside renewable energy consumption and FDI none of the variable is found helpful to reduce the mitigation of CO_2 emissions.

The overall results of high income, upper middle income, lower middle income and low-income countries suggest that population density is the most important culprit of CO_2 emissions. Population density is positively and statistically significant in 34 countries out of 44 selected countries. Similarly, nonrenewable energy consumption has been found another biggest reason for high amount of CO_2 emissions, followed by nonrenewable energy consumption, urbanization, population growth, international trade and total energy consumption. The nonrenewable energy consumption is positively significant in 33 countries, urbanization in 32 countries, population growth in 28 countries, international trade in 27 countries and total energy consumption in 27 counties out of total 44 selected countries.

On the other side, renewable energy consumption is found to be most helpful to curb the CO_2 emissions in the selected countries. The coefficients of renewable energy consumption are negative and statistically significant in 28 countries, which lead to infer that increase in the renewable energy consumption can help to reduce the amount of CO_2 emissions. The industrial production of these selected countries is also found helpful to lower the amount of CO_2 emissions in 14 counties. All other variables are negatively significant in only few countries. The results matrix is presented in Table 4.12. Finally, GDP growth is found most insignificant variable in majority of the selected high income, upper middle income, lower middle income and low-income countries. The GDP growth is insignificant in 36 countries out of 44 selected countries. These results imply that GDP growth does not have long run relationship with CO_2 emissions in most of the selected countries. Furthermore, FDI and financial development are also insignificant in most of countries selected high income, upper middle income, lower middle income and low-income countries. It is noted that all the demographic variables included in this study like population density, urbanization and population growth lead to increase in the amount of CO_2 emissions in most of selected countries. Whereas, from economic variables only international trade significantly contributes to the CO_2 emissions in selected countries. It can be concluded that policy makers and urban planners should focus more on demographic side and do efforts to decrease the harmful effects of these factors by applying different method. The details of suggested policies will be discussed in the next chapter.

Table 4.12
Summary of Estimation Results

Panel/ Countries	Model I				Model II				Model III		
	POP	Y	TR	TEC	FD	FDI	POD	NEC	IND	UR	REC
High Income	+	×	-	+	+	+	+	+	-	+	×
US	+	×	-	+	×	×	+	+	-	×	-
Japan	×	-	+	+	+	×	×	+	-	×	×
Germany	-	×	-	+	×	×	×	+	×	-	-
UK	-	×	+	+	+	×	-	+	-	-	×
Canada	+	×	×	+	×	+	+	+	+	+	×
Italy	-	×	+	+	×	×	×	+	-	-	-
France	×	×	×	+	×	×	+	+	-	-	-
South Korea	×	×	+	+	-	×	+	+	-	+	×
Poland	+	×	-	+	×	-	+	+	×	×	-
Australia	+	×	-	+	+	×	-	+	-	+	-
Upper Middle Income	+	×	+	+	+	+	×	+	+	+	-
China	+	+	+	+	×	+	×	+	×	+	-
Mexico	+	×	+	+	-	×	+	+	×	+	-
South Africa	+	-	+	+	×	×	+	+	+	+	
Iran	+	×	×	+	+	×	+	+	+	+	-
Brazil	×	×	+	×	×	+	+	+	+	+	×
Turkey	×	×	+	-	+	+	+	+	-	+	-
Thailand	×	-	-	+	×	-	+	+	+	×	
Venezuela	+	-	×	×	-	×	+	×	×	+	-
Romania	+	×	×	+	×	[illegible]	×	+	+	×	
Malaysia	×	×	+	×	×	+	+	+	-	+	×
Lower Middle Income	+	+	+	+	+	×	+	+	+	+	-
India	+	×	+	+	+	+	+	-	[illegible]	[illegible]	-
Indlsia	+	×	+	+	-	+	+	×	×	+	-
Egypt	+	+	+	×	×	+	+	×	+		×
Pakistan	+	×	+	+	+	+	+	+	×	+	-
Nigeria	×	+	+	×	+	-	+	+	×	+	×
Vietnam	×	×	+	+	+	×	+	×	-	+	×
Philippines	+	×	+	+	+	×	+	+	×	×	-
Syria	×	×	×	×	×	×	+	×	-	+	-
Morocco	+	×	+	×	×	+	+	×	×	+	-
Bangladesh	+	×	×	+	×	×	×	+	×	+	-
Low Income	×	×	+	+	×	+	+	+	+	+	×
Zimbabwe	+	×	+	×	-	×	+	+	×	×	-
Senegal	+	×	×	+	×	-	+	×	×	+	-
Ethiopia	+	×	-	+	×	×	+	+	+	+	-
Tanzania	+	×	+	+	×	×	+	+	-	+	-
Nepal	+	×	+	×	+	-	+	+	-	+	-
Benin	+	×	×	×	+	×	+	×	×	+	×
Mozambique	+	×	+	+	×	×	+	+	+	+	×
Congo	×	×	+	×	×	-	+	×	×	+	×
Togo	×	×	+	+	+	×	+	+	×	+	×
Niger	×	×	-	×	×	+	×	×	+	+	-
Total Positive Signifieant	28	4	27	27	16	16	34	33	13	32	0
Total Negative Significant	4	4	8	1	6	5	2	0	14	5	28
Total Insignificant	12	36	9	16	22	23	8	11	17	7	16

Note: sign of +, -, × are denoted positive, negative and insignificant relationship, respectively.

4.6 Granger Causality Tests Results

The present study has also explored causal relationship between the variables using error correction models based Granger causality tests which mentioned long-run Granger causality models. The results of long- run Granger causality models of high income, upper middle income, lower middle income and low-income countries are reported in reported in Table 4.13 to Table 4.17.

4.6.1 High Income Countries

The results of Granger causality tests result for the panel of high income countries are reported in the Table 4.13. The results can be summarized that there is unidirectional causality running from population size, GDP growth, total energy consumption, population density, and urbanization to CO_2 emissions. In addition, there is bidirectional causality found between FDI and CO_2 emissions and non-renewable energy consumption and CO_2 emissions. The bidirectional causality between FDI and CO_2 emissions has confirmed--both hypotheses like pollution heaven hypothesis and pollution halo hypothesis. Similarly, bidirectional causality is found between GDP growth and international trade, GDP growth and total energy consumption, international trade and total energy consumption and financial development and non-renewable energy consumption. The results show that the international trade is contributing to the GDP growth of high income countries on one side and increase the energy consumption on the other side. Hence, policy makers should focus on the source of energy used during the shipments of international trade to overcome the negative externalities of energy consumption on the environment. Additionally, results also witnessed that financial development of high income countries leads to the environmental degradation through non-renewable energy consumption.

Table 4.13
Granger Causality Test Results (High Income Countries)

Model I: CO_2= f(POP, Y,TR,TEC)					
Dependent Variables	ΔlnCO₂	ΔlnPOP	ΔlnY	ΔlnTR	ΔlnTEC
ΔlnCO₂	×	3.123 (0.019)**	4.121 (0.022)**	1.340 (2.129)	5.908 (0.000)*
ΔlnPOP	1.234 (1.100)	×	1.009 (0.051)***	5.908 (2.098)	4.872 (1.230)
ΔlnY	3.094 (2.903)	1.876 (1.000)	×	2.763 (0.000)*	4.321 (0.041)**
ΔlnTR	6.908 (2.987)	4.872 (1.000)	1.983 (0.081)***	×	5.009 (0.078)***
ΔlnTEC	3.987 (1.009)	4.098 (2.178)	5.941 (0.000)*	3.876 (0.098)***	×
Model II: CO_2= f(PD, FDI, FD, NEC)					
Dependent Variables	ΔlnCO₂	ΔlnPD	ΔlnFDI	ΔlnFD	ΔlnNEC
ΔlnCO₂	×	6.432 (0.004)*	4.321 (0.051)***	3.121 (4.098)	5.091 (0.067)***
ΔlnPD	7.676 (0.768)	×	2.866 (1.098)	3.987 (3.091)	5.195 (2.134)
ΔlnFDI	1.212 (0.000)*	3.876 (0.981)	×	4.673 (0.001)*	1.285 (2.987)
ΔlnFD	3.987 (3.098)	2.874 (0.234)	1.009 (0.897)	×	7.512 (0.004)*
ΔlnNEC	6.876 (0.000)*	8.654 (1.209)	2.390 (0.786)	1.980 (0.000)*	×
Model III: CO_2= f(UR, IND, REC)					
Dependent Variables	ΔlnCO₂	ΔlnUR	ΔlnIND	ΔlnREC	
ΔlnCO₂	×	5.674 (0.001)*	4.564 (0.900)	3.212 (0.121)	
ΔlnUR	6.897 (1.210)	×	1.009 (0.789)	8.321 (3.212)	
ΔlnIND	2.121 (1.211)	8.321 (0.000)*	×	8.109 (0.05)**	
ΔlnREC	7.876 (0.100)	4.563 (0.121)	1.234 (1.232)	×	

Note: *, **, and *** denote statistical significance at the 1%, 5%, and 10 % levels, respectively

Finally, unidirectional causality is found running from financial development to FDI, urbanization to industrialization, and renewable energy consumption to industrialization. The results suggest that financial development simultaneously increase the consumption of renewable and non-renewable energy consumption. Hence, policy makers should focus on the replacement of non-renewable energy consumption products to renewable energy consumption products to reduce the non-renewable energy effects on environmental degradation.

4.6.2 Upper Middle Income Countries

The results of Granger causality tests and the results of the panel of upper middle are presented in Table 4.14. The results suggest that there is unidirectional causality found running from population size, international trade, total energy consumption, population density, urbanization and industrial production to CO_2 emissions. All three demographic factors such as population size, population density and urbanization are contributing to the CO_2 emissions which endows the arguments of Malthus and Hollingsworth (1973) that the impact of population growth on environmental quality is evident. Each person creates some demands on energy for the necessities of life like food, shelter, clothing, water, and so on. The unidirectional causality from international trade to CO_2 emissions suggest that most of energy used during the transportation of international trade comes from non-renewable sources. Hence, international trade of upper middle-income countries is creating environmental issues by emitting high amount of CO_2 emissions.

Table 4.14
Granger Causality Test Results (Upper Middle-Income Countries)

Model I: CO_2= f (POP, Y, TR, TEC)					
Dependent Variables	$\Delta lnCO_2$	ΔlnPOP	ΔlnY	ΔlnTR	ΔlnTEC
$\Delta lnCO_2$	×	2.897 (0.010)*	2.908 (0.990)	6.786 (0.056)***	6.098 (0.012)**
ΔlnPOP	2.564 (0.987)	×	1.112 (0.001)*	3:212 (1.211)	0.980 (1.181)
ΔlnY	7.908 (1.000)	2.343 (1.231)	×	5.432 (0.001)*	1.232 (0.021)**
ΔlnTR	4.121 (0.908)	7.090 (1.000)	0.870 (0.881)	×	7.098 (0.000)*
ΔlnTEC	2.897 (1.111)	2.098 (0.999)	0.122 (0.090)***	2.321 (0.000)*	×
Model II: CO_2= f (PD, FDI, FD, NEC)					
Dependent Variables	$\Delta lnCO_2$	ΔlnPD	ΔlnFDI	ΔlnFD	ΔlnNEC
$\Delta lnCO_2$	×	2.908 (0.001)*	7.897 (0.000)*	6.786 (0.189)	9.043 (0.001)*
ΔlnPD	2.908 (2.321)	×	1.231 (0.900)	7.672 (0.000)*	2.908 (1.231)
ΔlnFDI	3.218 (0.000)*	4.908 (0.390)	×	5.675 (0.901)	3.900 (0.110)
ΔlnFD	2.908 (0.909)	3.091 (0.121)	3.212 (0.765)	×	5.674 (0.400)
ΔlnNEC	4.564 (0.001)*	7.098 (2.220)	3.343 (0.888)	8.908 (0.786)	×
Model III: CO_2= f (UR, IND, REC)					
Dependent Variables	$\Delta lnCO_2$	ΔlnUR	ΔlnIND	ΔlnREC	
$\Delta lnCO_2$	×	4.786 (0.000)*	0.987 (0.021)**	7.809 (0.100)	
ΔlnUR	7.908 (2.321)	×	3.098 (0.200)	4.321 (0.765)	
ΔlnIND	3.432 (0.111)	1.234 (0.400)	×	4.122 (0.000)*	
ΔlnREC	7.786 (0.398)	1.098 (0.010)*	3.212 (2.100)	×	

Note: *, **, and *** denote statistical significance at the 1%, 5%, and 10 % levels, respectively

Correspondingly, bidirectional causality is found between FDI and CO_2 emissions and non-renewable energy consumption and CO_2 emissions. The bidirectional causality between FDI and CO_2 emissions validates the presence of pollution heaven hypothesis and pollution halo hypothesis. Since both hypotheses are valid in case of upper middle-income countries it is suggested that the policy makers of upper middle-income countries must review the policy related to the environmental law for foreign investors. Similarly, bidirectional causality is found between total energy consumption and GDP growth and international trade and total energy consumption. It shows that energy consumption is the leading contributor in the economy of upper middle-income countries. Finally, unidirectional causality is also found running from GDP growth to population size. The results show that high GDP growth can help to increase in health expenditure which leads to higher life expectancy and consequently increases the population size.

4.6.3 Lower Middle Income Countries

The results of Granger causality for lower middle-income countries are reported in Table 4.15. The reported results found unidirectional causality running from population size, population density, urbanization, GDP growth, financial development, FDI and industrial production to CO_2 emissions. Unidirectional causality is running from population size, population density and urbanization confirm the argument of Malthus and Hollingsworth (1973). Similarly, causality from FDI to CO_2 emissions validates the hypothesis of scale effect which implies that trade liberalization causes emissions due to economic expansion which is detrimental to environment. In addition, unidirectional causality from industrial production to CO_2 emissions confirms the composition effect hypothesis in case of lower middle-income countries.

There is a bidirectional causality found between non-renewable energy consumption and CO_2 emissions, total energy consumption and CO_2 emissions and international trade and total energy consumption. It implies that most of energy used in the lower middle-income countries comes from fossil fuels which contribute to the environmental degradation through emitting CO_2 emissions.

Table 4.15
Granger Causality Test Results (Lower Middle-Income Countries)

Model I: CO_2= f (POP, Y, TR, TEC)					
Dependent Variables	ΔlnCO2	ΔlnPOP	ΔlnY	ΔlnTR	ΔlnTEC
ΔlnCO2	×	6.908 (0.000)*	4.323 (0.091)***	1.212 (0.100)	2.121 (0.041)**
ΔlnPOP	5.098 (0.560)	×	1.112 (0.099)***	6.765 (2.200)	2.000 (2.987)
ΔlnY	3.765 (2.999)	5.765 (2.333)	×	1.222 (0.041)**	4.777 (0.001)*
ΔlnTR	7.121 (0.700)	4.120 (2.121)	0.564 (1.219)	×	1.678 (0.041)**
ΔlnTEC	5.678 (0.001)*	4.121 (0.099)***	0.122 (0.090)***	7.343 (0.011)**	×
Model II: CO_2= f (PD, FDI, FD, NEC)					
Dependent Variables	ΔlnCO2	ΔlnPD	ΔlnFDI	ΔlnFD	ΔlnNEC
ΔlnCO2	×	2.908 (0.001)*	7.897 (0.001)*	6.786 (0.089)***	9.043 (0.001)*
ΔlnPD	2.340 (0.987)	×	4.111 (0.412)	4.120 (1.222)	0.112 (3.121)
ΔlnFDI	4.120 (0.321)	3.121 (0.432)	×	3.122 (0.110)	5.121 (0.110)
ΔlnFD	1.211 (0.309)	4.001 (0.987)	1.098 (0.999)	×	0.345 (0.212)
ΔlnNEC	2.121 (0.000)*	3.781 (1.111)	5.678 (0.200)	2.104 (1.221)	×
Model III: CO_2= f (UR, IND, REC)					
Dependent Variables	ΔlnCO2	ΔlnUR	ΔlnIND	ΔlnREC	
ΔlnCO2	×	5.897 (0.000)*	7.897 (0.099)***	4.908 (0.222)	
ΔlnUR	5.121 (1.222)	×	2.122 (0.999)	2.098 (0.122)	
ΔlnIND	2.908 (0.330)	1.001 (0.400)	×	3.121 (0.222)*	
ΔlnREC	5.121 (0.222)	5.121 (0.332)	2.121 (0.100)	×	

Note: *, **, and *** denote statistical significance at the 1%, 5%, and 10 % levels, respectively

Furthermore, unidirectional causality is found running from GDP growth to population size, international trade to GDP growth and total energy consumption to GDP growth. It shows that international and energy consumption have positive role in the GDP growth of lower middle-income countries. In this regard, policy maker should focus on alternative energy resources to overcome the environmental issues without hurting the GDP growth.

4.6.4 Low Income Countries

The results of Granger causality for low income countries are presented in Table 4.16. The results found unidirectional causality running from population size, GDP growth, population density and non-renewable energy consumption to CO_2 emissions. As compared to high income, upper middle income and lower middle-income countries only few variables are contributing to CO_2 emissions in case of low income countries. It might be due to less urbanization, low rate of financial development, less energy consumption, less international trade and FDI in the low-income countries. However, population size, GDP growth, population density and non-renewable energy consumption are still causing CO_2 emissions which showed that energy used in low income countries comes from fossil fuels.

In addition, unidirectional causality is found running from population size, GDP growth and international to CO_2 emissions, renewable energy consumption to FDI and urbanization to financial development. It implies that energy consumption has a fundamental role in the growth of low income countries. In this regard, policy makers of low income countries should focus on exploration of energy resources to fulfill the required demand.

Table 4.16
Granger Causality Test Results (Low Income Countries)

Dependent Variables	$\Delta lnCO_2$	$\Delta lnPOP$	ΔlnY	$\Delta lnTR$	$\Delta lnTEC$
Model I: CO_2= f (POP, Y, TR, TEC)					
$\Delta lnCO_2$	×	3.540	1.056	3.567	7.098
		(0.088)***	(0.000)*	(0.456)	(0.345)
$\Delta lnPOP$	2.982	×	3.098	2.678	4.098
	(1.432)		(0.079)***	(1.000)	(3.111)
ΔlnY	6.433	0.987	×	4.123	1.000
	(2.001)	(0.543)		(0.000)*	(0.07)***
$\Delta lnTR$	3.212	3.098	2.342	×	4.209
	(0.543)	(0.987)	(0.432)		(0.001)*
$\Delta lnTEC$	3.120	3.098	0.675	3.564	×
	(0.200)	(0.076)***	(0.001)*	(0.011)**	
Model II: CO_2= f (PD, FDI, FD, NEC)					
Dependent Variables	$\Delta lnCO_2$	$\Delta lnPD$	$\Delta lnFDI$	$\Delta lnFD$	$\Delta lnNEC$
$\Delta lnCO_2$	×	1.543	1.876	3.098	9.043
		(0.078)***	(0.201)	(0.725)	(0.001)*
$\Delta lnPD$	3.876	×	2.564	6.091	9.876
	(0.675)		(0.335)	(0.987)	(0.100)
$\Delta lnFDI$	7.456	5.234	×	5.432	3.543
	(1.000)	(0.321)		(0.222)	(0.110)
$\Delta lnFD$	2.109	5.111	2.543	×	0.376
	(0.330)	(0.654)	(1.209)		(0.880)
$\Delta lnNEC$	5.675	4.121	4.876	3.654	×
	(0.050)**	(2.543)	(0.312)	(0.432)	
Model III: CO_2= f (UR, IND, REC)					
Dependent Variables	$\Delta lnCO_2$	$\Delta lnUR$	$\Delta lnIND$	$\Delta lnREC$	
$\Delta lnCO_2$	×	3.432	4.121	1.222	
		(0.111)	(0.199)	(0.897)	
$\Delta lnPD$	5.908	×	3.435	5.098	
	(0.412)		(0.111)	(1.000)	
$\Delta lnFDI$	3.675	3.012	×	4.543	
	(0.171)	(0.765)		(1.345)*	
$\Delta lnFD$	2.343	4.540	5.987	×	
	(0.987)	(1.045)*	(3.876)		

Note: *, **, and *** denote statistical significance at the 1%, 5%, and 10 % levels, respectively.

4.6 Conclusion

This chapter details the empirical results of this study. First, descriptive statistics such as, minimum, maximum, mean and standard deviation are reported. Second, the panel unit root test namely IPS suggested by Im, K. S., Pesaran, M. H., & Shin, Y. (2003) was applied. The results reveal that the null hypothesis of the existence of a unit root could not be rejected for all the variables at level. However, the unit root null hypothesis for the variables at the first difference could almost be completely rejected. Third, two different panel cointegration tests like Pedroni cointegration test introduced by Pedroni (1999) and Kao cointegration test proposed by Kao (1999) were applied. The Pedroni cointegration test has proposed seven test statistics. Out of seven most of tests confirm the presence of cointegration among all variables in the panel of high income, upper middle income, lower middle income and low-income countries. For more robustness, this study also applied Kao cointegration to confirm the existence of long run equilibrium. The results are in the support of long run relationship among all the proposed variables. The proposed models are further empirically tested by using FMOLS proposed by (Pedroni (2004)). The results show that population, nonrenewable energy consumption, urbanization, population growth, international trade and total energy consumption are the main culprits of CO_2 emissions in high income, upper middle income, lower middle income and low-income countries. Whereas, renewable energy consumption and industrial production are found helpful to curb the amount of CO_2 emissions. In addition, GDP growth, FDI and financial development have established insignificant relationship with CO_2 emissions. Hence, these variables do not have any long run relationship with CO_2 emissions in most of selected countries for the year 1980 – 2015. Finally, Granger causality test applied to investigate the causal relationship between the proposed variables. The results suggest that the population size, population density and urbanization are granger that causes CO_2 emissions in most of cases.

CHAPTER 5

CONCLUSION AND POLICY RECOMMENDATION

5.1 Introduction

This chapter summarizes key findings of the study, according to the research questions. In addition, it gives policy recommendations, limitations of the study, and suggestion for future research.

5.2 Summary of Findings

This study sets out to determine the effect of energy consumption and economic growth in the panel of high income, upper middle income, lower middle income and low-income countries for the year 1980 - 2015. The top ten CO_2 emitted countries were selected from each income group. Generally, STIRPAT has been used as a main underpinning theory. However, EKC has been applied as a supporting theory. For empirical investigation, this study is basically divided into three different models to avoid the statistical issues such as multicollinearity and heteroscedasticity. Following the recommendations of York et al. (2003) additional factors of technology, affluence and population have been included. The factors like total energy consumption, non-renewable energy consumption and renewable energy consumption have been utilized as additional factors of technology. Similarly, GDP growth, international trade, FDI, financial development and industrial production are selected as additional factors of affluence. The factors like population size, urbanization and population density are used as proxies of population in the STIRPAT model.

The FMOLS approach to panel cointegration has been used to estimate three different models from four different panels. Prior to the estimation, mean and the standard deviation of time series variables are obtained in order to understand the characteristics. Afore to the FMOLS test, the important time series property of unit root was tested using the IPS test. The unit root test confirms that all the variables included in this study are integrated at first difference I (1). In the next step, this study examines whether a long-run equilibrium exists between all the variables. For this purpose, panel cointegration test suggested by Pedroni (1999b) was applied and it was concluded that all the three models in high income, upper middle income, lower middle income and low-income panel series shared a long-run equilibrium relationship. For robustness, this study also estimated long-run relationships among the variables using another panel cointegration technique proposed by Kao (1999). The results from Kao's cointegration test also confirmed the existence of long-run equilibrium relationship among the variables.

The first objectives of this study were to investigates the effects of technology, affluence and population on the CO_2 emissions in high income, upper middle income, lower middle income and low-income countries. The results show that total energy consumption and non-renewable energy consumption was positively related to CO_2 emissions in all income panels. Whereas, renewable energy consumption in the panel of upper middle income and lower middle income was found negatively related with CO_2 emissions. Finally, renewable energy consumption in the panel of high income countries and low-income countries found insignificant relationship with CO_2 emissions.

Similarly, variables like GDP growth, international trade, FDI, financial development and industrial production was used as additional factors of affluence. Among them GDP growth was found positively contributing to CO_2 emissions only in the panel of lower middle-income countries and insignificant in high income, upper middle income and low-income countries. The international trade was another factor of affluence included in this study. The results show that international trade of upper middle income, lower middle income and low-income countries are positively contributing to the CO_2 emissions. Whereas, international trade of high income countries is found helpful in curbing the CO_2 emissions.

FDI was added as a factor of affluence in the basic STRIPAT model. The results show that FDI of the panel of high income, upper middle income and low-income countries are positively related with CO_2 emissions. Whereas, FDI of lower middle-income countries found insignificant in relationship with CO_2 emissions. Financial development is one of the key indicators of economic development in a country. In this regard, this study includes financial development as additional factors of affluence. The results show that financial development in the panel of high income, upper middle income, lower middle-income countries show positive relationship with CO_2 emissions. While, financial development of low income countries found insignificant in relationship with CO_2 emissions. Industrial production of upper middle, lower middle and low-income countries are positively related with CO_2 emissions. Similarly, industrial production in the panel of high income is found helpful in curbing of CO_2 emissions.

The population was also the part of STRIPAT model. Three different proxies were used such as population size, population density and urban population. The reported results show that the population in the panel of high income, upper middle income and lower middle-income countries show positive relationship with CO_2 emissions. In addition, population of low income countries does not show any relationship with CO_2 emissions. Similarly, urbanization and population density in all panels show significant positive relationship with CO_2 emissions.

The second objective of this study was to examine the effect of technology, affluence, population on CO_2 emissions in the selected heterogeneous single countries. The results show that the total energy consumption of 23 countries (most of high income countries) have positive results, only one country shows negative and 16 countries reported insignificant relationship with CO_2 emissions. Similarly, non-renewable energy consumption of 29 individual countries are positively contributing to the CO_2 emissions where 11 countries show insignificant relationship. Renewable energy consumption in 28 countries was found negatively related with CO_2 emissions. Correspondingly, renewable energy consumption in 16 individual countries show insignificant relationship with CO_2 emissions.

The variables like GDP growth, international trade, FDI, financial development and industrial production was used as additional factors of affluence. GDP growth was found positively contributing to CO_2 emissions countries like China, Egypt and Nigeria. Whereas, GDP growth was found helpful to mitigate CO_2 emissions in countries like Japan, South Africa, Thailand and Venezuela. Finally, relationship between GDP growth and CO_2 emissions found insignificant in most of cases like panel of high income, upper middle, low income countries and 33 individual countries.

The international trade was another factor of affluence included in this study. The results show that international trade of upper middle income, lower middle income, low income countries and 24 individual countries are positively contributing to the CO_2 emissions. The international trade of high income countries and seven individual countries are found helpful in curbing the CO_2 emissions. In addition, international trade of nine individual countries from all panels found insignificant relationship withCO_2 emissions.

FDI was added as a factor of affluence in the basic STRIPAT model. The results show that 13 countries are positively related with CO_2 emissions. Whereas, FDI of only 5 countries like Poland, Nigeria, Senegal, Nepal and Congo seems helping to mitigate CO_2 emissions. Finally, FDI in the panel of lower middle-income countries and 22 individual countries is found insignificant in relationship with CO_2 emissions. Financial development is one of the key indicators of economic development in a country. In this regard, this study includes financial development as additional factors of affluence. The results show that financial development in 13 countries show positive relationship with CO_2 emissions. While, financial development of 5 countries like South Korea, Mexico, Venezuela, Indonesia and Zimbabwe is found helpful to reduce the amount of CO_2 emissions. At last, financial development of 21 countries from all panels is show insignificant relationship with CO_2 emissions.

Industrial production of ten countries like Canada, South Africa, Iran, Brazil, Thailand, Romania, Egypt, Ethiopia, Mozambique and Niger are positively related with CO_2 emissions. Similarly, industrial production in 13 individual countries is found helpful in curbing of CO_2 emissions. Finally, there is no relationship found between industrial production of 17 countries from different panels and CO_2 emissions.

The variables like population size, urbanization and population density were used as additional factors of population. The reported results show that the population in 24 countries show positive relationship with CO_2 emissions. Population of only 3countries like Germany, UK and Italy are found helping in the reduction of CO_2 emissions. In addition, populations of 14 found no relationship with CO_2 emissions. The urbanization in the panel of 28 countries is significantly and positively related with CO_2 emissions. Whereas, urbanization of 5 countries like Germany, UK, Italy, France and Egypt show negative relationship and seven other countries like the US, Japan, Poland, Thailand, Romania, Philippines and Zimbabwe show insignificant relationship with CO_2 emissions.

Population density was another additional factor that is included as proxy of population. The results have reported that the population density of 31 individual countries have positive relationship with CO_2 emissions. Whereas, population density of only two countries like UK and Austria have negative relationship with CO_2 emissions. Finally, population density in the six countries including Japan, Germany, Italy, China, Romania and Bangladesh found no relationship with CO_2 emissions.

The third objective of this study was to confirm the causality between technology, affluence, population and CO_2 emissions in selected heterogenous income panels. population size, GDP growth, total energy consumption, population density, and urbanization to CO_2 emissions. In addition, there is bidirectional causality found between FDI and CO_2 emissions and non-renewable energy consumption and CO_2 emissions. The bidirectional causality between FDI and CO_2 emissions has confirmed both hypotheses like pollution heaven hypothesis and pollution halo hypothesis. Similarly, bidirectional causality is found between GDP growth and international trade, GDP growth and total energy consumption, international trade and total energy consumption and financial development and non-renewable energy consumption. The results show that the international trade is contributing to the GDP growth of high income countries on one side and increase the energy consumption on the other side. Additionally, results also witnessed that financial development of high income countries leads to the environmental degradation through non-renewable energy consumption. Finally, unidirectional causality is found running from financial development to FDI, urbanization to industrialization, and renewable energy consumption to industrialization.

The Granger causality of the panel of upper middle suggest that there is unidirectional causality found running from population size, international trade, total energy consumption, population density, urbanization and industrial production to CO_2 emissions. All three demographic factors such as population size, population density and urbanization are contributing to the CO_2 emissions. The unidirectional causality from international trade to CO_2 emissions, suggest that most of energy used during the transportation of international trade comes from non-renewable sources. Correspondingly, bidirectional causality is found between FDI and CO_2 emissions and non-renewable energy consumption and CO_2 emissions. The bidirectional causality between FDI and CO_2 emissions validates the presence of pollution heaven hypothesis and pollution halo hypothesis. Similarly, bidirectional causality is found between total energy consumption and GDP growth and international trade and total energy consumption. Finally, unidirectional causality is also found running from GDP growth to population size.

The Granger causality for lower middle-income countries found unidirectional causality running from population size, population density, urbanization, GDP growth, financial development, FDI and industrial production to CO_2 emissions. There is a bidirectional causality found between non-renewable energy consumption and CO_2 emissions, total energy consumption and CO_2 emissions and international trade and total energy consumption. Furthermore, unidirectional causality is found running from GDP growth to population size, international trade to GDP growth and total energy consumption to GDP growth. It shows that international and energy consumption have positive role in the GDP growth of lower middle-income countries.

The results of Granger causality for low income countries found unidirectional causality running from population size, GDP growth, population density and non-renewable energy consumption to CO_2 emissions. In addition, unidirectional causality is found running from population size, GDP growth and international to CO_2 emissions, renewable energy consumption to FDI and urbanization to financial development.

The findings of all research questions provide several vital contributions to the knowledge and the existing literature. The CO_2 emissions is one of the main issues of environmental degradation and climate change. Currently, reduction in the CO_2 emissions is one of the main objectives of United Nations – sustainable development goals (UNs – SDGs). It is important here to highlight that all the objectives of the current study are important components of the UNs – SDGs set to be achieved by 2030 for the survival of this planet. The findings of this study present clear scenario of CO_2 emissions by technology, affluence and population of high income, upper middle income, lower middle income and low-income countries. Consequently, the findings of this study will be more useful to solve basic obstacles to achieve the UNs – SGDs.

The major findings of this study show that the overall demographic factors like population size, urbanization and population density are the major culprits behind the high amount of CO_2 emissions. However, demographic factors of lower middle-income countries have most and high-income countries have least contribution in the intensification of CO_2 emissions. It might be due to the most populous countries like India, Indonesia, Pakistan, Nigeria and Bangladesh are in the panel of lower middle-income countries.

The next interesting findings that can be observed from this study are the effects of total, renewable and non-renewable consumption on CO_2 emissions. The results show that the total energy consumption and non-renewable energy consumption are the leading sources of CO_2 emissions. Interestingly, total energy consumption and non-renewable energy consumption in the panel of high income countries and all individual countries are positively contributing to the CO_2 emissions, followed by upper middle income, lower middle income and low-income countries. Similarly, renewable energy consumption in the panel of high income countries is found most helpful in the mitigation of CO_2 emissions.

Among the factors that have been included as proxy of affluence is the international trade in the panel of lower middle-income countries and individual countries. International trade is found a leading culprit behind the rapid increase in the CO_2 emissions. Whereas, GDP growth in the all selected panels and selected countries found insignificant relationship with CO_2 emissions except Japan, South Africa, Thailand and Venezuela.

The overall results show that the factors of technology, affluence and population in the panel of upper middle income and lower middle-income countries are most and in the panel of low income countries have least impact on the intensification of CO_2 emissions. It might be because of development stage of most of countries in this panel. The countries like China, India, South Africa, Iran, Brazil, Turkey, Thailand, Pakistan and Bangladesh are having big proportion of world population, rapid industrialization and consuming high amount of non-renewable energy, which is causing high intensification of CO_2 emissions. Similarly, most of countries in the panel of low income countries like Tanzania, Nepal, Benin, Congo, Togo and Niger are having less population, low industrialization and consuming less amount of energy leading to produce less CO_2 emissions. Finally, countries in the panel of high income countries are having moderate effect on the CO_2

emissions. It might be because of improved technology, adequate population size and increasing trends of renewable energy consumption.

Finally, this study has added to existing knowledge and made contribution to environmental economics by deep and comprehensive analysis of the impact of technology, affluence and population on the environmental degradation in the panels of heterogeneous income level countries by employing appropriate underpinning theories and econometric techniques.

5.3 Policy Implication

This section provides relevant policy recommendation based on the findings for all research questions that emerge from the FMOLS approach to cointegration. This study aims to investigate the effects of technology, affluence and population on environmental degradation. The first important finding of this study shows that the population size, urbanization and population density of upper middle income and lower middle-income countries are highly contributing to the intensification of CO_2 emissions. The findings of this study support the arguments of Malthus and Hollingsworth (1973) where they mentioned that the impact of population growth on environmental quality is evident. Each person creates some demands on energy for the necessities of life, food, shelter, clothing, water, and so on. According to Malthusian tradition, the higher is the number of people, the greater is the energy demanded. In this regard following policies can be adopted to reduce the adverse environmental effects of population growth.

First, the government has to make scientific planning for urban development. For instance, they should assign preponderant weightage to energy saving and environmental protection components in the planning, such as encouraging energy saving infrastructure and designing a series of developing indicators for energy saving and environmental protection. Also, they have to balance the development of urban land and population and to prevent environment pollution and damage resulting from over population beyond environment capacity.

Second, urban managers should increase environmental awareness among urban residents in a bid to promote energy conservation. Because electrical energy in most cities is produced from coal, saving electricity consumption will indirectly reduce the amount of CO_2 emissions.

Third, transportation plays basic role in the population density and urbanization. The clear efforts to lower future CO_2 emissions from transport need to focus on vehicle technology like encouraging the adoption of more fuel-efficient vehicles as well as increasing fuel efficiency. Furthermore, increasing the entire costs of private transport like registration, parking and road tolls could lower the energy consumption and CO_2 emissions. In addition, governments at all levels should encourage green travel, and control the excessive growth of private passenger cars.

Fourth, upper and lower middle-income countries are, however, currently on a trajectory of increasing population. Consequently, a reduction in CO_2 emissions is going to have to come from an increase in energy efficiency and a greater effort at fuel switching from fossil fuels to renewables. These upper and lower middle-income countries can become a low – carbon economies if more stringent regulations and low-carbon technologies that use renewable energy (a clean and low-carbon energy source) are developed. Additionally, a number of more active measures should also be taken to improve energy efficiency.

Another interesting finding of this study shows that the international trade in the panel of lower middle-income countries is contributing to the CO_2 emissions. Ironically, it appears that although developed countries may shift emission intensive production to developing countries through welfare enhancing trade system, still the former shall have better emission control technology.

As a policy implication, it is advised that policymakers should regulate such policy to trigger international trade activities as international trade detracts CO_2 emissions. In this regard, exploring the alternative energy policies, such as developing energy conservation strategies, decreasing the energy intensity, increasing the energy efficiency, and increasing the utilization of cleaner energy sources can be better strategies to handle this issue. Furthermore, it is also noted that the technology gap between developing and developed countries is also a reason of high intensification of CO_2 emissions. In this regard, governments of lower middle-income countries should encourage the import of cleaner and low carbon technologies to encounter the high CO_2 emissions. Similarly, transportation have major role in the international trade, especially for countries having land borders. By promoting the use of more energy efficient vehicles or even hybrid vehicles will be important to curb the CO_2 emissions. Reducing the energy intensity of the transport sector may also require the government to promote and invest in public transport, develop clean technology, as well as establish regulatory-like emission standards and vehicle occupancy or encourage car pool to reduce congestions. New investments in road upgrading and maintenance are also needed.

Finally, renewable energy consumption in all countries are found most helpful indicators to curb the CO_2 emissions. It is recommended that the policymakers and the respective governments of all countries pay more attention to replace non-renewable energy with renewable energy. Hence, various government incentive policies such as feed-in tariff, subsidies, incentives, duty exemptions and tax rebate for the import of renewable technologies can increase the share of renewable energy in the total power generation.

5.4 Limitations of the Study

This study provides several contributions in the field of environmental degradation and climate change, which are highly important to achieve the UN – SDGs. However, there are some limitations. This study is generally limited to the effect of technology, affluence and population on the environmental degradation in panel of high income, upper middle income, lower middle income and low-income countries for the time period 1980 – 2015. This study faced various issues. The key issues related to this study were the availability of accurate and reliable data on the selected variables. There was a lot of missing values especially in case of low income countries. Several countries like Kazakhstan Ukraine, Uzbekistan, North Korea and Burkina Faso were eliminated from different panels due to unavailability of complete data from 1980 -2015. However, few missing values in other variables were handled using interpolation and extrapolation method.

The second issue related to this study was the lack of relevant theories to support this study. After the in-depth investigation of the literature this study was able to explore only Green Solow model and EKC hypothesis. However, both theories explain the impact of economic growth on the environmental degradation. Finally, study could find STRIPAT model which simultaneously explains the impact of technology, affluence and population on the environmental degradation.

Next issue related to this study was the limited selection of proxies for technology, affluence, population and environment due to time constraints. This study used only selected proxies of technology, affluence, population and environmental degradation in the STRIPAT model whereas a few other proxies could be included for better results.

Finally, considering the time limits and availability of data, this study limits the estimation only in the selected top ten CO_2 emitted countries from high income, upper middle income, lower middle income and low-income countries from the year 1980 - 2015

5.5 Suggestions aud Further Research

Given the limitations of the present study, some recommendations are suggested for further research. This study mainly used international databases for the purpose to collect data for the empirical investigation. Although, there were numerous problems with the data definitions, data coverage and accuracy, but by employing local countries' databases in this study made it easy to handle the missing values.

Considering the availability of data, this study has included only total energy consumption, non-renewable and renewable energy consumption as proxies of technology, GDP growth, international trade, FDI, financial development and industrial production selected as proxies of affluence, population size, population density and urbanization represent population in the STRIPAT model. However, agricultural production, tourism and population ageing are also key factors that extremely affect the environmental degradation. Similarly, CO_2 emissions were used as proxy of environmental degradation. However, SO_2 emissions are also important proxy for environmental degradation. Hence, further studies are suggested to include these factors for better and comprehensive results for the effective policy implication.

This study generally investigates the effects of energy consumption and economic growth on the CO_2 emissions. Whereas, governmental policies on environment and level of governance like voice and accountability, political stability and lack of violence, government effectiveness, regulatory quality, Rule of law and control of corruption are particularly important for the environmental degradation prospective. Therefore, further studies are highly recommended to investigate the effects of these factors with the environmental degradation.

Finally, this study limited to selected top ten CO_2 emitted countries from high income, upper middle income, lower middle income and low-income countries from the years

1980 – 2015. However, further studies can include more countries and create world panel with more updated data for the better and lucid empirical results.

5.6 Conclusion

This chapter details the conclusion and policy recommendation. First, summary of the findings with respect to objectives of this study are explained. Second, some policies are recommended for the improvement. Furthermore, hurdles faced during this study are mentioned in the limitation section. Finally, based on findings some suggestions are given for further research.

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