RENEWABLE ENERGY CONSUMPTION, CARBON EMISSIONS AND OIL PRICES: A PANEL DATA ANALYSIS FOR G7 AND BRICT COUNTRIES

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RENEWABLE ENERGY CONSUMPTION, CARBON EMISSIONS AND OIL PRICES: A PANEL DATA ANALYSIS FOR G7 AND BRICT COUNTRIES

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Renewable Energy Consumption, Carbon Emissions and Oil Prices:

A Panel Data Analysis for G7 and BRICT Countries

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DECLARATION OF ORIGINALITY

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ABSTRACT

Renewable Energy Consumption, Carbon Emissions and Oil Prices:

A Panel Data Analysis for G7 and BRICT Countries

Economic and social concern on energy dependence and climate change is making renewable energy the central theme of decision-making in energy policies and consumption. This thesis brings forward and builds an empirical model of renewable energy consumption in G7 and BRICT countries over the period 1990-2013. Results of our analysis show that both in G7 and BRICT countries, increases in oil prices have positive effect on renewable energy consumption. However, GDP per capita and renewable consumption are negatively related in G7 countries, but positively related in BRICT countries. For BRICT countries, on the other hand, estimates found no significant relationship between carbon emissions and renewable consumption, yet a positive relation is observed for G7 countries. As the estimates differ across countries, it might be helpful to account domestic factors.

ÖZET

Yenilenebilir Enerji Tüketimi, Karbon Emisyonu ve Petrol Fiyatları:

G7 ve BRICT Ülkeleri için Panel Data Analizi

Yenilenebilir enerji, enerji bağlılığı ve iklim değişikliği üzerine olan ekonomik ve sosyal kaygılar ile beraber enerji yönetimi ve tüketimi alanlarında merkez konumda yer almaktadır. G7 ve BRİCT ülkelerinde 1990-2013 dönemini kapsayan bu çalışma yenilenebilir enerji tüketimi üzerine bir veri çalışması sunmaktadır. Dinamik OLS sonuçları, G7 ve BRICT ülkeleri için petrol fiyatlarının enerji tüketimini olumlu yönde etkilemekte olduğunu göstermektedir. Ancak BRICT ülkeleri için gayri safi yurtiçi hasıla ve yenilenebilir enerji tüketimi arasında gözlenen pozitif ilişki G7 ülkelerinde gözlenmemektedir. Diğer yandan BRICT ülkeleri için karbon emisyonu ve yenilenebilir enerji tüketimi arasında anlamlı bir korelasyon gözlemlenmese de pozitif bir korelasyon G7 ülkeleri için mevcuttur. Tahminlerin ülkeler için farklılık teşkil etmesi, yurt içi faktörler ve görünümlerin hesaba alınmasının gerekliliğine işaret etmektedir.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ARDL	Autoregressive Distributed Lag
BBL	Barrel
BLN	Billion
BP	British Petroleum
BRIC	Brazil, Russia, India, China
BRICS	Brazil, Russia, India, China, South Africa
BRICT	Brazil, Russia, India, China, Turkey
BTOE	Billion Tons of Oil Equivalent
C°	Celsius
CAGR	Compound Annual Growth Rate
CES	Clean Energy Standard
CO_2	Carbon Dioxide
EGARCH	Exponential Generalized Autoregressive Conditional Heteroskedastic
EIA	Energy Information Association
EU	The European Union
FEVD	Fixed Effects Vector Decomposition
G7	Group of Seven
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GLS	Generalized least squares
GMM	Generalized Method of Moments
GSR	Global Status Report

IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
MLN	Million
NPAM	Network Performance Assessment Model
OECD	Organization of Economic Co-operation and Development
OLS	Ordinary Least Square
OPEC	Organization of the Petroleum Exporting Countries
PCSE	Panel-Corrected Standard Error
PLS	Partial Least Squares
PV	Photovoltaic System
R&D	Research and Development
RES	Renewable Energy Standard
RGGI	Regional Greenhouse Gas Initiative
TIMER	Targets Image Energy Regional
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
UCS	Union of Concerned Scientists
UN	United Nations
US	The United States
VECM	Vector Error Correction Model

CHAPTER 1

INTRODUCTION

1.1 Introductory remarks

The rising concern over environmental issues and rapid technological improvements as well as the uncertainty on future of fuel resources have been forcing the governments to search for policies to extend the energy mix and make more investments in the alternative energy sources through new developments. The facts that there is no stable flow of energy from a reliable source and there will always be fluctuations in energy prices have made energy economics and politics a necessary concept for decision makers. Industrial economies particularly depend on fossil fuel sources. The corresponding environmental impact of their use has generated a great deal of interest for intensive calculations for sustainable energy usage. In this regard, the alternative energy sources appeal both policymakers and the general public. As a response to global warming many countries are considering reducing oil, natural gas and coal consumption and substituting them with the renewable energy.

Energy substitution as an economic model of energy mixing looks like the principle energy policy instrument in enhancing sustainability. There are wide range of studies concentrating on the energy mixing strategies and renewable energy growth with some focusing on renewables. However, particular studies on the substitution effect of oil and renewable energy are still in need of deeper analysis. This thesis have a comparative look at G7 and BRICT countries in analyzing the impacts of oil price changes, gross domestic product per capita and carbon emissions on renewable consumption.[1]

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[1] G7 as Group of Seven includes seven most advanced economies (US, Canada, Japan, UK, Germany, France and Italy) as reported by the IMF making 46% of world GDP. BRICT includes countries

1.2 Background

This thesis takes two major primary energy sources, oil and renewables, at the center of its analysis dealing with three of the most permanent topics in international energy agenda: First, the growth of renewable energy consumption as a response to climate change at global scale and green-gas reduction policies. Second, the vulnerability economic activities in oppose to highly volatile oil prices as national economies get energy intensive. Third, to which extend the income level, economic development of a nation affects its respective national policies on energy utilization.

The critical motive behind the topic of the thesis is the sharp fall in the oil price over 40% in less than 8 months since June, 2014. Crude oil prices declined severely as global oil supply overcame demand pushing down Brent Crude from $112 per barrel (bbl.) in June to $62/bbl. (US EIA, 2015) in the end of 2014. Over the course of editing the thesis, oil prices fell even further as Crude Oil Brent was priced $32/bbl. (26 January, 2016).

Motivated by the recent sharp fall of global oil prices over a year to less than $40/bbl., this thesis aims to test a long-term relation between oil prices and renewable energy markets, in order to be able to examine how the developed and emerging economies may re-adjust their energy policies and strategies in response to these price changes.

After a decade of solid oil price performance, this latest oil price drop caused critical changes in the balance sheets of almost all states and made many to check

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(Brazil, Russia, India, China and Turkey) with emerging economies which are at similar phase of development with newly advanced economies and fast pace growth. For the study Turkey was added to original BRIC countries. Together they make 23% of world GDP.
International Monetary Fund (2015). World Economic Outlook Database.
Retrieved from https://www.imf.org/external/pubs/ft/weo/2015/01/weodata/index.aspx

future policy alternatives. Many recent headlines emphasized the potential impacts on renewables.

Concerns on the climate change and pressure to reduce oil consumption has been most prominent in Organization for Economic Co-operation and Development (OECD) and the European Union (EU) countries with high income per capita. These countries have been more successful in fulfilling renewable supporting policies and in establishing renewable energy systems. On the other hand, developing and underdeveloped countries look like slow in supporting renewable development, where BRICT countries can be seen as frontrunners in renewable investment. In this regard, this gives the motivation to take comparative look at G7 and BRICT countries adding carbon emissions and income level as principle variables. Through this perspective, we are able to generate comparative look at two most prominent groups of countries in global scale which allows us to take solid results looking at economic background. Despite the key belief that there exists correlation between oil prices and renewables with being weakened in contemporary global markets, there is still little consensus on what falling oil prices might mean for the future of the renewables.

The uncertainty and indefinite correlation was stemming from varying findings of different academic researches as well. Different empirical analysis in national, regional and international level with varying level of implications support for different hypothesis with differing methodological analysis. Varying time series analysis and samplings in different studies proves the reasoning behind non-integrated results, as well.

1.3 Problem formulation in relation with literature

Renewables are new energy sources compared to fossil fuels which are dominant for the last century, and the substitution relation between two energy alternatives is not clearly revealed. The fact that most of the technical and scientific developments and findings are explored in latest decades explains the knowledge gap in previous studies. In the literature on renewable energy, the role of carbon emissions and GDP are more widely examined, whereas the centralized look at oil prices and renewable energies and peculiar comparative analysis of emerging and developed markets are missing. There is no wide range of academic studies that focus on oil price and renewable consumption relation. Another missing spot which deserves a detailed explanation is on differentiated results on statistical significance over different regions. In other words, with the reference to varying groups of countries, findings are not compared with the different results on correlations, e.g. a negative significance in the EU in contrast to positive significance in China.

1.4 Purpose of the study

This thesis aims to look at oil price- renewable energy relation adding the probable effects of GDP per capita and carbon emissions and to make a comparative analysis to observe causing mechanisms. The analysis use of crude oil prices in 24 years since 1990, as well as the renewable energy consumptions in G7 and BRICT countries which vary with different geographies, income levels and energy consumption mixes.

This thesis makes major contributions to the existing literature. Firstly, it is among a few studies that take oil price, carbon emissions, GDP, renewable interaction into the core, and aims to make comparative look and to extend the analysis to a more contemporary data series. Secondly, covering the years after global economic crisis of 2009 and including more recent economic developments the thesis becomes a supplementary for previously held studies. Results of the data analysis are categorized and compared between the G7 and BRICT states referring them as energy producing, consuming and importing countries.

1.5 Outline of the study

The study starts with an overview of general energy markets and developments. Main theme of this chapter is the energy consumption trends of different sources on global and country levels to see the importance of energy mix in national policies. Following chapter reviews the related literature. Third chapter reveals the data methodology to be used in the study and how data was covered for the reliability. Next chapter discusses over the results of the empirical study. Conclusion covers final discussions and future implementations of the study.

CHAPTER 2

OVERALL ENERGY TRENDS

2.1 History and profile

Energy is commonly defined as the ability to do work or to produce heat being derived by several ways such as burning fuel, capturing sun's rays or from the rocks below the Earth's surface (Bhattacharyya, 2011). From using car to lighting factory, from powering electronics to manufacturing machines, it is a primary tool inseparably linked to daily human life, as well as economic and industrial development.

Considered as a key of modern industrial economy, energy is an essential ingredient in development policies. Energy consumption is a crucial component in economic growth, directly or indirectly, as a complement to capital and labor as input factors of production.[2] Studies show that with the rise of income, investment in energy consumption increases and in return further economic development evolves. Mixed and positive correlation between energy consumption and economic development are found in supportive conclusions of Bloch et al. (2015), Aslan (2013), Oh & Lee (2004), Ghali & El-Sakka (2004) and Soytas & Sari (2003).

As clear indicator of this relation, 2013 global energy consumption per day totaled to 12.7 billion tons oil equivalent (btoe.), 56% up from 1990 whereas the world real GDP increased 87% during the same period (BP, 2014). In addition to this relation, energy consumption is observed to fall with respect to fall in World Gross

[2] Belke, A., Dreger, C., & de Haan, F. (2010). Energy Consumption and Economic Growth: New Insights into the Cointegration Relationship. Ruhr Economic Papers. Ruhr-Universitat Bochum. Germany.

Domestic Product during early and late 1990's, early 2000s and 2008 global financial crisis (Figure 1).

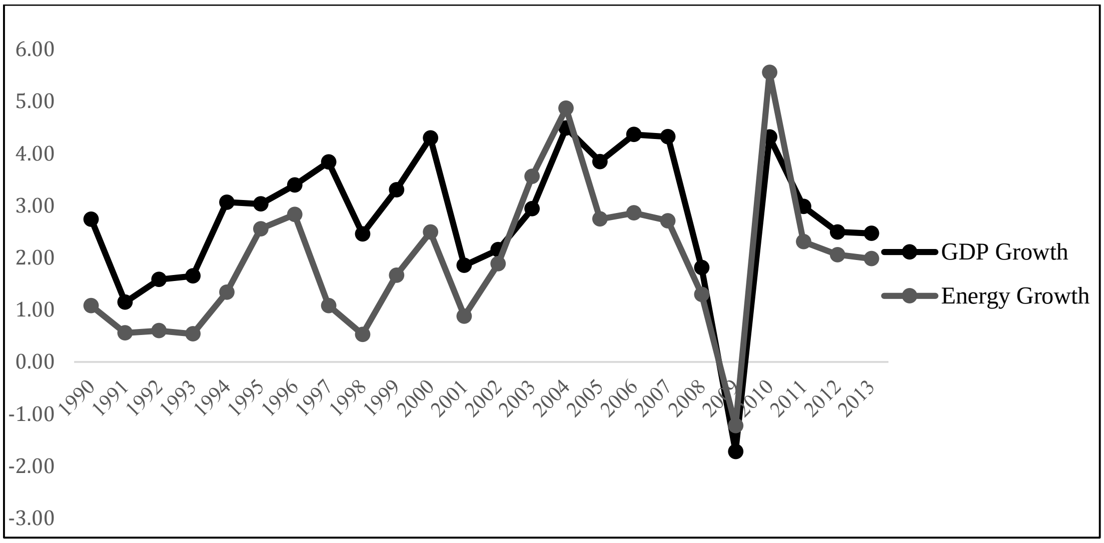

Figure 1. World Energy Consumption Growth and Real GDP Growth Trends, 1990-2013 (BP, 2014)

Vast growth of energy consumption was not continuous. The rising energy demand has started the discussions over the impacts of accelerating industrialization on environment and pollution. Besides, high volatility in energy prices and the question of secure/continuous access to energy sources have brought new questions on the future of energy investments. Recently, energy efficiency is another hot issue within the last decade as countries are more inclined to increase output with holding energy input stable.

2.2 Consumption in advanced and emerging markets

Today, about 13 billion tons of energy is being consumed in the world, annually as equivalent of 10 times as much energy used a century ago. As clearly observed from Figure 1, energy consumption rose steadily since 1990, except early, late 1990s and 2008 when global financial crisis deeply hurt national economies. World energy consumption is expected to increase in a fast pace by Compound Annual Growth Rate (CAGR) of 1.64% until 2030 (Deloitte, 2013).

Consumption mix and growth trends differ across countries, mainly because of income level, geographic position, and energy resource availability etc. Countries with high income levels demand more energy utilization, compared to developing ones, thus leading to more energy demanded in transportation, industrial and commercial sectors. Developing markets, on the other hand, as being in earlier stage of industrial development has been experiencing vast growth in demand for energy.

On this regard, in recent years emerging economies have been the biggest contributors to the dynamic growth of energy utilization. In 2013, 80% of global energy consumption growth was accounted by the emerging and developing economies. Despite the decade low of 3.1% growth, the annual growth in this group of dynamically growing economies was still way higher than OECD average of 1.2% (of which majority was driven by the growth in the US). BRIC (Brazil, Russia, India and China) states as defined to be major emerging economies were the mainstream behind the phenomenal growth. For comparison between 1990 and 2013 energy consumption rose by 141.6% in BRIC states versus 11.5% in G7.

In early 1990, over 57% percent of global energy consumption came from the OECD countries, whereas in 2013 this portion has fallen to 43% and expected to fall further. In 2013 alone, China accounted 22% of total consumption and generated 4.7% growth over the previous year. As the leading energy consuming country surpassing the US since 2010, China’s growth primarily backed to decades’ long industrial growth and domestic production that fueled the demand for energy sources, primarily for fossil fuels (Figure 2).

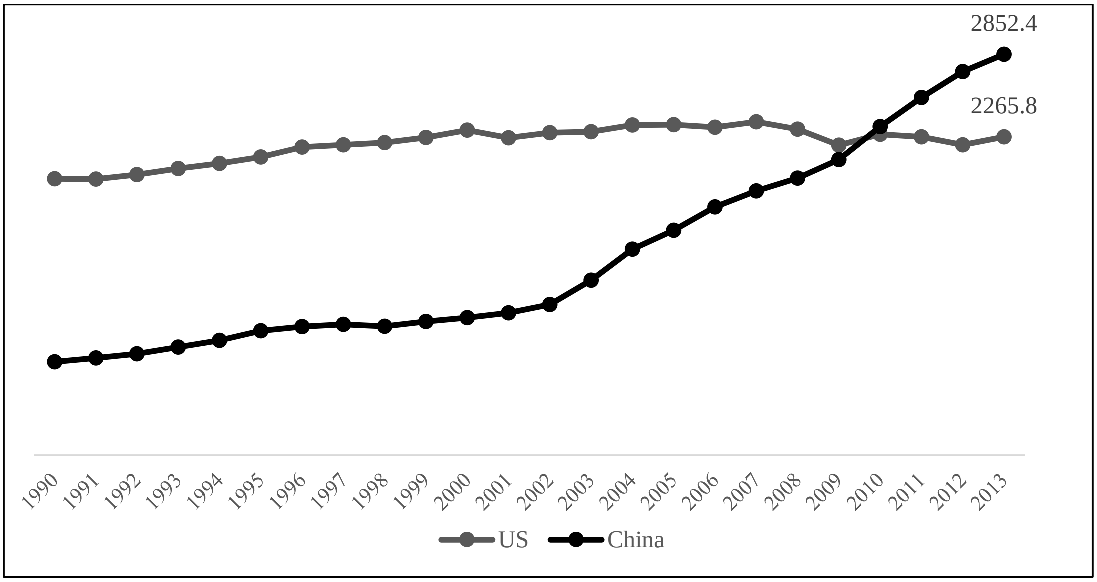

Figure 2. Energy Consumption of China and US in mln. toe., 1990-2013 (BP, 2014)

Backed by growth of emerging economies, world energy consumption increased by 2.3% in 2013, reaching a record level for each fuel source, excluding nuclear energy (BP, 2014). Although growth of 2013 was higher than previous year, it was still below the average of last 10 years. The European Union, North America and China alone consumed two thirds of the world energy. China and USA were the biggest energy consuming countries together having 70% share of total energy demand, where China is the leader in overall category.

Growth in OECD countries was slower than developing countries in 2013 but higher than the average of last 10 years. China accounted biggest growth and followed by the United States. Despite the dynamic growth of the emerging economies, almost 44% of total primary energy is still consumed in OECD countries which are comprising only 18% of world population (Figure 3). However, the energy consumption gap between OECD and non-OECD countries has been decreasing.

Opposite to vast growth in the developing markets, energy consumption in advanced states like the EU and Japan have fallen in last 2 decades. In 2013, energy consumption in the EU and Japan fell to the lowest levels since 1995 and 1993 respectively (BP, 2014). Whereas slow economic growth is an apparent factor, policy mechanisms towards improving energy efficiency and reducing energy intensity are also significant causes of decrease in energy usage in these regions, particularly in the EU.

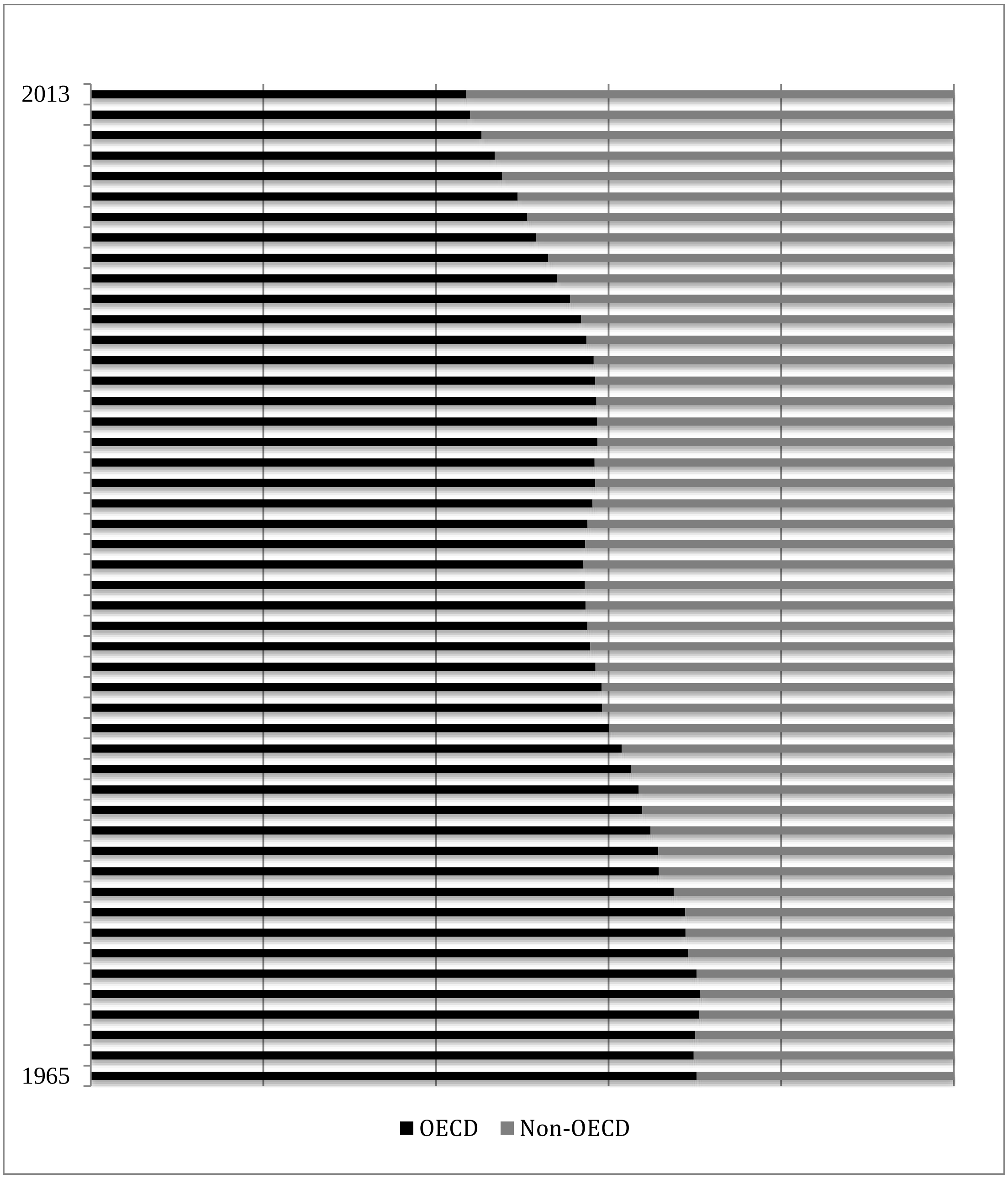

Figure 3. Energy Consumption in OECD and Non-OECD (BP, 2014)

In the on-going trend, the energy demand by developing countries is expected to grow 93% until 2030, due to higher living standards, population growth, rapid urbanization and gradual expansion in the use of commercial fuel.

In addition to differences in income levels and growth trends in energy consumption, OECD and emerging economies also differ in terms of energy mixing. As group of advanced economies, OECD countries consumed more renewable sources in energy mix compared to the rest of the world and it is primarily backed to higher renewable shares in the EU states. In 2013, average share of renewables in total energy consumption was 13% for OECD countries while non-OECD countries had less than 11% renewables in total energy mix.

2.3 Energy systems and sources.

Energetics is the field that researches on how energy is provided naturally and in what forms it is transformed for final usage. Energy systems are those devices in which energy is processed to end use through transformation and conversion processes and flows.[3]

As energy can be obtained from various sources, the classification of energy cycle is customary, in order to indicate how they are utilized, such as; primary and secondary forms of energy, renewable and non-renewable forms of energy; commercial and non-commercial energies (Bhattacharyya, 2011). Primary energy is defined as energy source that is extracted directly from the nature without passing any transformation. Focus and data of our analysis is on this type of energy that most notably includes crude oil, natural gas, coal, wind power, nuclear power etc.

[3] Orecchini, F. & Naso, V. (2012). Energy Systems in the Era of Energy Vectors, Green Energy and Technology. Springer-Verlag London Limited (2012). doi: 10.1007/978-0-85729-244-5

Classification of energy as renewable or non-renewable stems depends on whether the primary source is coming from finite stocks in nature or not. As in simple economics, the less is the stock of energy means higher price. This is critical for contemporary and future energy projections as fossil fuels, which make over 80% of total primary energy consumption, fall under this category and will run out before the end of this century.

Commercial energies are those that can be traded, thus, subject to price range, opposed to non-commercial ones that are consumed without being traded. Historically, energy consumption could not be tracked accurately as majority of consumption derived from non-commercial energy that were used for personal means (e.g. earlier fuel- wood). Boundaries between the categories not only change in time but also in space. Today, non-commercial energy still is widely used in many geographies in the world notably in developing countries where purchasing power is low.

Firewood and biomass were meeting basic home needs as heating and cooking. After those supplies of energy were to be proved insufficient to support growing economies in Europe and the United States, people turned to hydropower (also a form of stored solar energy), then to coal during the nineteenth century, and then to oil and natural gas during the twentieth century (Timmons et al, 2014).

Rapid industrial and economic growth are seen to have boosted the demand for all primary energy sources in last two or three decades (Figure 4). Renewable energy has been the fastest growing energy source whereas nuclear energy has been slowest.

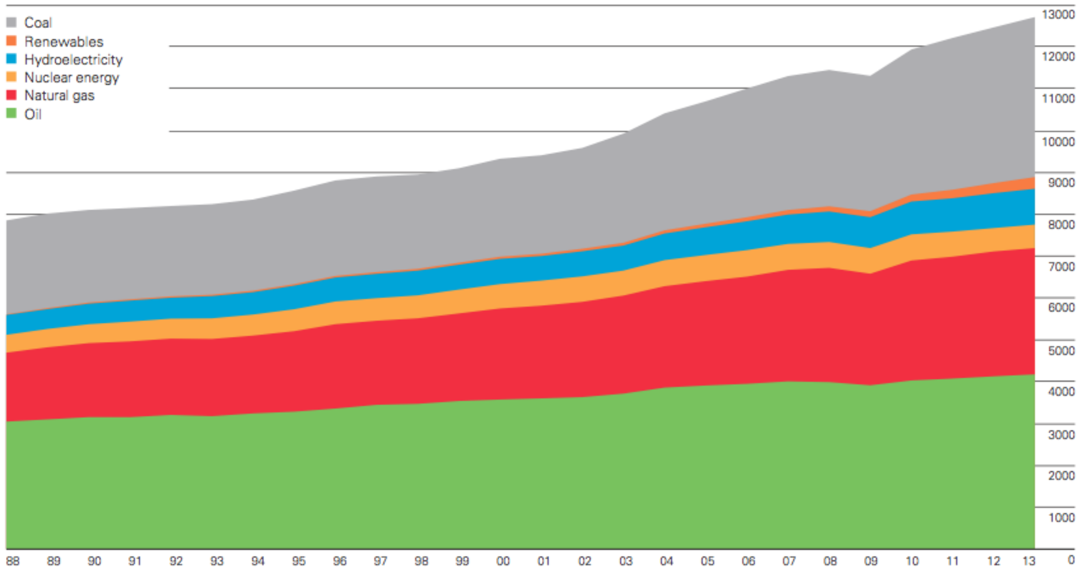

Figure 4. World Primary Energy Consumption by Source, 1988-2013, (BP, 2014)

Today global energy system mostly rely on fossil fuels which historically and contemporarily are accounting the majority of global energy supply and generated over 85% of primary energy consumed in 2013. Formed from organic material over the course of millions of years, fossil fuels have actually fueled U.S. and global economic development over the past century.[4] The easy availability and extraction relative to renewables, comparatively low cost and advanced transportation and storage systems make fossil fuels preferable in industrial production and irreplaceable in transportation.

Among the fossil fuels, oil is the most consumed energy source with 32.9% share of total primary energy consumption. During the 1970s, crude oil has been constituting around 50% of world energy consumption and has been used for everything, from transportation to heating, but chipped away by renewables, coal and natural gas, its use now is concentrated in the transportation sector (Maugeri, 2010).

[4] Environmental and Energy Study Institute. Fossil Fuels.
Retrieved From- http://www.eesi.org/topics/fossil-fuels/description

Today 48% of accessible oil reserves are found in the Middle East, particularly in five countries (Saudi Arabia, United Arab Emirates, Qatar, Iraq and Kuwait) and consumption is primarily driven by the transportation sector (Figure 5).

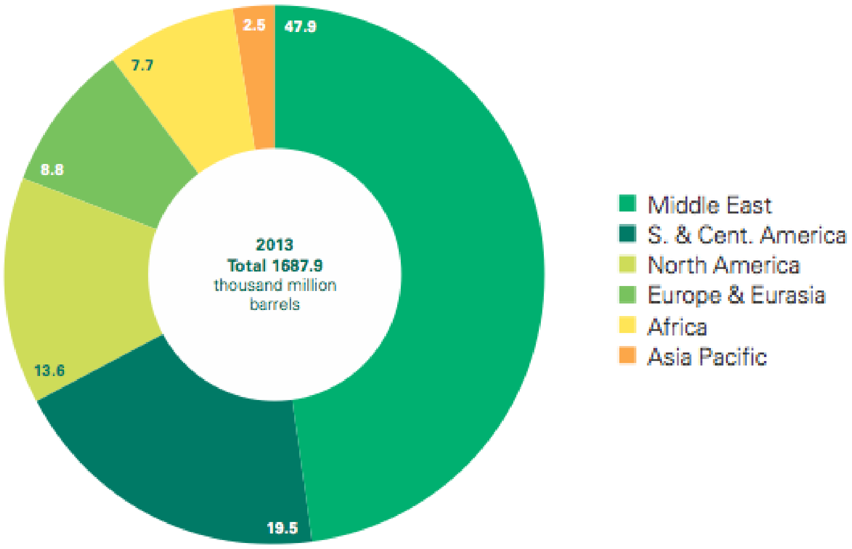

Figure 5. Distribution of Proved Oil Reserves by Region, 2013 (BP, 2014)

Although demand for oil has been most notably visible during the two World Wars, oil trading as commodity and economic mechanism came into critical agenda shortly after Arab- Israeli war when oil exporter Arab countries decided to cut production and adopt embargo on the USA and other countries for their support to Israel. Historically known as the first “oil shock”, this led to hyper valuation of oil and strict restraints on oil consumption for some time.

Since 1970s reducing energy dependency on Middle East has been in the agenda of western governments and decision makers. Then, three strategies have been followed by oil consuming countries: increasing production, extending energy mix and decreasing consumption. Since 1970s, oil prices has fluctuated and peaked in 2007 with 147$ per barrel. In following years, price of oil remained over 100$ per barrel, until the summer 2014, since when it has gone through sharp fall.

As the second highest consumed energy source with 30.1% share, coal is still expected to grow with the demand in power generation. The relative high supply and low costs to use has made the coal the majorly preferred fuel for building Power Plants. China solely is the biggest consumer country accounting over the half of total coal consumption. However, coal is criticized as being the biggest polluting fuel.

Natural gas follows coal as the third most consumed primary energy with 23.7% share and grows rapidly with continuous demand by heating, process use and power generation. Carrying lower risk in extraction process, causing less carbon emission and providing high and more secure financial return, natural gas is a preferred energy supply of electricity for particular industries. Similar to oil, proved natural gas reserves are concentrated in Middle East, making the region highly prioritized for natural gas dependent countries (Figure 6).

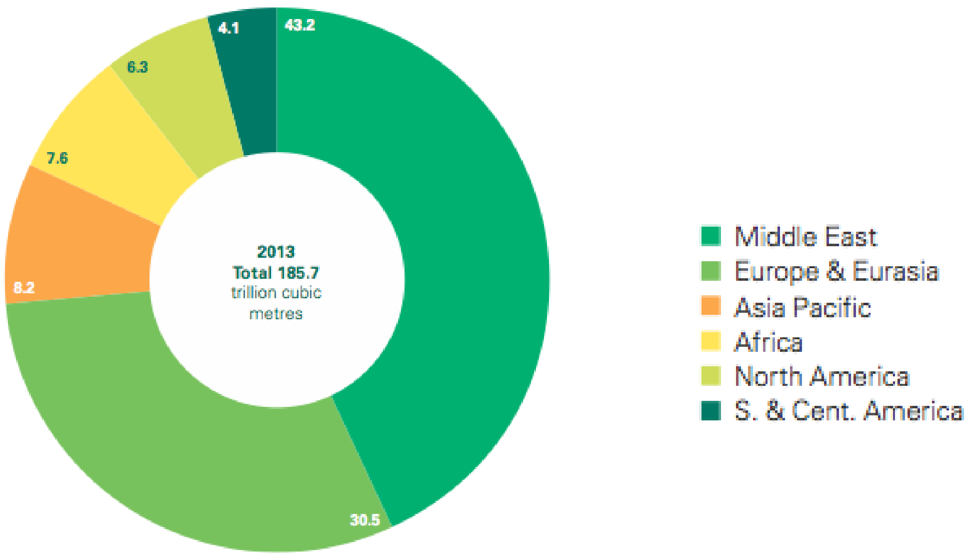

Figure 6. Distribution of Proved Natural Gas Reserves, 2013 (BP, 2014)

However, hard transportation networks and lack of stocking availability are the disadvantages of using natural gas. In advanced economies, the similarity of generation and final consumption sectors has made it as substitutive source vis-à-vis coal. For example in the United States, changes in relative prices of gas and coal might give rise to switching from coal to gas or vice versa in the generation mix (IEA, 2014).

Renewable energies follow fossil fuels with over 10% share (including hydropower) in total consumption and are growing more rapidly making record 2.7% share of global energy growth. Many factors are determinant in the rapid growth of the renewables which includes biomass, wind, solar, geothermal and hydropower energies. Global warming and environmental concerns are essential factors pushing many countries for renewable consumption. Availability and infiniteness also make them more preferable and attractive energy sources.

Nuclear energy, as final major energy source, accounted 4.4% of total World energy consumption. Similar to fossil fuels, the nuclear energy is also generated from the heat and steam which is stimmed by uranium in nuclear power plants. Today, nuclear energy is considered as ecology-friendly energy source, making less carbon emissions in comparison to fossil fuels. Even though the fixed costs of setting up a nuclear power plants is high, the running costs are quite low. The normal life of a nuclear reactor reaches to 40-60 years.[5] Furthermore, nuclear energy is more reliable and accessible than fossil fuels and renewables which might depend on weather or geographic conditions.

What makes nuclear energy a risky bet, is its environmental impacts through hazardous waste materials which are generated in the production and distribution process. The most notable risk of producing nuclear energy is nuclear accidents that might have very tremendous catastrophic effects e.g. accidents in Chernobyl in 1986 and Fukushima in 2011. Moreover, uranium as the primary source of nuclear energy

[5] Conserve Energy Future. (2016). Nuclear energy pros and cons. Retrieved from http://www.conserve-energy-future.com/pros-and-cons-of-nuclear-energy.php

is not infinite as renewable sources and are available in few countries. Nuclear energy grew 0.9% in 2013, first time since 2010. Over 80% of nuclear consumption is accounted for OECD countries with 50% granted to the United States and France.

CHAPTER 3

CLIMATE CHANGE AND RENEWABLE EXPANSION

3.1 Climate change

Climate change and global warming has been a dispute topic related to energy policies in the twenty first century. During the last 5 decades CO_2 emissions have risen threefold reaching over 35bn. tons of emitted carbon dioxide in 2013. Average surface air temperatures so far are 0.9 C° higher than three decades before (Economist, 2015). Most critical point agreed by consensus is that global temperature must not increase by over 2 C° above pre-industrial levels in nineteenth century.[6] It is estimated that world temperature would rise between 3C° and 10C° by 2200 if nothing is done regarding global warming. Because of these concerns, climate change has been major force behind renewable energy preference over crude oil for decades (Figure 7).

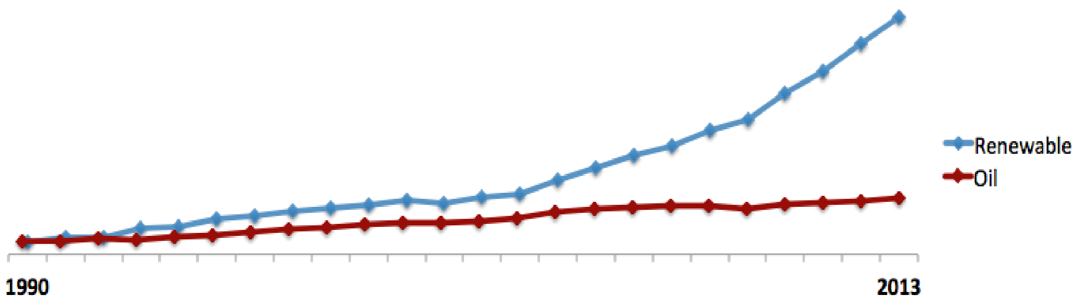

Figure 7. Oil and Renewable Energy Growth Trend, 1990-2013 (BP, 2014)

[6] 2 C° limit was set by the EU in 1996 and is agreed by politicians and green organizations upon scientific calculations. Temperature rising above that level might lead to some organisms to run into trouble.
Climate Change Special Report. (2015, November). The Economist, 417/ 8966 (2015). Retrieved from http://www.economist.com/news/international/21679868-reach-deal-negotiators-must-now-solve-toughest-issues-paris-climate-talks?zid=313&ah=fe2aac0b11adef572d67aed9273b6e55
Source 2- http://www.economist.com/blogs/economist-explains/2015/12/economist-explains-4

The major human activity that causes carbon dioxide (CO_2) emission stems from the usage of fossil fuels in particularly electricity, transportation and industry sectors.[7] Both Intergovernmental Panel on Climate Change (IPCC) and Stern reports (2006) came to the same conclusions that fossil fueled economic growth, through its release of CO_2 emissions into the atmosphere, is the main driver of global warming (Sadorsky, 2009). Fossil fuels are regarded as primary factors behind climate change and contribute ¾ of all carbon, methane and other greenhouse gas emissions (EIA, 2013). Many analysts suggest that greenhouse gas concentrations in the atmosphere has increased substantially leading to the warming of earth unnaturally in the last decade. In this regard, general belief is that fossil fuels cause the majority of carbon dioxide in the atmosphere. Since the last decade of twentieth century, environmental challenge has been the reduction of fossil fuels use and to reduce its impacts on the global warming. Many governments were finally persuaded to develop alternative energy sources. As Figure 8 shows, world carbon emissions growth rate has been more stable in twenty first century than earlier decades.

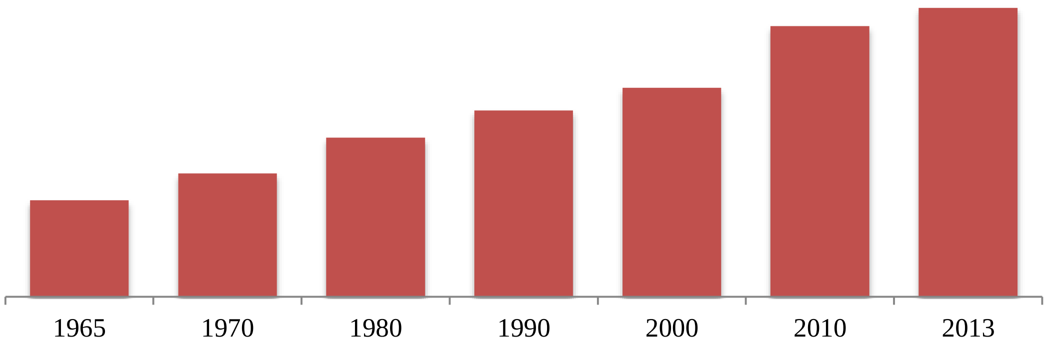

Figure 8. World Carbon Emissions, 1965- 2013 (BP, 2014)

[7]Electricity from the fossil fuels accounts for 31% of total US green gas emissions in 2013. Transportation from gasoline and diesel make 26% while industry made 12% of total US green gas emissions in 2013.
Overview of Greenhouse Gases. United States Environmental Protection Agency
Online Source- http://www3.epa.gov/climatechange/ghgemissions/gases/co2.html

Since 1990s environmental policies are being promoted to lower greenhouse gases through the deduction of fossil fuel consumption, higher capacity and production of renewable energy and the expansion of low carbon technologies. After the Intergovernmental Panel on Climate Change (IPCC), United Nations Framework Convention on Climate Change (UNFCCC) was adopted as greenhouse gas reduction mechanism that provides framework to negotiate international conventions and aims to enforce limits on greenhouse emissions. First major conclusion came with Kyoto Protocol in 1997 that included binding agreements and obligations for developed countries in order to reduce greenhouse gases. Regulatory policies, fiscal incentives and public financing mechanisms have been adopted in order to support the governments to meet the annual targets. By early 2014, at least 144 countries had renewable energy targets and 138 countries had renewable energy support policies in place, up from the 138 and 127 countries, respectively, over previous year (Renewables GSR, 2014).

Until recent days, environment protective policies have been mostly domestic with very limited international convergence. Countries that failed to make an international agreement have shifted their attention towards national level policies. For this reason, success of carbon emission reduction policies were different across countries. As seen in Figure 9, the developed countries in the EU and North America have been more accountable in reducing carbon emissions since the adoption of Kyoto Protocol in 1997. However, developing countries of Asia Pacific, Africa and oil rich Middle East regions have stayed behind in curbing carbon emission targets (Figure 9). Aggressive economic growth policies and uncontrolled industrialization in these regions can be considered as a major cause of CO_2 emissions.

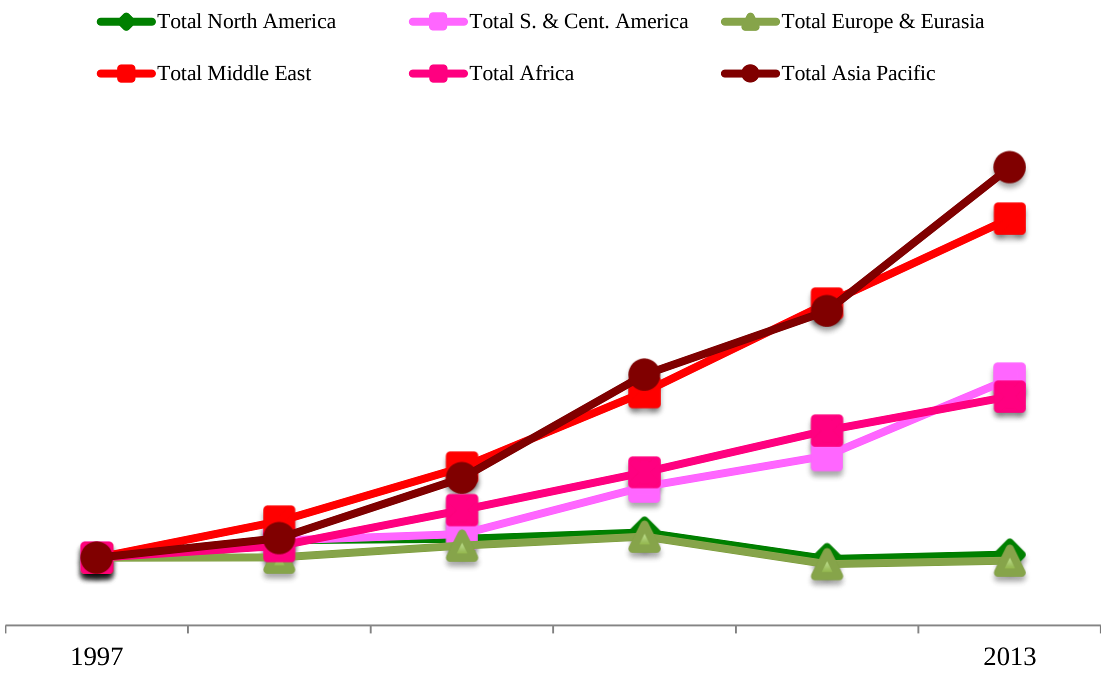

Figure 9. Total Carbon Emissions by the Regions since the Kyoto Protocol, 1997-2013 (BP, 2014)

3.2 Renewable energy profile and growth

Domestic development of renewable energy has been encouraging domestic governments in fulfilling carbon emission target whereas providing opportunity for countries to come to universal agreement on climate change to be realized in 2020 (UNEP, 2014).

Besides reducing carbon emissions, sustainability of renewable energy make it more preferable over the fossil fuels, as well. Renewable energy is favorable for being unlimited in nature, but availability might be varying, depending on time of year and geography.

Due to technological advances that reduce manufacturing and construction costs besides being sustainable and ecological-friendly, renewable energy appeals more interest. A study done by Jacubsen & Delucchi (2010) suggested that renewable energy in available locations can meet global energy demand by 2030 whereas non-renewables can meet by 2050. The study adds up that in oppose to general belief, renewables can meet global energy demand with today's technological advancements.

Future predictability of renewables' prices which stems from their reliability and security is another reason that makes renewable energies a favorable energy source. In advanced economies, renewables already provide affordable electricity. According to the analysis of Union of Concerned Scientists (UCS) a 25 percent renewable electricity standard would lead to 4.1 percent lower natural gas prices and 7.6 percent lower electricity prices by 2030 (UCS, 2009).

Technological advances related to renewables lead decreases in energy costs, substantially. For example, the average price of a solar panel, which is the most expensive to set up, has dropped almost 60 percent since 2011 whereas the cost of generating electricity from wind dropped more than 80 percent since 1980.[8] The cost of start-up in producing renewable energy is already less than in extraction of fossil fuels, in some parts of the world. Solar photovoltaic and wind power generation as a major force behind it (Figures 10 and 11). Solar photovoltaic power generation alone, fell four times during in 5 years until 2013 according to a report by US Department of Energy as mentioned in Figure 11.

[8] Solar Cost data was taken from Solar Market Insight Report 2013 by Solar Energy Industries Association. Wind Energy cost data was taken from American Wind Energy Association 2013 Report. America Wind Energy Association. (AWEA). (2014). U.S. Wind Industry Annual Market Report 2013. Washington.

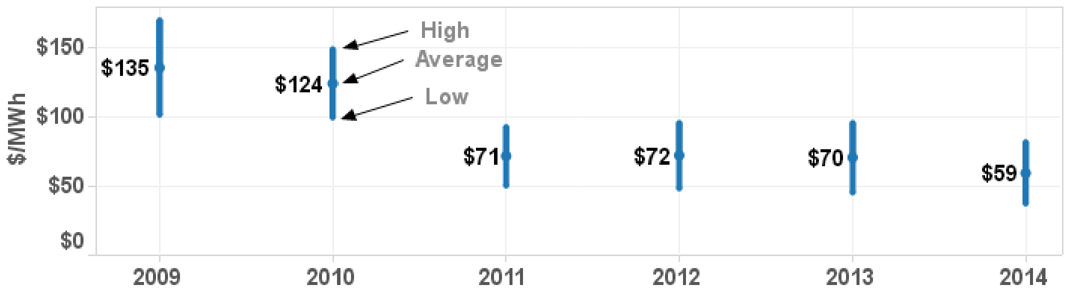

Figure 10. Levelized Cost of Energy: Wind Power.[9]

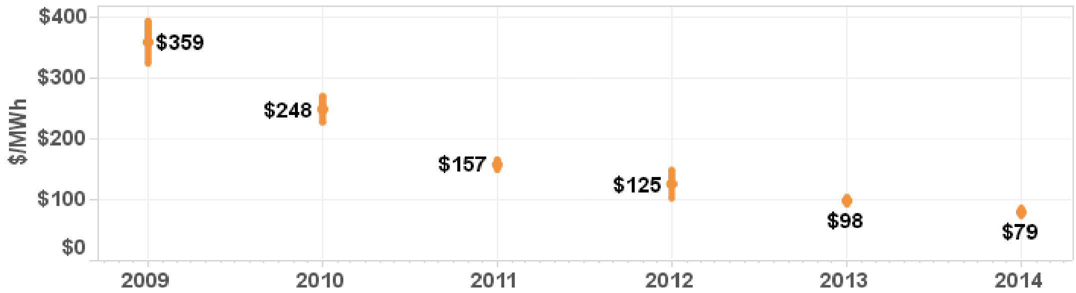

Figure 11. Levelized Cost of Energy: Solar Photovoltaic.[10]

The given financial progresses results mostly from intensive renewable investments which have increased drastically in the last decade. Global annual renewable energy investment rose six-fold between 2004 and 2012, reaching $249 bn. due to the increasing concerns on climate change. Incentive policies in the European Union and the United States were the primary motivators. Due to the uncertainty in incentive policies in the EU and the US, investments on renewables decreased for two consecutive years, 2012 and 2013, after decades of growth.

[9] Comparing the costs of renewable and conventional energy sources. (2015 February). Energy Innovation. Retrieved from http://energyinnovation.org/2015/02/07/levelized-cost-of-energy/
[10] Comparing the costs of renewable and conventional energy sources. (2015 February). Energy Innovation. Retrieved from http://energyinnovation.org/2015/02/07/levelized-cost-of-energy/

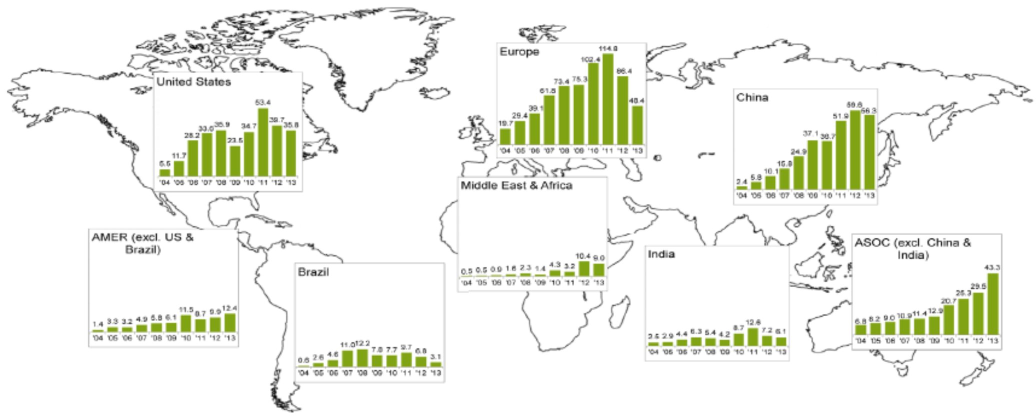

Figure 12. Global New Investment in Renewable Energy by Region, $bn., 2004-2013 (UNEP, 2014)

The European Union has the top 20 countries having per capita renewable capacities, although BRIC among the developing countries is leading in renewable investment, production and consumption (Figure 12). Led by China, India and Brazil renewable energy investments (excluding hydropower) in developing states increased ten-fold to 93$ billion in 2013 (The Climate Institute, 2014). Developing states were particularly active in solar, wind and geothermal investments when compared to the developed states. In 2014, about half of solar and wind energy investments were accumulated by developing countries (Figure 13). In 2013, China spent more on renewable investment than the EU countries in total and is projected to meet over 30% of electricity capacity in 2020.

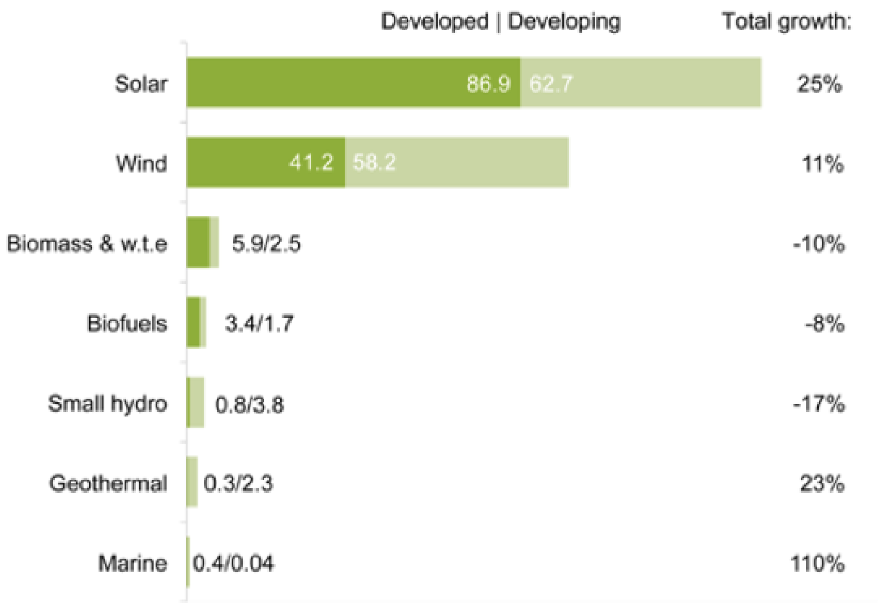

Figure 13. Global New Investment in Renewable Energy, Developed vs Developing, 2014, and Total Growth on 2013, $bn., (UNEP, 2014)

Renewables' main drawback is still their high installation and management costs for the end-users. Cost comparisons between renewables and fossil fuels in electricity generation through calculation of the levelized cost of energy (LCOE) shows fossil fuels yet more cost efficient compared to renewables, particularly solar panels and offshore wind and will yet be in 2020 (Table 1). [11] Renewables can be cost competitive, if their costs fall to the wholesale electricity price, or to the price at which fossil-fuel power plants sell electricity to the grid.[12]

[11] Levelized cost of energy represent the present value of building and operating a plant over an assumed lifetime, expressed in real terms.
[12] Timmons, D., Harris, J. M., & Roach, B. (2014). The Economics of Renewable Energy. Global Development and Environment Institute. Tufts University.

Table 1. U.S. Average Levelized Costs (2013 $/MWh) for Plants Entering Service in 2020, (EIA, 2015)

Plant type	Capacity factor (%)	Levelized capital cost	Fixed O&M	Variable O&M (including fuel)	Transmission investment	Total system LCOE	Subsidy[2]	Total LCOE including Subsidy
Dispatchable Technologies								
Conventional Coal	85	60.4	4.2	29.4	1.2	95.1		
Advanced Coal	85	76.9	6.9	30.7	1.2	115.7		
Advanced Coal with CCS	85	97.3	9.8	36.1	1.2	144.4		
Natural Gas-fired								
ConventionalCombined Cycle	87	14.4	1.7	57.8	1.2	75.2		
Advanced Combined Cycle	87	15.9	2.0	53.6	1.2	72.6		
Advanced CC with CCS	87	30.1	4.2	64.7	1.2	100.2		
Conventional Combustion Turbine	30	40.7	2.8	94.6	3.5	141.5		
Advanced Combustion Turbine	30	27.8	2.7	79.6	3.5	113.5		
Advanced Nuclear	90	70.1	11.8	12.2	1.1	95.2		
Geothermal	92	34.1	12.3	0.0	1.4	47.8	-3.4	44.4
Biomass	83	47.1	14.5	37.6	1.2	100.5		
Non-Dispatchable Technologies								
Wind	36	57.7	12.8	0.0	3.1	73.6		
Wind – Offshore	38	168.6	22.5	0.0	5.8	196.9		
Solar PV[3]	25	109.8	11.4	0.0	4.1	125.3	-11.0	114.3
Solar Thermal	20	191.6	42.1	0.0	6.0	239.7	-19.2	220.6
Hydroelectric[4]	54	70.7	3.9	7.0	2.0	83.5		

Despite recent developments, developing and establishing renewable energy systems are costly and hard to execute. For example, transition to renewable energy has made some difficulties for Germany. High costs of wind and solar panels is returning to German households as part of feed-in tariffs.[13] When German government decided to shut down coal plant Janschwalde, it faced thousands of unemployed miners who protest the government in Berlin. German government is declared also to phase out nuclear energy latest by 2022 against the discussions on how energy demand will be met with green investment.

[13] Average German household is paying 0.30 euro per a kilowatt-hour of electricity compared to 0.16 Euros in France.
Climate Change Special Report. (2015, November). The Economist, 417/ 8966 (2015). Retrieved from http://www.economist.com/news/international/21679868-reach-deal-negotiators-must-now-solve-toughest-issues-paris-climate-talks?zid=313&ah=fe2aac0b11adef572d67aed9273b6e55

Consumers' low willingness to pay higher taxes because of renewable energy, has been another barrier to expand transition to renewable energy systems but public opinion has been changing. Soon (2014) estimates that initially consumers and households are not happy with paying more to support sustainable growth however with more knowledge, information, awareness and exposure to renewable energy systems residents become more willing to pay for renewable systems particularly in urban areas and Western countries (Soon & Ahmad, 2015).

Cases as such in Germany show that implying renewable energy expansion might have limited or negative causes on economic growth and employment, in short term. However, in long term, increasing utilization of renewable energy sources might have net positive outcome for economy and employment as suggested by J. Blazejczak et al. (2014).

The fact that renewable energy sources are not adaptable to every geography or single society is another reason why renewables are not easily adoptable. The availability of the natural resource for the given geography or energy utilization dependents on previously established systems (Mohtasham, 2015). Even if the geographic distribution of resource is more homogenous, a transition to renewable system might be vulnerable due to the local limits such as ecological conflicts, high land area requirements etc. Development of local institutional regularities might be necessary to prevent such conflicts (Mansson, 2015).

Transition to renewable energy systems may also differ in terms of level of economic development and policy support mechanisms. Hua et al. (2016) shows that Australia and China, two countries committed to renewable energy development, have different mechanisms and development experiences. China, the giant energy consumer, needs more renewable energy growth, due to environmental concerns at critical levels. As a result Chinese government shows more confidence in renewable energy development compared to the Australian Government. Australia on the other hand despite little support for renewable energy industry has more effective renewable energy implementation backed by highly developed renewable energy technologies and resources.

3.3 Energy efficiency and sustainability

Economies' vulnerability to energy shocks and intensive energy usage along with green-gas emissions have prompted the rational use of energy and energy saving which is defined as energy efficiency. Technically, energy efficiency means producing output with less unit input of energy with given time, allowing to reduce consumption without changing the same result obtained. Energy efficiency measures are among four key measures suggested by IEU. First measure is to achieve a 2°C increase scenario and avoid global warming whereas other three are related to fossil fuel use limiting measures.[14]

Only in 2012, between $310bn and $360bn was invested to improve energy efficiency (IEA, 2014). Investment in energy efficiency was larger than supply-side investment in renewable electricity or in coal, oil and gas electricity generation, and around half the size of upstream oil and gas investment.[15] In many EU countries today, effects of energy efficiency policies are clearly observed in everyday life. Across industries and residential regions, energy efficient technologies are widely

[14] BRICS: Balancing economic growth and environmental sustainability. (2014). World Economic Forum. Retrieved from http://reports.weforum.org/global-energy-architecture-performance-index-2014/brics-balancing-economic-growth-and-environmental-sustainability/

[15] International Energy Agency (IEA). (2014). Energy Efficiency Market Report 2014. OECD/ International Energy Agency.

adopted as they reduce the energy input, so the costs and energy loss during energy transformation.

During the first decade of twenty first century, 1.7 billion metric tons of oil, higher than total energy consumed by China in 2011 was saved. Similar efforts in developed and emerging markets have saved billions metrics tons of oil, in last decade. Energy efficient targets and technologies are expected to positively support renewable consumption as both policies focus on clean environment. On the other, hand improving energy efficiency is seen to have negative impact on oil consumption. During a panel discussion at a Financial Times—IRENA event, Michael Liebreich stated that US oil imports have dropped by about 7–8 million barrels a day while its production only increased by about 3–4 million barrels a day highlighting reduction in the oil consumption (Shahan, 2015).

Over last decades, developed countries of the EU have been particularly successful in cutting energy intensity and improving efficiency. As stated by Filipovic (2015) taxation mechanisms for electricity and rising income per capita are seen as critical factors behind successful energy efficiency implementation in the EU.

Emerging and developing economies of BRIC have experienced energy intense economic growth and have largely upheld policies to ensure affordability of energy to drive competitiveness in industry.[16] However, these countries are already taking solid steps for pushing energy intensity down. China's Five Year Plan targets to cut energy intensity by 20% latest by 2015 from 2010 levels. India plans to cut carbon intensity by about 20% by 2020. South Africa has managed to decline energy

[16] BRICS: Balancing economic growth and environmental sustainability. (2014). World Economic Forum. Retrieved from http://reports.weforum.org/global-energy-architecture-performance-index-2014/brics-balancing-economic-growth-and-environmental-sustainability/

intensity with the help of de-industrialization since 1980’s and flow of efficient technologies through FDI’s (Adom, 2015). Russia, one of the highest energy intense country, improved energy efficiency with enabling structural changes in the economy, but still is in need of energy intensity reducing policies, especially in private sector.

Managing energy efficiency might push oil price down. Efficient use of energy decreases the consumption. The same level of supply with lower demand implies less price. Indeed, high fossil fuel prices may indirectly support the energy efficiency through the usage of renewable energy technologies, and hence leading to less carbon emissions.

CHAPTER 4

OIL PRICE VOLATILITIES

Oil price volatility is one of primary obstacles in contemporary energy economics. Abrupt shifts in oil prices is affecting national economies in negative way, making it hard in making future demand forecasts and planning. In history, oil price shifts, as seen in Figure 14, have challenged policy-makers with difficult choices as they simultaneously posed upside risks to inflation and downside risks to growth.[17] All four global economic recessions since 1965 occurred immediately after an abrupt oil price increase. (Andrews, 2014). Overdependence of global oil demand on the Middle East Region has brought the questions of oil supply security, vulnerability and social/ economic development, as Arab countries have been unreliable in holding stable flow of oil especially during the time of crisis or conflict.

Widespread nationalization in the Arab world after 1950s' Israel-Palestinian conflict moved regional political motives in parallel with strategic oil movements. In this regards, following the political conflicts and debates, the first oil crisis was started in 1970's and was deepened by the enforcements of Organization of Petroleum Exporting Countries (OPEC) that ended the domination of Western multinational companies. During 1980s, as OPEC was proved to be unable to manage the delicate balance of prices, demand and production, a second major crisis hit the oil market (Maugeri, 2010).

Oil price volatility was worse after 1990s when prices came to a record low at below 10$ a barrel in late 1998. With early 2000s, following 9/11 attacks, invasion of Afghanistan and Iraq rebounded prices again to over 100$ a barrel levels again.

[17] Jimenez- Rodriguez, R. (2011). Macroeconomic Structure and Oil Price Shocks at the Industrial Level. International Economic Journal. doi: 10.1080/10168737.2010.487913

Then, the most spectacular rebound in history culminated on July 11, 2008, at 147.29$ a barrel, the highest intra-day trading level ever reached by oil.[18]

Despite the high volatility, trend in oil prices has been mostly on positive direction, rising continuously for decades in much higher pace over other fossil fuels (Figure 15). Between 1990 and 2013, Light Brent crude rose 6.55% CAGR whereas natural gas and coal prices increased more moderately with 3.46% and 2.67% respectively. Most notable increase in the oil prices was observed in 1973 when prices quadrupled after the Arab members of OPEC countries decided to put an oil embargo against the western countries as a reaction to Israel Palestinian war. It is not wrong to state that since then, academic interest on the energy economics, energy risk and security and energy efficiency has been intensified.

Concerning the latest fall in oil prices in 2014, policy analyzers assumed five factors as major ones. On demand side, growth was low due to the weak economic activity. On the supply side, the exploitation of deep water reserves is the first factor that leads higher production and reserves. Findings of new reserves in North America, Europe and China boosted the energy supply called as “shale revolution”. Secondly, major oil producing countries in OPEC failed to reach consensus on making cuts in production. Particularly, some supplier countries such as Saudi Arabia resisted cutting supply with fear of losing share in the global market. Thirdly, the development of alternative sources eased to make energy mix and lessen the oil dependence. Most notably, many countries were already considering commitments in renewable energies and making investment strategies (ISN, 2014).

Many structural mechanisms and drivers might have led to short-term and long-term oil price shifts. Primary factors affecting oil prices are generally

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[18] Maugeri, L. (2010). Beyond the Age of Oil; the Myths, Realities, and Future of Fossil Fuels and their Alternatives. ABC-CLIO, Greenwood.

characterized as geophysical, economic and political. Especially, impact of critical political downturns and autocratic decisions by policy makers were highly significant. However, these factors are not enough to explain recent shifts in oil prices which basically is related to uncertainty in oil supply and demand (Forbes, 2014).

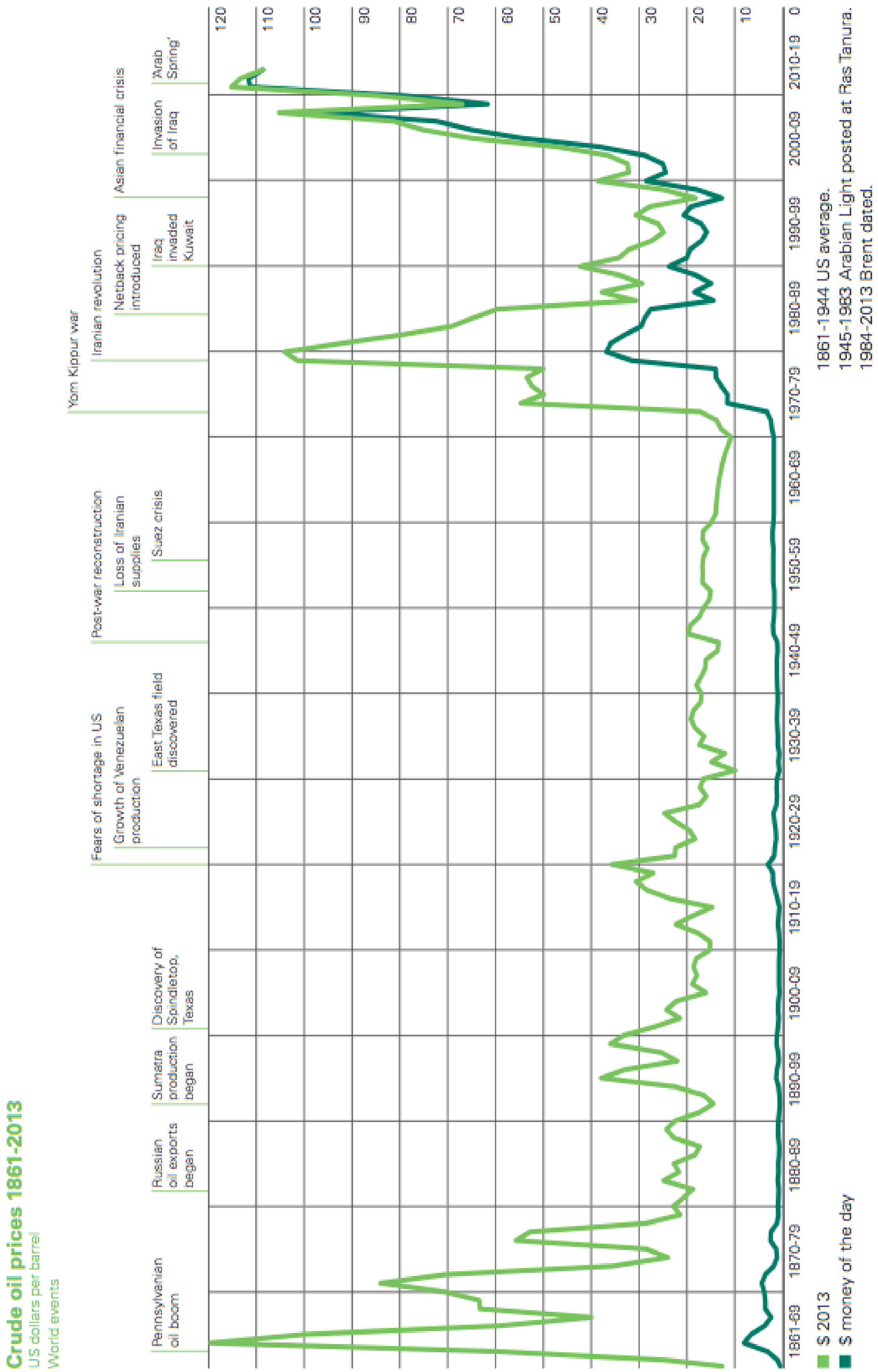

Figure 14. Oil Price Evolution, 1861-2005 (BP, 2014)

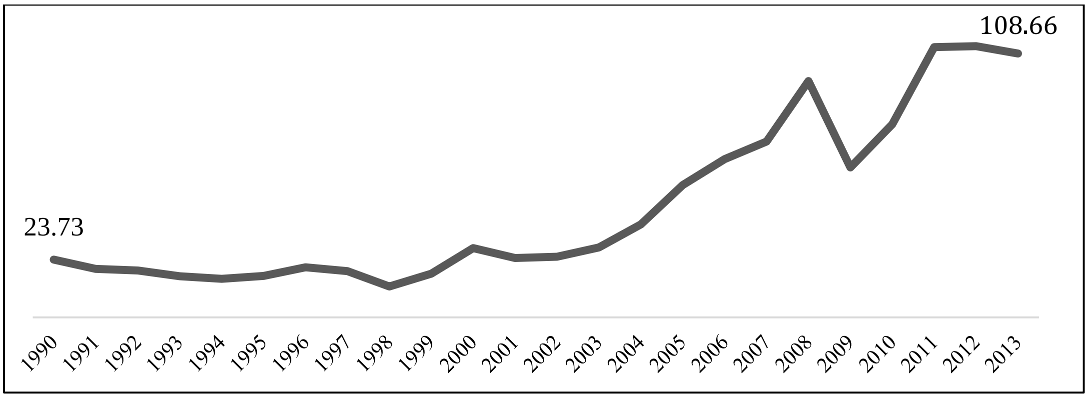

Figure 15. Oil Price Evolution, 1990-2013, (BP, 2014)

In demand side, primary explanations are linked to geophysical determinants such as exhaustion of resources and culminating production. Production costs based on geophysical factors are not the sole drivers that lead to escalating prices for decades. Forecasts predicts that there are enough oil resources available to meet expected demand until 2030.[19]

Peak production capacity impacts oil prices, as well. Until early 2000s, when prices were on high seas, cheap oil had discouraged the exploitation and development of new reserves, and led to closure of refineries, thus letting prices down.

The fact that the unpredictable political and macroeconomic shocks has a significant role in oil prices, makes it hard to project oil prices. M. King Hubbert's peak oil hypothesis (1956) which assumes that world oil extraction will reach maximum in early 2000s after which production is expected to fall terminally, is the most imminent theory on the subject (Figures 16 and 17).[20]

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[19] Analysis was made by B. Van Ruijven, D. P. van Vuuren (2009) with references from Aguilera et al. 2009; IEA 2005, 2008; USGS, 2000; World Energy Council 2007.
[20] With Hubbert Curve, peak oil hypothesis projected US oil production to peak between 1965 and 1971 and global oil production in early 2000s. The suggested numbers used in the study included total

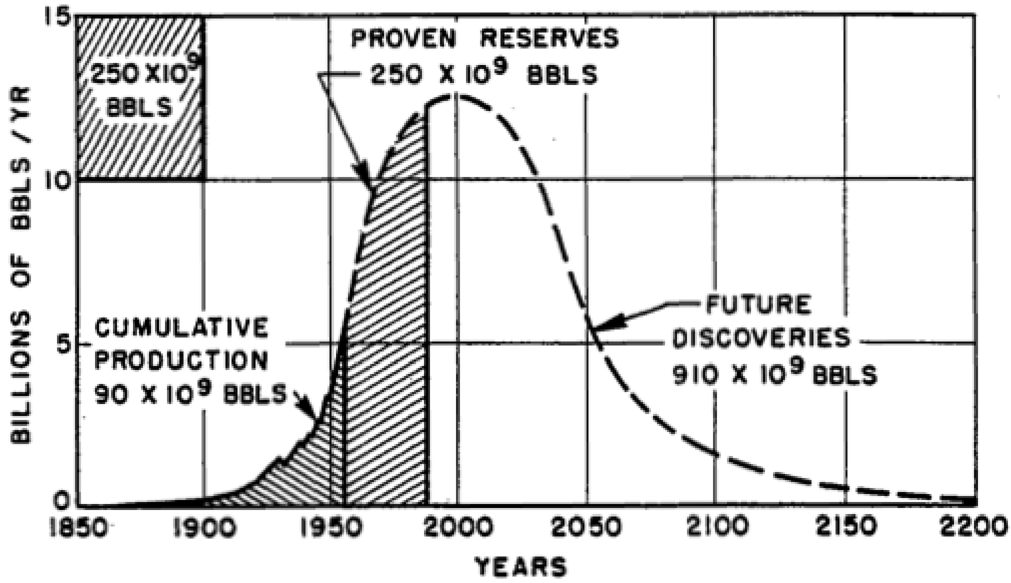

Figure 16. Hubbert Curve with ultimate world crude-oil production (Hubbert, 1956).

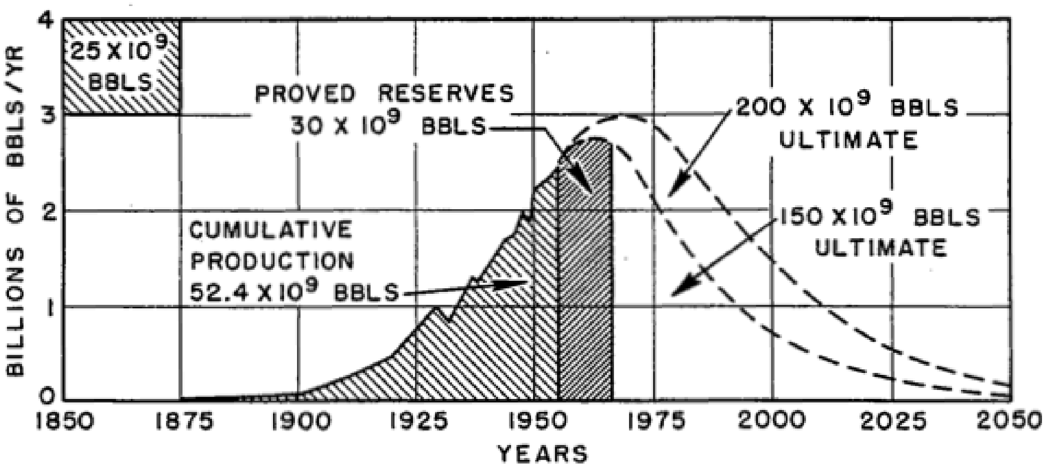

Figure 17. Hubbert Curve with ultimate United States crude-oil production (Hubbert, 1956).

Hubbert's analysis and predictions have attracted many supporters and at the same time harshly criticized in many models such as by Fisher (2008), Lynch (2006)

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amount of oil discovered as sum of cumulative production and proved reserves along with projected future discoveries.
Hubbert, M. K. (1956). Nuclear Energy and the Fossil Fuels. Presented before the Spring Meeting of the Southern District Division of Production, American Petroleum Institute, Plaza Hotel, San Antonio, Texas, 7-9 March 1956.

etc. Major opposing arguments have been particularly on that Hubbert's Analysis' had ignored innovation, exploration of new fields and non-conventional production. Today, similar debate may extend to worldwide discoveries of shale oil resources in the U.S., China, Russia, Poland and France which could mean that potential world oil production could double or triple in the next few decades but also may be limited with early and short peak in oil production.

Reynolds (2014) made future production estimations referring to Hubbert curve and historic trends in oil prices. He predicted a stable world oil production for a very long time with a slight increase until 2050 before a peak and then a slow decline in the world oil supply. If historic trends hold, a quick peak and decline for oil prices in near future would potentially be disastrous for global economy.

Uncertainty in demand is a significant variable in theoretical models that aim to explain oil price volatility. Oil price volatility is related to rapid and uncertain growth of demand outpacing production capacity. Wirl (2008) compares the recent oil price volatility to the oil crisis of 1970's using the demand shocks.

Demand uncertainty leads drastic price changes when coupled with sluggish increase in supply in energy markets. In that respect, high volatility of oil prices were very much encouraged by the low responsiveness or "inelasticity" of both supply and demand. (EIA, 2015). More clearly, because it is not easy to immediately change the production technology for manufacturers and to shift to other energy resources for final consumers, when there is a steep change in supply or demand, the oil prices are drastically affected.

Uncertainty in demand, is a significant factor in oil price changes, in the long term. Indeed, critical changes in energy consumption tendencies do not take place in months or years but in decades. Recasting consumer habits is a large undertaking.

The inflexibility of the technological standards and physical infrastructure that shapes the energy supply chain are the obstacles in front of the immediate changes.[21] As a result, the market equilibrium obliged to be balanced with varying price changes.

Speculations in financial markets are also considered to be a factor causing oil price changes. News shocks on oil market fundamentals, mispricing in the oil futures market, and global real interest rate shocks are the main speculative demand shocks.[22]

Tokic (2015) brought different approach to oil price volatility through exchange rate volatility between the US Dollar and Euro. He examined that economic growth divergence between the US and the EU was critical factor behind the volatility of currencies which was likely to create inefficiency in oil pricing. Brahmasrene et al. (2014) reveal similar findings:

"…crude oil price movements always come after currency fluctuations in the short run while currency fluctuations always follow crude oil price movements in the long run".

[21] Tertzakian, P. (2007). A Thousand Barrels a Second: The Coming Oil Break Point and the Challenges Facing an Energy Dependent World. McGraw-Hill, USA.
[22] Strom, S. B., & Pescatori, A. (2014, December). Oil Price Volatility and the Role of Speculation. IMF Working Paper. WP/14/218. Retrieved from https://www.imf.org/external/pubs/ft/wp/2014/wp14218.pdf

CHAPTER 5

LITERATURE REVIEW

The initial economic analysis of the thesis is based on very basics: Law of Demand. When price of a good/ commodity rises demand for it should fall being all other factors that may affect the demand stays the same. Exception to the law, Giffen's Paradox, was introduced by British economist Sir Robert Giffen who suggested the rise of bread prices despite the rising demand as evidence (Mason, 1989). Oil prices and consumption often is brought as appropriate examples of Giffen's paradox. We observe that over past years, oil consumption and demand stably increased despite the rising price. Recently, the demand decreases despite the decreasing price.

5.1 Oil and renewable energy substitution

Despite the fact that oil price and renewable consumption have been focus of numerous previous analysis, research history concentrating on the relationship between two is not over a decade. About all of the studies that have looked into the renewable consumption and development included several variables and oil prices were one of them. Economic indicators, income level, carbon emissions have been main factors of empirical researches to analyze renewables' growth while the impacts of oil and other energy sources' prices have been secondarily examined.

The results and findings of previous studies also differ. While most of the results show statistical significance, in some cases, correlation between oil prices and renewable consumption is mentioned to be insignificant as with Marques et al. (2010). Even when the relation is significant, findings differ in whether there is positive or negative cross-elasticity. In most cases, results show positive cross-elasticity and strong substitutability effect as from Chang et al. (2009), Apergis & James (2013), Bloch et al. (2014), meaning that higher oil prices is correlated with increase in renewable consumption.

One of the early studies was made by Awerbuch & Sauter (2006) who analyzed oil price- GDP relation to test the correlation between renewable consumption and investment. The results showed that during the existence of higher oil prices, renewable energy may be an effective tool in avoiding the GDP loss which is a result of a macroeconomic crisis caused by high oil prices. A detailed study shows that renewable investment may effective in avoiding GDP loss. If avoided GDP loss is interpreted in benefit streams, it might push oil prices down and encourage more renewable and economic growth. However, the research can't give definite empirical results on the potential of incentive for investments in renewables.

A different approach was taken by Reddy & Yanadiga (2007) for Fiji to analyze how energy inputs change in the period of energy price shifts. Using trans-log function model and data between 1970 and 1990, they achieved limited findings on inter-fuel substitution. The only reference in the study was the development of hydro-electricity facilities, where the rising costs resulted in decline of the energy imports for some period.

Henriques & Sadorsky (2008) used vector autoregressive model to examine correlation between oil prices, alternative energy stock prices and technology stock prices, and interest rates. They found Granger causality of crude oil prices with stock prices of alternative energy companies. However, it was noted that oil prices had less significant effect on alternative energy stock prices than potential shocks to technology stock prices.

One of the first brief studies on, oil prices and correlation with renewable energy consumption, was done by Sadorsky (2009). The econometric model of this thesis follows the model by Sadorsky (2009). The study utilizing panel co-integration model and dynamic OLS estimators for G7 countries between 1980 and 2005 came to conclusion that GDP per capita and CO_2 emissions were primary determinants of renewable energy consumption demonstrating strong statistical significance. On the other hand, oil prices have low statistical significance showing negative impact on renewable consumption suggesting no effect of substitutability. The period of the panel data was covering years when oil prices were falling much of the time.

Marques et al. (2010) analyzed the drivers that promoted renewable energy using panel data for 24 European countries and found that there was no general significance between oil prices and renewable energy development as similar to findings of Sadorsky (2009). While EU member states were observed to hold statistical significance with negative effect, non-EU states showed no significance in most of the cases. Small increase in the oil price was shown to be not sufficient tool to encourage promotion of green energy policies and renewable shift. For the EU members, environmental restrictions, are stated to be major drivers of renewable consumption. In the absence of restrictions, the other fossils and nuclear power are shown to be supplementary sources to oil rather than renewables. As the study's analysis ended in 2006, it does not cover peaks and bottoms in oil prices during the later years.

Chang et al. (2009) used panel threshold regression model to examine the relation between energy price and renewable energy development under various economic growth rates for OECD countries between 1997 and 2006. The study found that countries with high income level managed to make substitution to renewable energy when energy prices were up. On the other hand, low income countries were seen to fail to use renewable energy as a responding tool for rising energy prices.

Chang & Su (2010) analyzed the substitutive effect of particular renewable sources, biofuels, on fossil fuels to test whether there was correlation between the two during the lower and higher crude oil price periods. Considering corn and soybeans as indicators of biofuels consumption, they looked at the future prices of these commodities and checked whether there was significance in price spillover effect from crude oil futures to corn and soybean futures. The results of bivariate EGARCH model showed significant substitutive effect during higher oil prices but insignificant effect during lower oil prices. Biofuels were good replacement when crude oil prices were high, as they were profitable and produced less CO_2 emissions. However, it remains under question how increased production of biofuels might influence food and agriculture prices. Thus, even if oil prices continuously increase, upward rise of biofuels might remain indefinitely limited by food prices.

Daubanes & Lasserre (2012) test the supply effect of non-renewable resources by introducing supply functions and various price models. They introduced various decision making models for resource suppliers and showed that substitution was yet the most preferable scenario in the case of price increase of any fuel. The study also claimed that Giffen paradox should not be an objective fit for energy resource supply.

Another study by Apergis & James (2013) examined drivers of renewable energy consumption for seven Central American countries over the period 1980-2010 extending literature on drivers of renewable consumption using nonlinear panel smooth transition vector error transition modeling. Using renewable energy consumption per cap as variable, they showed statistically significant and positive coefficient in estimating the oil prices. They claimed that the renewable energy is a potential source to substitute oil and coal.

Omri & Niguyen (2013) made a comparative analysis of international determinants of renewable energy consumption. Using a dynamic system-GMM panel model, they took data by international panel of 64 countries over the period between 1990 and 2011, and categorized countries in terms of income level (high-, middle-, and low income subpanels). The results showed that renewable energy consumption is mainly driven by trade openness and CO_2 emission. Findings suggest that fossil fuel prices have a smaller and negative impact on renewable energy consumption in global level, particularly for middle-income countries. They concluded that that renewable energy complements, but not substitutes crude oil in consumption. Major drivers behind lack of substitutability effect was given to be country's capacity to support renewable development ignoring oil price risk and the uncertainty in future oil prices that undermines potential future benefit of shifting to renewables.

One of the most detailed country based cross-elasticity study was done by Bloch, Rafiq & Salim (2014) who explored the relationship between Chinese aggregate production and consumption of three major energy sources: coal, oil and renewable energy. Analysis included economic growth, environmental sustainability and fuel substitution through cross-price effects. They used panel data from 1965 to 2013 and found positive elasticity for both coal (2.711) and oil prices (1.257) with renewable energy consumption. Findings revealed strong GDP growth for China as the country switches to greener energy resources. The study hints on intra-fuel substitution among coal, oil and renewable energy. As a policy implication, they showed that it was possible to have reduction of green-gas emissions and economic growth at the same time, during the rise in the fossil fuel prices.

Mediavilla et al. (2013) studied exhaustion models of fossil fuels and their replacement by renewables. The study concluded that neither electric cars nor biofuels might be enough to replace fossil fuel consumption because of limited performance of the former and low productivity of the latter. But the study projected that fossil fuels as well as nuclear energy might be replaced with renewable energy for electricity consumption. It was suggested that during peak oil price periods slowing demand would result in electricity cuts generated from fossil areas thus providing more share for renewables in electricity generation.

Wong et al. (2013) took different look at the topic through the perspective of renewable R&D. They estimated the elasticity of energy consumption and R&D in short and long term to changes in oil prices using the Nerlove partial adjustment model (NPAM). Findings from 20 OECD countries over the period of 1980 and 2010 indicated indirect effect of low fossil fuel prices on R&D and consumption of renewable energy. The study assumes that low fossil fuel prices encourage economic growth which is found to be significantly linked to renewable energy development. Renewable energy R&D as more responsive to economic growth reduces fossil fuel consumption and R&D. Additional to these findings it was given that policies promoting renewable R&D and reducing fossil fuel R&D are more effective on economic and energy growth than increasing environmental awareness.

Reboredo (2014) looked at systemic risk and dependence between oil and renewable energy markets, and examined how renewable energy firms were impacted by the oil prices. They analyzed the relation between oil prices and renewable energy stock prices and quantified the systemic impact of extreme oil price fluctuations. Findings showed that oil and renewable energy stock returns exhibited average positive time-varying dependence. Besides, oil and renewable energy markets were integrated given the evidence of symmetric tail dependence. Oil prices were shown to have influence of about 30% to downsize and upside risk of renewable energy companies. Findings also supported that high oil prices encouraged development of the renewable energy sector, advancing economic vitality of renewable energy projects, while low oil prices were shown to have the opposite effect.

Aguirre & Ibikunle (2014) using FEVD, PCSE and GLS estimation models making country-level comparative study for the EU, OECD and BRIC’s. Similar to Marques et. al. (2010) their insights assumed fossil fuel prices were not relevant to renewable energy development. The study however, accepted the fact that it would be unable to reflect transition from oil to renewable in the case of occurrence, as the process is slow and happens in long term.

The relationship between fossil fuel prices and renewable consumption might depend on other factors as being analyzed in various studies. Ruijven & Van Vuuren (2009) noted that in the absence of climate policy or greenhouse gas emission target, rise in oil and gas prices would not drive more renewable consumption but contrarily would increase consumption of carbon instead. Adopting global energy model TIMER, they analyzed the energy system impacts of hydrocarbon price scenarios, with and without climate policy. Particularly in electricity production renewable consumption improves when there is climate policy.

Gelabert et al. (2011) explored the substitutability of renewable and other fossil fuels through electricity markets. They looked at impacts of introduction of renewable energy and cogeneration on wholesale electricity prices. Adopting ex-post empirical analysis and looking at use of technologies and hourly electricity prices for 2005-2009 in Spain, they revealed that increase in electricity production using renewable energy was associated with reduction in prices. This was given as supportive of the theory that renewable energy would potentially be substitute for fossil fuels. However, the study was unable to analyze the effect in the long term as it was stated that price reduction being temporary would lead to lower investment and therefore might evolve to higher prices. Similar studies have been made by Jonnson et al. (2010), de Miera et al. (2008) where impact of renewables on electricity prices were shown to be higher.

5.2 CO_2 emission, economic growth and energy portfolio

Apergis & Payne (2010) surveyed 13 Eurasian countries to see whether there was causal relationship between renewable consumption and economic development. Their remarks concluded positive relation between the two variables in both short-run and long-run. The study also brought this correlation as a useful way to lessen dependence on fossil fuels.

Correlation between carbon emissions, economic development and energy consumption has been studied more profoundly in previous researches. Most of the time studies found relation as strongly significant for all variables. In most studies, renewable consumption was suggested to be positively correlated with economic growth whereas negatively correlated with carbon emissions.

One central theme of renewable energy and economic growth is over the potential benefits of renewable consumption and supporting systems on long term economic development. Mathiesen et al. (2011) worked on 100% renewable energy systems and analyzed potential impacts. Results showed that renewable energy as well as efficiency enhancing systems provided positive socio-economic impacts through creating employment and earnings on exports. The results concluded that economic growth might be supported with adopting climate mitigation strategies.

Tahvonen & Salo (2001) looked at economic growth, carbon emissions and transition to renewable energy from non-renewables. Their empirical results showed U-shape development of renewable and non-renewable production. Renewable sources showed decline during mid-income level period but rises when income is high level. On the other hand, they find an inverted-U shape relation between income level and carbon emissions indicating carbon emissions to rise until mid-income period but later fall afterwards.

Apergis et al. (2010) looked at the causal relationship between emissions, nuclear energy, renewable energy and energy growth for developed and developing countries. Findings revealed positive and statistically significant relationship between carbon emissions and renewable energy consumption in long term. Interestingly, further estimations showed renewable energy as ineffective in reducing carbon emissions, in short term, mainly due to lack of renewable supply systems to meet demand during peak load.

Similar assumption was provided in the analysis of Inglesi-Lotz (2015), Frondel et al. (2010). Their findings showed that renewable energy development and consumption was positively related to economic growth through job creation and market efficiency. At the same time, developments in renewable consumption or share in energy mix were mentioned to be necessarily beneficial to environmental protection.

Using Toda Yamamoto test and bootstrap-causality test, Yildirim et al. (2012) analyzed causal relationship between renewable consumption and main economic growth indicators as employment, GDP and investment for the US. Unlike previous studies, the results showed that only usage of biomass-waste-derived energy among renewable sources contributed to economic growth while other renewable sources showed no causal relationship with economic growth.

Another country based study was done for Brazil by Pao & Fu (2013) to examine causal relationship between GDP growth and renewable and non-renewable energy sources. Renewable energy unlike fossil fuels were given to significantly contribute to economic development. Study revealed bi-directional causal relationship between renewable sources and economic growth implying that renewable energy was important contributor to economic development.

Sebri & Ben-Salha (2014) explored causal dynamics between economic development, renewable energy consumption, carbon emissions and trade openness for BRICS countries. With ARDL bounds testing approach to co-integration and vector error correction model (VECM) they found long-term relationship between the given variables. Similar to Pao & Fu (2013) economic growth and renewable consumption showed bi-directional Granger causality estimating that renewables were necessary factor behind rapid growth of BRICS and vice versa. Moreover, carbon emissions also found to possess positive causal relationship with renewable energy growth because increase in CO_2 emissions forced national governments to reduce fossil fuel usage.

Another similar model was developed by Omri et al. (2014) for developed and developing countries. Similar results were observed as in Sadorsky (2009) as there exists unidirectional causality between economic growth and renewable energy consumption implying that economic growth was as effective on the renewable growth but expansion of renewables did not show keen effect on economic growth.

Jebli & Youssef (2015) used panel of 69 countries and analyzed causality between output, renewable and non-renewable consumption, and international trade. The Granger causality showed uni-directional relation from renewable consumption to trade in short term but bi-directional causality in long term. This implies that international trade is optimal tool for the transfer of renewable energy technology and thus, expansion of renewable energy consumption.

Silva et al. (2013) analyzed the interaction and compatibility between economic growth and clean environment with effect under renewable and non-renewable energy substitution. Her findings showed that if costs remain constant there exists trade-off between economic growth and clean environment. Attainability of more output with less emission is shown to be potential with endogenous technical change which might be possible with more investment on renewable energy resources.

Pfenninger & Keirstead (2015) examined Great Britain's power systems looking at energy cost, emissions and security. Their results revealed that Britain can rely solely on solar and wind energy sources for lower renewable share which increases cost for only 10%. For relying on solar and wind with making above 50% share levelized cost becomes 35% higher.

Rausch & Mowers (2014) focused on CES (Clean Energy Standards) and RES (Renewable Energy Standards) policies in the United States and found that achieving 70% renewable electricity generation by 2050 would significantly decline carbon emissions. However, it would be much more costly to the economy.

Boluk & Mert (2014) used panel data for the EU countries to test interconnection between fossil and renewable energy consumption, greenhouse gas emissions and economic growth. In the analysis, they also tested EKC

(Environmental Kuznets Curve) hypothesis.[23] Their findings showed U-shaped relation between economic growth and carbon emission as opposite to EKC hypothesis stating that carbon emissions actually rose in parallel with economic growth after certain income level. Their final conclusion suggested that economic development did not contribute to carbon emission reductions alone and other factors such as taxing and trading mechanisms as well as technological improvement should be considered for solid carbon emission reduction mechanism.

Menegaki (2011) looked at causal relationship between economic growth and renewable energy for the EU countries. Similar to Boluk & Mert (2014), Menegaki's findings did not support strong positive relationship between economic growth and renewable consumption. The results were explained with uneven and insufficient utilization of renewable energy across Europe.

Panel co-integration study by Salim et al. (2014) for OECD countries showed uni-directional causal relationship between GDP growth and renewable consumption indicating that both renewable and non-renewable energies were major drivers of economic growth. Besides, substitution into renewable energy would enhance a sustainable economy with higher energy security and less climate change issues.

Al-mulali et al. (2014) made panel DOLS test for Latin America countries and examined how renewable and non-renewable electricity consumption affected economic growth. Their findings showed that renewable energy sources were more significant than non-renewable sources in promoting economic growth. They also

[23] The environmental Kuznets curve is a hypothesized relationship between of environmental degradation and income per capita suggesting that in the early stages of economic growth degradation and pollution increase, but beyond some level of income per capita the trend reverses, so that at high-income levels economic growth leads to environmental improvement.
D. I. Stern (2003). The Environmental Kuznets Curve. International Society for Ecological Economics Internet Encyclopedia of Ecological Economics.
Online Source- http://isecoeco.org/pdf/stern.pdf

showed that expanding the implementation of energy saving projects and increasing energy efficiency were necessary tools to lower non-renewable energy consumption in the investigated countries.

Ocal & Aslan’s (2013) study from ARDL approach for Turkey found no significant relationship between economic growth and renewable consumption.

Ohler & Fetters’ (2014) showed bi-directional causal relationship between renewable consumption and GDP growth with particular emphasis stated on hydroelectricity and wind energy, across OECD.

Long et al. (2015) analyzed the relation between renewables and fossil energy development together with the impacts of carbon emissions and economic growth in China. His used data between 1952 and 2012 and revealed that oil was the most important determinant of carbon emissions and economic growth. Whereas renewable energy sources such as hydropower cause reduction of carbon emissions improving sustainable economic growth as well.

Apergis & Payne’s (2011) study for 16 emerging markets revealed uni-directional relationship between economic growth and renewable energy consumption in short term but they found bi-directional relationship in long term. Their findings indicated that renewable energy consumption did not have immediate positive effect on economic growth in short term whereas it revealed to have positive effects in long term.

5.3 Other determinants of renewable energy consumption

Several early studies have made contributions to the field of renewable energy consumption. In firm level, a recent study has been done by Kuei. et. al. (2015) who identified critical factors influencing the adoption of green supply chain practices in

Chinese firms. With Partial Least Squares (PLS) model, the study identified that environmental uncertainty and government support were important factors among others in adopting green practices.

Borcher's (2014) US based study on determinants of wind and solar energy generation found income per capita and abundance of resources by state level as major factors that increase propensity for solar and wind energy generation.

Stadelmann & Castro (2014) made analysis on international determinants of renewable energies for developing and emerging economies. Their findings, using 1998 and 2009 dataset, showed that countries with high income level and population were more inclined for renewable energy development and adoption. Having post-colonial relationship and EU membership were found to be major international determinants.

Di Vita (2006) examined rate of technical substitutability between exhaustible and renewable energy resources, and how it is related with economic growth. His findings suggested that under current circumstance technical substitution to renewable energy might lead to weaker performance of economy and waste of resources. Economic growth on the other hand, accompanied with technological advances might facilitate technical substitutability.

Polzin et al. (2015) examined public policies that effectively drive renewable energy consumption in OECD countries. Main policy measures affecting renewable energy were shown to be economic and fiscal incentives such as feed-in tariffs and market-based mechanisms such as carbon emission trading systems which were seen to directly impact renewable energy investments and risks.

Atalay et al. (2016) did focus on the adoption of renewable energy and causing factors for Gulf Cooperation Council (GCC) states which have been dominated by the fossil fuels for years. His findings showed that adoption of renewable energy technologies in the Gulf would be explained with internal factors such as political leadership or internal support mechanisms instead of external factors such as international pressure on reduction of carbon emissions or alignment with international conventions. As conclusion, decision makers of Gulf States were given as critical players in terms of adopting international environmental negotiations.

Ackah & Kizys (2015) have done panel study for oil producing African states to examine the renewable growth, existing demand and influencing factors. Their findings suggested that rising income level and carbon emissions had positive effect on renewable energy growth encouraging these states to remove technological barriers and reach to residential areas and consumers for more renewable energy access.

5.4 Oil price drivers and major effects

Previous literature on oil prices and volatility has been wide and covers long history. Anne-Marrie et al. (2004) took broad look at the factors behind the oil prices and its evolution over next quarter century. As the final remarks the study projected global dependence on oil to continue and stated that there will still be increasing concentration on OPEC supplies.

Crucial analysis was made over demand elasticity, during high and low oil prices. When oil prices are very high, demand elasticity is given to be high, as rising prices cause the improvement of more energy-efficient technology and with time capital is replaced with energy-efficient technology. However, it is not reversed when prices fall meaning that such advancements do not go into decline when oil price fall. Oil shocks of 1974 and 1985 are particularly referred to lead to fall in oil consumption in advanced OECD countries. Transportation, where oil is dominantly used, is the only sector that was not majorly affected. Oil consumption is given to have been growing in this sector for decades compared to other end use sectors.

Theoretically, oil price shocks have supply-side and demand-side effects on national economies. On supply-side it directly impacts energy output and consumption while indirectly affects capital and labor reallocation. On demand-side, oil price shocks may directly concern income transfer and thus purchasing power, whereas it has significant influence of heightened uncertainty.

Oil prices and their effect on national economies has been central theme of many studies as well. Analysis by Jimenez- Rodriguez & Sanchez (2011), as well as Sotoudeh & Worthington (2015) found oil prices to have significant impact on domestic economies. Particularly, during 1970s oil shocks and 1980's oil crisis impact on economic activity was detected to significantly high.

Jimenez- Rodriguez (2011) found that oil shocks' effects were observed differently in some states as France, Germany, and Spain etc. but similarly in the UK and the US.

Gounder & Bartleet (2007) looked at oil price shocks and economic growth for New Zealand, concluding that oil price increase had significant effect on economy while oil price decrease did not show significance.

Of the seven OECD countries analyzed by Mork, Olsen & Mysen (1994) only Norway showed negative correlation between oil shocks and economic growth.

Although previous studies remarked oil as most volatile energy fuel in terms of price fluctuations, Regnier (2007) examined that crude oil and natural gas prices were more volatile than most goods produced in the US.

Mork (1989) found one way relationship between oil price shifts and economic development. Findings showed that effects of oil price increases were different than oil price decreases which were not statistically significant. On the contrary, Kilian & Vifgusson (2009) found that non-linear effects of oil price changes provided inconsistent results and showed impacts of such shocks were overestimated.

CHAPTER 6

DATA AND METHODOLOGY

Key terms of this study are renewable consumption, oil prices, GDP growth and carbon emissions. Renewable consumption is put as dependent variable to be tracked with potential causal effects of independent variables which are oil prices, GDP growth and carbon emissions. We refer to Sadorsky (2009) in our model and data selection.

We looked at G7 (USA, Japan, Canada, Germany, France, UK, Italy) countries which are economically most advanced countries and BRICT (Brazil, Russia, India, China and Turkey) as the emerging economies and tried to examine how renewable energy consumption and development evolved in these countries. There are multiple reason for us to choose G7 and BRICT. One of them is that they possess biggest and industrially most advanced economies in the world. These are the countries that emit highest amount of CO_2 into the atmosphere making about 70% of global carbon emissions in 2013. In particular, G7 countries are the most successful in terms of implementing renewable energy growth, while BRICT countries were observed to make high economic growth during last decades. At the same time, BRICT countries are main reason of increasing carbon emissions, as fast industrialization policies are applied to central economic activity in these countries.

Table 2. Descriptive Statistics by Group Panels.

G7	Mean	Std. Dev.	Min.	Max.
renewable	-1.20408	1.127452	-3.788114	1.029844
oil	3.557504	0.7107164	2.543176	4.715548
GDP	10.34852	0.2911727	9.819508	10.87767
carbon	2.364389	0.3720847	1.735113	3.026032
BRICT				
renewable	-2.167363	1.11861	-4.137636	-0.5568398
oil	3.557504	0.7115691	2.543176	4.715548
GDP	7.795741	1.094049	5.733341	9.581007
carbon	1.155281	0.8469797	-0.2760286	2.801401

We took annual data between 1990 and 2013 for all of the variables and countries separately (Appendix A). The reason for including these years was the availability of data. As independent variable, we used annual oil prices for given years taken from BP Statistical Review 2014. Oil prices were based on Light Brent crude oil, as it was most widely traded oil commodity and is considered as the benchmark for international oil prices.[24] The descriptive statistics of the data is seen in Table 2.

Income level in country level is included as gross domestic product per capita with data being taken from World Bank, World Development Indicators. Numbers were given in US dollars with current exchange rate vis-à-vis local currencies.

[24] Brent Crude is light Crude oil being extracted in North Sea. It possesses low density and sweet. Over 60% of internationally traded oil supplies are priced in accordance with Brent Crude.

Table 3. GDP per Capita (US$) Growth Rates to 2013 (World Bank, 2015)

G7	US	Japan	Canada	UK	Germany	France	Italy
23 years growth	121%	54%	146%	119%	108%	95%	71%
10 years growth	34%	15%	87%	28%	53%	44%	29%
5 years growth	9%	2%	13%	-8%	1%	-6%	-13%

BRICT	China	India	Brazil	Russia	Turkey
23 years growth	2113%	295%	287%	316%	294%
10 years growth	446%	163%	288%	387%	139%
5 years growth	103%	43%	35%	25%	6%

When looking at Table 3 for economic growth within the covered period, obviously BRICT countries had clear pace over G7 states. As already stated, industrial growth in these countries and more mature economic foundation of G7 explains this gap in growth pace between two groups. What is common for all the countries is that growth rates have been slow critically in last 10 years and declines more in last 5 years. 2008 financial crisis is the most common cause for the sluggish growth along with national economic issues such as the problem of deflation in Japanese economy.

Among all countries, during the covered period, China experienced fastest growing economy with GDP per cap in 2013 making 21 times higher than in 1990. China’s growth has been spectacular particularly during the last decade of twenty first century. On the other hand, Japan has the slowest growing economy. European Union states have been peculiarly static as they were more deeply impacted from financial crisis and debt crisis. Only Germany had positive growth during the last 5 years whereas Italy, which was one of the central pieces of European Debt Crisis, had deepest recession.

Carbon emissions are given by tons of carbon dioxide per capita. Total carbon emissions data was taken from BP Statistical Review 2014 and divided by population number of respective countries as taken by World Bank.

Table 4. Carbon Emissions Growth Rates in % to 2013 (BP, 2014)

G7	US	Japan	Canada	UK	Germany	France	Italy
23 years growth	-16%	13%	-3%	-27%	-20%	-17%	-15%
10 years growth	-17%	4%	-14%	-19%	-3%	-17%	-23%
5 years growth	-12%	9%	-7%	-13%	-1%	-10%	-16%

BRICT	China	India	Brazil	Russia	Turkey
23 years growth	250%	118%	75%	-23%	60%
10 years growth	117%	57%	36%	7%	27%
5 years growth	29%	24%	19%	1%	9%

As seen in Table 4, G7 and BRICT states differ as well in terms of carbon emissions evolution. On general, despite the fact that not all the states have ratified or have binding targets under Kyoto Protocol, still we see improvements in terms of carbon emissions, especially, for G7 countries. Among 12 states only EU states (Germany, France, Italy, and UK) have binding targets for both first and second commitment periods. Reasonably these states have been most successful in terms of implementing carbon emissions reductions. Looking at 23 years of carbon emissions evolution, the UK is seen to have lowest emission growth.

Russia and Japan had binding target during first period (2008-2012) but not for second extension period (2012-2020).[25] Japan as being far behind of -6% reduction target has failed in expanding renewable energy with comparison to other

[25] Russia and Japan did not join for second round questioning the fairness and effectiveness of Protocol.
Online Sources: http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php
http://www.mofa.go.jp/policy/environment/warm/cop/kp_pos_1012.html

G7 countries but mostly relied on nuclear energy and carbon emission trading.[26] In last 5 years, carbon emissions in Japan is seen to rebound. Fukushima nuclear crisis in 2011 overshadowed public confidence and arose safety questions on nuclear strategy. After Fukushima, Japan's fossil fuel imports soared leading to emissions to steadily increase.

Other BRICT states (China, Turkey, India and Brazil) are parties ratifying the protocol but without any binding targets. All performed very poorly in terms of carbon emissions experiencing double digit growth in carbon emissions in 23 years with intense industrialization and urbanization. Emission growth was lowest in Turkey, which despite noticeable growth of renewable plants in last 5 years, is still lacking national strategic planning.

North America as the second highest carbon emitting region is staying out of Kyoto Protocol right now critically weakening its jurisdiction. The region also covers highest carbon emitter countries by per capita. Canada had binding target for the first period but withdrew from the Protocol whereas US has been out of the Protocol as the only state among samples that signed the Protocol but has not ratified it yet.[27]

The fact that both the US and Canada are naturally fossil rich countries and are oil producers coupled with long developed industrial foundation and high income level explains high number of carbon emissions per capita in the region. Especially during Obama presidency, US has been proactive in targeting near Kyoto Protocol goals with some support from local and regional governments and foundation of

[26] Despite Fukushima disaster Japan is still planning to add 14 nuclear plants to present 55 by 2030 targeting 35% increase in nuclear energy capacity and plans to trade 100 million toe emissions from developing countries such as Ukraine.
Online Source- http://ourworld.unu.edu/en/japan-should-jump-over-its-kyoto-climate-target

[27] Canada withdrew from Kyoto Protocol joining other non-binding agreements as Copenhagen Accord stating lack of efficiency and non-being of the US and China as the decision criteria. Lack of consensus between national and provincial governments on energy policy was another critical reason.
http://www.theguardian.com/environment/2011/dec/13/canada-pulls-out-kyoto-protocol

Regional Greenhouse Gas Initiative (RGGI).[28] As the result carbon emission per capita have been more successfully reduced during last 5-10 years vis-à-vis 1990s and early 2000s. Carbon emissions in both countries is yet below 1990s level and is decreasing from year to year.

In the dependent variable, we put annual renewable energy consumption per capita in respectable countries. For the renewable energy as in tons of oil equivalent, we use per capita consumption as in other variables and looked at annual consumption numbers. The data was taken from BP Statistical Review 2014. For renewable energy consumption we included solar energy, wind energy, hydroelectricity, geo biomass and other renewables.

Table 5. Renewable Energy Growth Rates in % to 2013 (BP, 2014)

G7	US	Japan	Canada	UK	Germany	France	Italy
23 years growth	47%	44%	12%	1354%	1270%	86%	307%
10 years growth	63%	19%	9%	417%	295%	67%	167%
5 years growth	47%	21%	2%	150%	73%	46%	109%

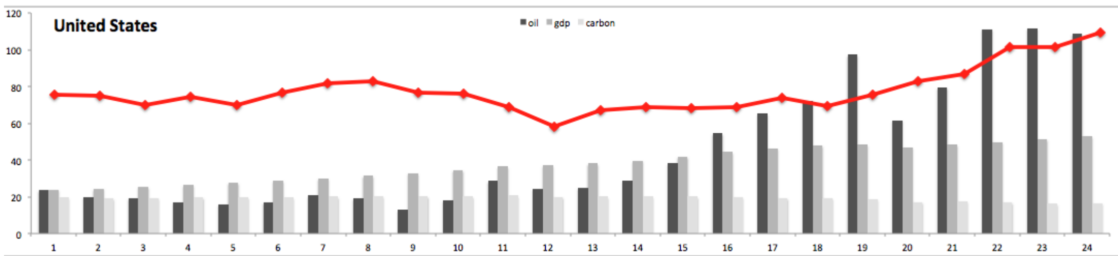
BRICT	China	India	Brazil	Russia	Turkey
23 years growth	751%	140%	71%	13%	143%
10 years growth	321%	155%	34%	16%	93%
5 years growth	104%	40%	14%	8%	107%

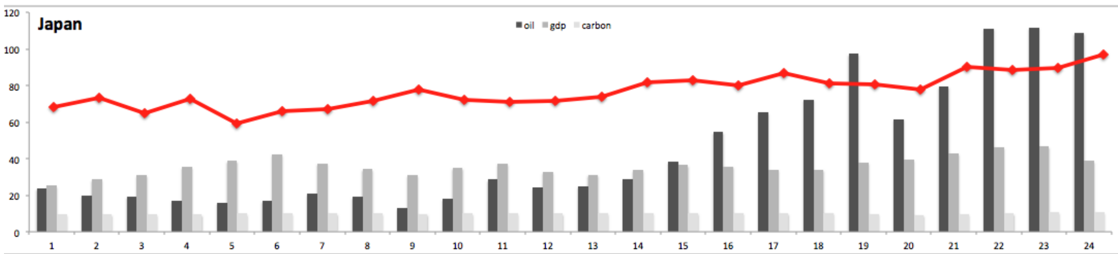
As in carbon emissions, the EU states are the most environmentally friendly states with highest renewable energy consumption per capita (Table 5). When looking at growth evolution in last 23 years the UK and Germany are observed as

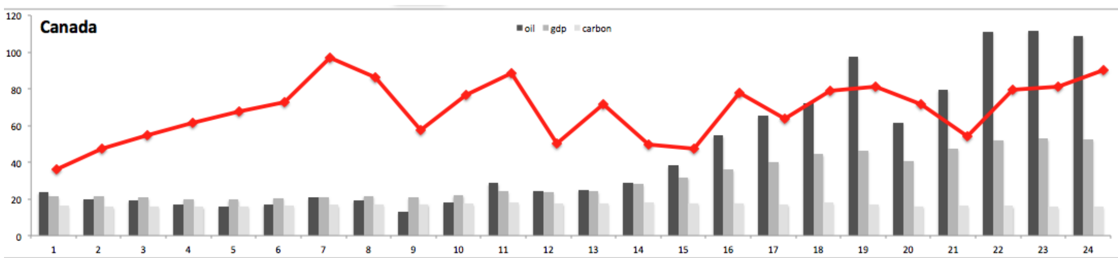
[28] RGGI as intergovernmental organization was founded in 2003 among nine Northeastern US and Eastern Canada to reduce carbon dioxide (CO_2) emissions from the electric power sector through coordinated state cap and inter-state emission trading.
EITA. (2013). Regional Greenhouse Gas Initiative. The World's Carbon Markets: A Case Study Guide to Emissions Trading. International Emissions Trading Associations. Retrieved from http://www.ieta.org/assets/Reports/EmissionsTradingAroundTheWorld/edf_ieta_rggi_case_study_may_2013.pdf

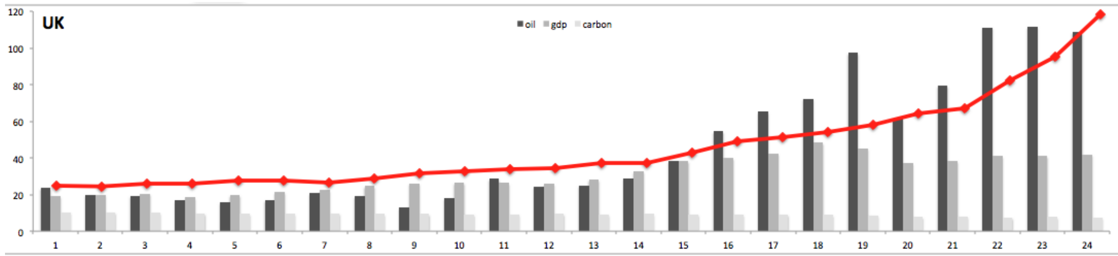
highest growing countries. Growth in Italy has been mediocre while France poses lowest growth pace, due to more concentrated nuclear energy development and capacity.

Among all, Canada is the slowest growing country followed by Russia which has shown little interest in developing renewable energy sources as one of the leading oil producers. Renewable energy consumption majorly grows to the account of hydroelectricity terminals most of which date to Soviet period establishments. On the other hand, as in France, nuclear energy is the leading energy source in meeting recently growing energy capacity and helps carbon emissions in relatively low. China as the leading renewable consumer has been the highest renewable energy investor and the most dynamic growing country as well.





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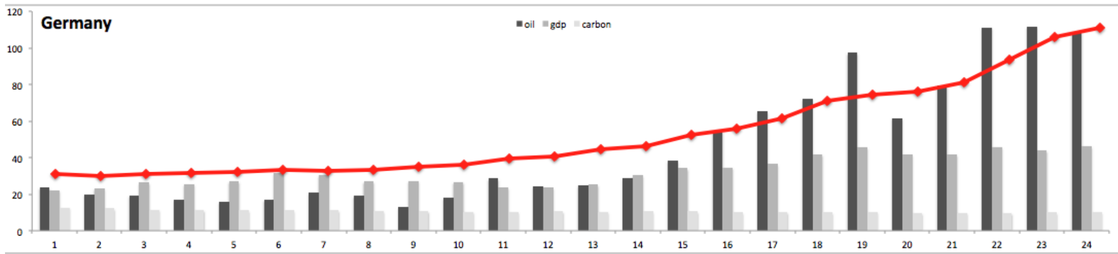
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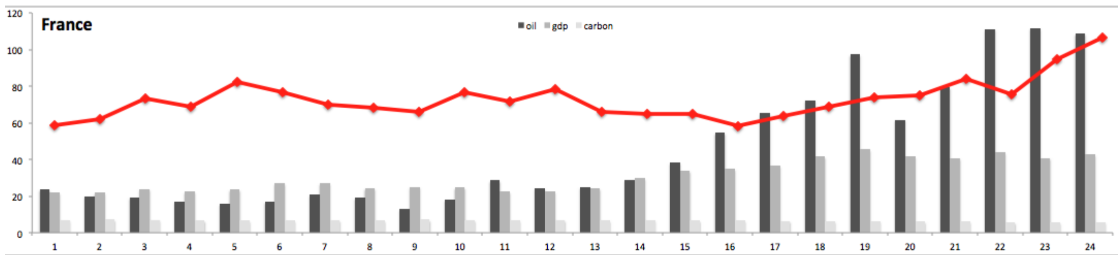
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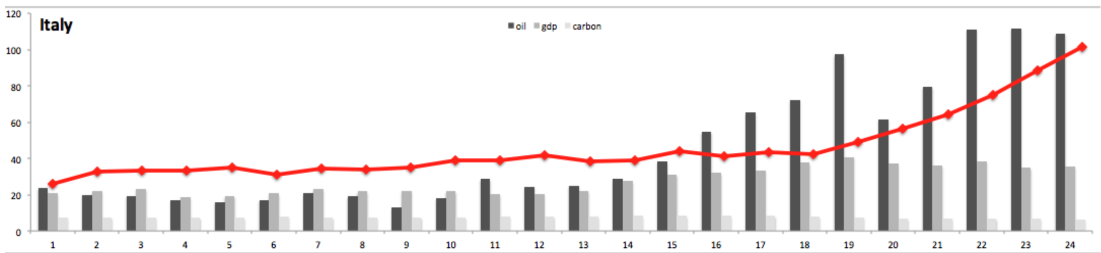
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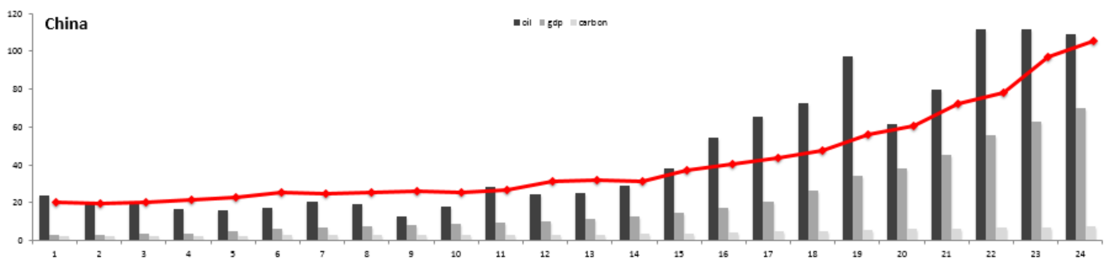
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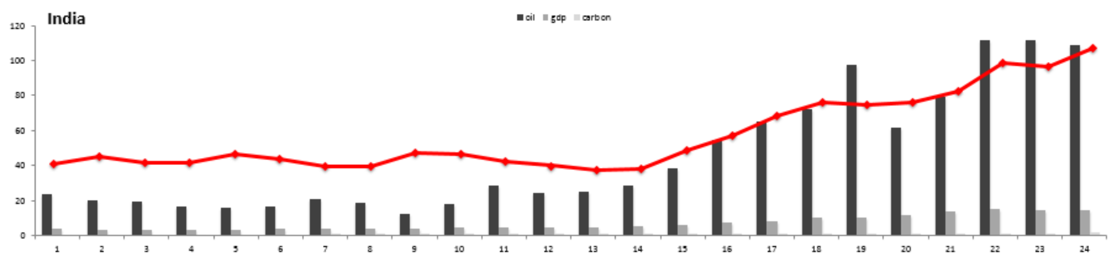
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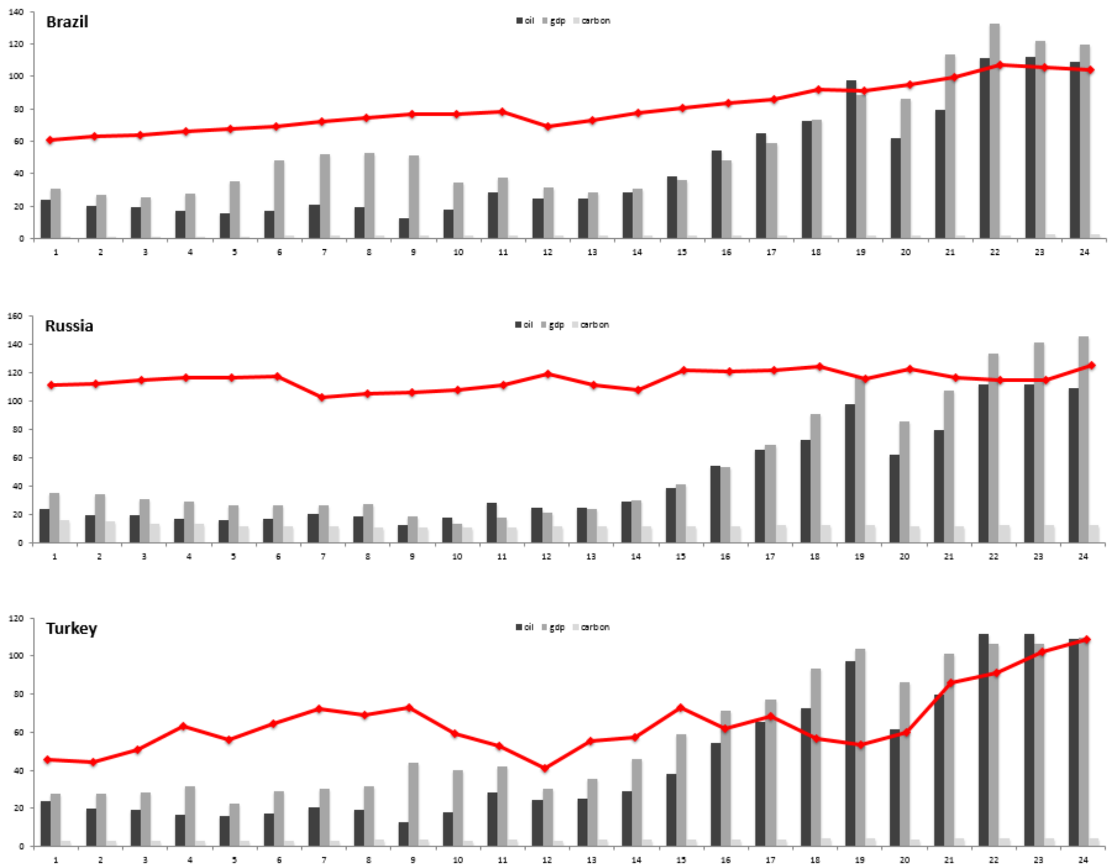

Figure 18. Oil Price, GDP per cap, Carbon Emissions per Cap, Renewable Energy Consumption per Cap Evolution by Country, 1990-2013 (BP, 2014)

From the evolution charts in Figure 18, we see renewable consumption per capita increased continuously in all the EU countries. Only in France, we see some decrease during the early 2000s but rebounds after 2005. Among the G7 countries, Canada has the highest floating trend in renewable consumption. Highest renewable consumption was seen during 1996 and floated later during late 1990s, early 2000s and 2010s.

CHAPTER 7

EMPRICAL ANALYSIS AND RESULTS

In parallel with Sadorsky (2009), we used panel data to examine stationarity of annual variables and to track the changes separately in annual and country basis. We carried out the empirical study with three objectives. First was to examine the long run link between the variables. Second objective was the examination of dynamic relationship between the variables. Third was to take comparative look between the samples, in country level or group level (G7 vs BRICT). During the analysis, we made comparison with Sadorsky (2009) whose analysis covered years between 1980 and 2005 thus missing the years of 2009 crisis that led to decreases in income of G7 and led to fall in oil prices for some term.

In our model, natural logarithms of data were used for all independent and dependent variables (Appendix B). Before formal modeling, we made tests of unit root and co-integration to analyze time series structure of the data and to check whether our data series contained significant number of unobserved heterogeneity. Three types of panel unit root tests were figured (Levin et al., 2002; Breitung, 2000 and Pesaran, 2003).

Table 6. Panel Unit Root Tests.[29]

Unit Root Tests			
G7	Renewable	GDP	Carbon
Levin Li Chu	2.5083	1.8201	0.762
	0.9983	0.0344	0.777
Breitung	1.1509	0.0846	1.4461
	0.8751	0.5337	0.9259
Pesaran	-1.3979	-0.6576	-0.0804
	0.0811	0.2554	0.4679
BRICT	Renewable	GDP	Carbon
Levin Li Chu	-0.4905	-1.5146	-1.8377
	0.3119	0.0649	0.0331
Breitung	0.5006	0.5363	0.9027
	0.6917	0.7041	0.8167
Pesaran	-0.7051	-1.0488	-0.795
	0.2404	0.1471	0.2133

Common results for renewable consumption, GDP and carbon emissions in three tests assume that there is common unit root in all three variables (Table 6). For the tests, null hypothesis indicates the existence of unit roots whereas alternative hypothesis means there is no unit roots. Only Levin et al. (2002) proved the null hypothesis with others proving otherwise. Breitung test (Breitung, 2000) showed that existence of unit roots was common for all variables. On the other hand, Pesaran test (Pesaran, 2003) showed individual unit root within each variable. From the results we can state that yearly series for all variables of renewable, GDP and carbon emission is not stationary as similar with the results of Sadorsky (2009).

[29] Variables Renewable, GDP and carbon are given in natural logarithms. P values are mentioned below test statistics. The null hypothesis for the first two tests is common unit root. The null hypothesis for third is individual unit root.

Table 7. Unit Root Tests for Oil Prices.[30]

Unit Root Tests for Oil		
	ADF	PP
ROP	-2.783	-2.793

For oil prices series, we used Augmented Dickey Fuller (1979) and Phillips and Perron (1988) unit root tests (Table 7). Both tests indicates unit roots in real oil prices, making it necessary to check panel co-integration test. Our results contradicts with the study done by Sadorsky (2009) whose findings showed that oil prices were stationary. The global financial crisis of 2009 and following years when oil prices had ups and downs through years can be considered as the cause of non-stationarity. Indeed, at this point of the analysis, non- stationarity of data can be dealt with by adding a dummy variable to the equation to represent the effects of structural breaks. However, in order to be on the same page with Sadorsky (2009) we will not follow this way.

In our model we use an objective in the form:

$$[renewable] = \beta_0 + \beta_1 [oil] + \beta_2 [GDP] + \beta_3 [carbon]$$

Here *renewable* represents the natural logarithm of the renewables per capita, *oil* represents natural logarithm of the Brent oil prices, *GDP* natural logarithm of the GDP per capita and *carbon* represents natural logarithm of the carbon dioxide emissions per capita. β_i ‘s represent the coefficients, we test to estimate.

[30] The variable Oil Prices is given in natural logarithms.
***, p<0.01, **, p<0.05.

Table 8. Panel Co-integration Tests.[31]

Panel Co-integration			
G7	Statistic	BRICT	Statistic
Panel V statistics	-1.777*	Panel V statistics	0.4297*
Panel rho statistic	1.916**	Panel rho statistic	0.4645*
panel t statistic	1.544*	panel t statistic	-0.06923*
panel adf statistic	2.894***	panel adf statistic	0.6845*
group rho	1.746**	group rho	1.522*
group PP	0.8706*	group t	0.5386*
group ADF	1.384*	group ADF	1.14*

Panel co-integration test using Pedroni (2004), let us check cross section co-integration and see whether common factors influenced variables (Table 8). Pedroni (2004) tests provides seven statistics for tests of the null hypothesis containing no co-integration in heterogeneous panels. The tests are classified into two categories: within dimension (panel tests) or between dimension (group tests). Although test results reveal no co-integration except ADF tests, the co-integration pointed by ADF statics make us run dynamic ordinary least square estimation.

[31] In the table Pedroni (2004) residual co-integration is reported. The null hypothesis is no co-integration.

Table 9. Renewable Energy Consumption Long-run Elasticities.[32]

Dynamic OLS			
	Oil	GDP	Carbon
Total G7	9.32***	-5.64***	2.11***
US	-4.53***	3.97***	-10.34***
Japan	15.16***	-13.67***	-3.75***
Canada	1.07*	-0.85*	1.19*
UK	4.38***	5.65***	-12.22***
Germany	7.00***	3.63***	-13.66***
France	3.90***	-6.86***	-3.96***
Italy	4.87***	-1.97***	-4.82***
Total BRICT	-8.39***	14.02***	0.27*
China	-5.72***	8.63***	3.51***
India	3.34***	0.03*	1.60*
Brazil	10.36***	21.24***	6.54***
Russia	-2.64***	3.31***	11.40***
Turkey	-1.32*	0.59*	1.77*

We looked at Dynamic ordinary least square estimator with parameters being stated in long run elasticities. Country specific values were interpreted separately to clarify influencing factors whereas common group values for G7 and BRICT were compared to identify general affecting components.

From the Dynamic OLS estimator seen in Table 9, we see that for all country statistics for oil, carbon emissions and GDP are all statistically significant in determining renewable consumption except Canada and Turkey. For India, statistics for oil prices was significant whereas carbon emissions and GDP do not have significant impact on renewable consumption.

For most of the countries, we see positive correlation between oil prices and renewable consumption meaning that for most of the samples increase in oil prices has led to increase in renewable consumption.

[32] T Statistic is seen for variables Oil, GDP and Carbon for BRICT and G7. Minus values mean negative correlation with the rest indicating positive correlation.
***, $p<0.01$, **, $p<0.05$, *, $p<0.10$

Our findings fit with general assumption that the more expensive is oil energy, the more it is probable for countries to substitute for renewable energy. Values for oil prices range from highest 15.16 (Japan) to lowest 1.07 (Canada).

In only US, China and Russia we get negative correlation. In the United States where there is negative correlation, both renewable energy consumption and oil prices are up vs 1990 but we see stable or decreasing trend in renewable consumption when oil prices rise. Only after the 2009 crisis, we see strong positive correlation. In China, throughout 1990s we see negative correlation between renewables and oil price. Even during the periods of oil price falls renewable energy consumption goes up owing to much extent to previously made investments and already established capacity.

In general, overall relationship between oil price and renewable consumption is given as positive for G7 countries, whereas for BRICT countries the results are negative. We link these estimations to uneven growth pace of renewable energy from country to country. Indeed, the uneven growth pace of renewables can be represented by adding another dummy variable in the equation.

Looking at income level through GDP per capita most of the countries contain positive correlation. We found strongest correlation for Brazil as supportive of previous findings of Pao & Fu (2013), Ben-Salha (2014) etc. 1% increase in GDP per capita in Brazil increases renewable consumption per capita by 21.24%.

Only for Japan, France and Italy there exists negative relationship with renewable consumption. Findings for Japan is similar as in Sadorsky (2009). In the cases of France and Italy findings differ because renewable energy consumption goes on climbing even after the 2008 financial crisis when we see GDP decline through the period.[33] This mainly stems from the fact that previously done investments in renewable energy supports expansion even if there is economic recession.

Economic recession and slow growth in G7 countries commonly is accompanied with stably rising renewable consumption thus showing negative correlation. In BRICT countries, on the other hand, the relationship is statistically significant and positive indicating rising national level support for renewable energy encouraged by increasing income.

CO_2 emissions show different results for G7 and BRICT countries. For G7 we see that increase or decrease in carbon emissions per capita is negatively related to renewable consumption. Correlation metrics is highest for the United States (-10.34), the UK (-12.22) and Germany (-13.66). Principal understanding from the metrics is that through the analysis period developed countries focused on expanding renewable energy consumption in parallel with reducing carbon emissions. As carbon emission reduction policies and targets carry the common objective through the renewable expansion it is clearly observable to receive high value of negative correlation between these variables.

Distinct to G7 countries our findings for BRICT countries clearly show no significance because of India and Turkey. For Brazil, Russia and China we observe statistical significance and positive relationship between carbon emissions and renewable consumption. Elasticity is particularly high for Russia (11.40) and Brazil (6.54). Major criteria in these countries is the vast industrialization and urbanization. As emerging markets enjoy fast improving economies, demand for both renewables and fossil fuels is accompanied by rising carbon emissions in these markets. As the result we see upside trend in both carbon emissions and renewable consumption.

[33] Years after 2005 were not covered by Sadorsky (2009). On the other hand, our data starts with 1990 missing the years before.

CHAPTER 8

CONCLUSION

From our analysis, we conclude that oil consumption will continue to be the major energy source for decades despite the floating and unexpected prices, increasing carbon emissions and expansion of renewable energy systems. However, renewable energy sources have been gaining momentum winning over fossil fuels. We see oil prices as a significant factor behind substitution to renewable energy. However, even during the period of oil price falls, we observe renewable consumption increases in many countries stemming from the fact that with already done investment and expanded renewable capacity, countries still continue on increasing renewable consumption instead of moving to cheaper oil. Increasing carbon emissions is good indicator in that respect.

Our panel data results for BRICT countries obviously showed that as economic expansion, industrialization and urbanization increases, these countries consume more energy. As the traditional energy sources, fossil fuels were more preferable and were more subsidized by the national governments due to the high start-up costs of the renewables, easier access with better established and expanded traditional markets of fossil fuels.[34] As the result, we see higher and faster increase in carbon emissions through years in these countries. However, with the expansion of climate change in social and political agenda, BRICT countries have increased focus on renewable energy investments and have become frontrunners among the emerging economies in the development of new renewable energy capacities. Our analysis

[34] About $200bn is spent annually by OECD member countries for subsidizing oil, coal and gas. For 2020 the target is set for $100bn according to OECD report.
Online Source- http://www.theguardian.com/environment/2015/sep/21/oecd-nations-200bn-subsidisies-fossil-fuels-climate-change

support that this is a right strategy to follow. The oil dependence and the significant effects of CO_2 emissions could cause long-term problems in these countries where the aggressive economic growth policies are applied.

For G7 countries we observe slower developing economies compared to BRICT countries because of more matured economy and markets. Also they have more mature renewable energy systems, thus consuming more renewable energy per capita compared to BRICT countries. Despite the fact that G7 countries are still way ahead of BRICT in terms of emission per capita, as the result of social pressure of Climate change and Global Warming, carbon emissions are seen to decrease in G7. Carbon emissions decline more rapidly over the last 5-10 years owing to much extent international agreements and conventions such as Kyoto Protocol.

Expert analysis on the recent headlines assumed that historic correlation between oil prices and renewable energy consumption is not as strong as before. Particularly reference is given to 1980s and 1990s when renewable energy markets were hardly impacted by cheap oil prices. Our findings however, show that oil prices still are effective on renewable energy consumption. Two variables are correlated in many aspects. Firstly increasing oil price make other energy sources as better choice in terms of cost efficiency. Secondly, oil price increase is the result of rising demand. Yet, consumption of oil is leading to higher carbon emission. On that part, increasing carbon emissions puts more pressure on the issues of climate change which is the primary motivator for renewable energy development. From both analysis, we see oil price increase is significant motivation for energy substitution.

In his speech in 2015, former US Secretary Steven Chu assumed that decline in fossil-fuel prices does have some effect on renewable consumption, but the renewable portfolio standards for minimum usage makes the effect in limited range.

Christina Figueres, the Executive Secretary of the UN Framework Convention on Climate Change (UNFCC) as well had similar statement referring to the latest drop in oil prices and any interference with renewable energy. In her report, she stated that drop in oil prices did not have a major effect on renewables as the rate of increase in installed solar and wind power has been exponential considering the fact that zero cost value of renewable energy source.

As our study covers the years of mostly increasing oil prices and look at long-term elasticity, we can't analyze how renewable energy would react if oil prices fall for over 2 years period. As previously indicating main motivation behind this study, as recent sharp fall in oil prices we were interested how renewable consumption was influenced by sudden fall of oil prices after 2008 global financial crisis. Examination clearly showed that in neither of the countries except Canada renewable energy consumption fell during the period. However, as reactions in market demand takes long term developments, it is hard to take reliable conclusion from that short term period.

Besides economic growth, carbon emission stand as a necessary factor that drives the incentive for renewable energies. Not much have come of all efforts, since the Kyoto Protocol of 1997 which is considered as the most resolute attempt by the United Nations. Recent national efforts to develop sustainable energies across countries have been insignificant in addressing the challenges of climate change, indicating the necessity of greater international cooperation in order to push more sustainable development (Reboredo, 2015). There is yet consensus that total energy consumption will continue to grow for the next 20 years. Economic and industrial development along with population growth as the primary factors behind energy consumption will still boost energy demand until 2030.

Many countries have ambitious targets. For example, by 2025 US aims to cut greenhouse-gas emissions by 26-28% vs 2005. Motives are varying across countries. Particularly in Western Europe, China and the US wind turbines and solar panels are become inseparable feature of daily life. Inside the car or residential areas, any function consuming energy gives how much is the cost of emission. Many companies like Coca-Cola, Dell, Procter&Gamble, Sony etc. have made initiatives to set emission reduction targets to contribute to effort for avoiding global warming.[35]

Despite some future uncertainties, our study shows that developing renewable energy systems offer a win-win scenario for countries in terms of clean environment and economic growth. Taking volatile oil prices into account, we see that expanding renewable energy utilization creates an opportunity for ensuring safer and more sustainable economic future.

As a future work, we offer that a model which analyzes the relation between the investments on renewables and oil prices would yield an interesting results. Our analysis, which tests a model on the relation between the renewable consumption and oil prices, give hints about that already made investments on renewables has a certain impact on defining the relation between the oil price and renewable consumption.

In our analysis, we have reached a point where the oil prices are non-stationary and the panel data outcomes are different from country level outcomes. In other words, we observe structural breaks on data. We claim that the structural break is the result of 2008 crisis. However, we didn't test this claim. As a future study, an econometric analysis can be run to explain the non-stationarity by adding a new dummy variable into the equation. The strength of renewables as an alternative to oil

[35] "The Science Based Targets" Initiative includes 114 companies who annually make carbon emission equivalent to the total emissions of South Africa.
Online Source- http://sciencebasedtargets.org/2015/12/08/114-companies-commit-to-set-ambitious-science-based-emissions-reduction-targets-surpassing-goal/

varies in countries considering different energy mixes in country level and capacity of other energy sources. On this regard, another dummy variable may be incorporated into the model. In order to overcome these obstacles, a future work can use some extra econometric analysis changing the objective equation, properly. Moreover, we observed the long term relation between the renewable energy consumption and oil prices. However, a short term analysis over the relation between the renewable energy and the oil prices would be interesting and fruitful.

APPENDIX A

COUNTRIES' INDEPENDENT AND DEPENDENT VARIABLE SCORES

country	year	renewable	oil	Gdp	carbon
US	1990	0.38	23.73	23.954	19.6
US	1991	0.38	20	24.405	19.3
US	1992	0.35	19.32	25.493	19.4
US	1993	0.38	16.97	26.465	19.8
US	1994	0.35	15.82	27.777	19.8
US	1995	0.39	17.02	28.782	19.6
US	1996	0.42	20.67	30.068	20.1
US	1997	0.42	19.09	31.573	20.3
US	1998	0.39	12.72	32.949	20.3
US	1999	0.39	17.97	34.621	20.2
US	2000	0.35	28.5	36.45	20.6
US	2001	0.29	24.44	37.274	20
US	2002	0.34	25.02	38.166	20.1
US	2003	0.35	28.83	39.677	20.1
US	2004	0.34	38.27	41.922	20.1
US	2005	0.35	54.52	44.308	19.9
US	2006	0.37	65.14	46.437	19.4
US	2007	0.35	72.39	48.062	19.5
US	2008	0.39	97.26	48.401	18.7
US	2009	0.42	61.67	47.002	17.2
US	2010	0.44	79.5	48.374	17.6
US	2011	0.52	111.26	49.781	17.1
US	2012	0.52	111.67	51.457	16.3
US	2013	0.56	108.66	52.98	16.6
country	year	renewable	oil	gdp	carbon
Japan	1990	0.2	23.73	25.124	9.5
Japan	1991	0.22	20	28.541	9.6
Japan	1992	0.19	19.32	31.014	9.6
Japan	1993	0.22	16.97	35.451	9.5
Japan	1994	0.18	15.82	38.815	9.9
Japan	1995	0.2	17.02	42.522	10
Japan	1996	0.2	20.67	37.423	10.1
Japan	1997	0.22	19.09	34.304	10
Japan	1998	0.23	12.72	30.97	9.8

Japan	1999	0.22	17.97	35.004	10.1
Japan	2000	0.21	28.5	37.3	10.2
Japan	2001	0.22	24.44	32.716	10
Japan	2002	0.22	25.02	31.236	10.3
Japan	2003	0.25	28.83	33.691	10.3
Japan	2004	0.25	38.27	36.442	10.3
Japan	2005	0.24	54.52	35.781	10.4
Japan	2006	0.26	65.14	34.076	10.2
Japan	2007	0.25	72.39	34.034	10.4
Japan	2008	0.24	97.26	37.866	9.8
Japan	2009	0.24	61.67	39.323	9.3
Japan	2010	0.27	79.5	42.909	9.7
Japan	2011	0.27	111.26	46.204	10.1
Japan	2012	0.27	111.67	46.679	10.8
Japan	2013	0.29	108.66	38.634	10.7
country	year	renewable	oil	gdp	carbon
Canada	1990	2.48	23.73	21.302	16.2
Canada	1991	2.54	20	21.591	15.7
Canada	1992	2.58	19.32	20.693	16
Canada	1993	2.61	16.97	19.936	15.7
Canada	1994	2.64	15.82	19.786	16.1
Canada	1995	2.67	17.02	20.509	16.3
Canada	1996	2.8	20.67	21.129	16.7
Canada	1997	2.74	19.09	21.709	17.1
Canada	1998	2.59	12.72	20.875	17.2
Canada	1999	2.69	17.97	22.11	17.3
Canada	2000	2.76	28.5	24.032	17.9
Canada	2001	2.55	24.44	23.574	17.5
Canada	2002	2.67	25.02	23.995	17.6
Canada	2003	2.55	28.83	28.026	18.1
Canada	2004	2.54	38.27	31.83	17.8
Canada	2005	2.7	54.52	36.028	17.8
Canada	2006	2.63	65.14	40.244	17
Canada	2007	2.71	72.39	44.328	17.9
Canada	2008	2.72	97.26	46.4	16.9
Canada	2009	2.67	61.67	40.764	16.1
Canada	2010	2.57	79.5	47.464	16.2
Canada	2011	2.71	111.26	52.087	16.1
Canada	2012	2.72	111.67	52.733	15.7
Canada	2013	2.76	108.66	52.305	15.7

country	year	renewable	oil	gdp	carbon
UK	1990	0.02	23.73	19.095	10.3
UK	1991	0.02	20	19.901	10.4
UK	1992	0.03	19.32	20.487	10.1
UK	1993	0.03	16.97	18.389	9.7
UK	1994	0.03	15.82	19.709	9.5
UK	1995	0.03	17.02	21.296	9.6
UK	1996	0.03	20.67	22.427	9.8
UK	1997	0.04	19.09	24.671	9.3
UK	1998	0.05	12.72	26.145	9.4
UK	1999	0.05	17.97	26.555	9.2
UK	2000	0.06	28.5	26.296	9.2
UK	2001	0.06	24.44	25.864	9.5
UK	2002	0.07	25.02	28.203	9.2
UK	2003	0.07	28.83	32.587	9.3
UK	2004	0.09	38.27	38.308	9.2
UK	2005	0.11	54.52	39.935	9.2
UK	2006	0.12	65.14	42.447	9.1
UK	2007	0.13	72.39	48.32	8.9
UK	2008	0.14	97.26	45.168	8.7
UK	2009	0.16	61.67	37.077	7.9
UK	2010	0.17	79.5	38.362	8.2
UK	2011	0.23	111.26	40.975	7.5
UK	2012	0.27	111.67	41.051	7.8
UK	2013	0.36	108.66	41.777	7.5
country	year	renewable	oil	gdp	carbon
Germany	1990	0.06	23.73	22.22	12.7
Germany	1991	0.05	20	23.269	12.2
Germany	1992	0.06	19.32	26.334	11.5
Germany	1993	0.07	16.97	25.489	11.4
Germany	1994	0.07	15.82	27.088	11.1
Germany	1995	0.08	17.02	31.716	11
Germany	1996	0.07	20.67	30.539	11.3
Germany	1997	0.08	19.09	27.012	10.9
Germany	1998	0.1	12.72	27.3	10.8
Germany	1999	0.11	17.97	26.756	10.4
Germany	2000	0.14	28.5	23.685	10.4
Germany	2001	0.15	24.44	23.654	10.6
Germany	2002	0.19	25.02	25.171	10.4
Germany	2003	0.2	28.83	30.319	10.5

Germany	2004	0.25	38.27	34.12	10.5
Germany	2005	0.29	54.52	34.651	10.1
Germany	2006	0.34	65.14	36.401	10.3
Germany	2007	0.43	72.39	41.763	10
Germany	2008	0.46	97.26	45.633	10.3
Germany	2009	0.47	61.67	41.671	9.8
Germany	2010	0.52	79.5	41.726	9.9
Germany	2011	0.64	111.26	45.868	9.7
Germany	2012	0.75	111.67	43.932	10
Germany	2013	0.79	108.66	46.255	10.2
country	year	renewable	oil	gdp	carbon
France	1990	0.22	23.73	21.834	6.9
France	1991	0.24	20	21.783	7.3
France	1992	0.28	19.32	23.938	7.1
France	1993	0.26	16.97	22.504	6.7
France	1994	0.32	15.82	23.626	6.6
France	1995	0.29	17.02	27.039	6.7
France	1996	0.27	20.67	27.016	6.9
France	1997	0.26	19.09	24.36	6.7
France	1998	0.25	12.72	25.102	7.1
France	1999	0.29	17.97	24.8	6.9
France	2000	0.27	28.5	22.466	6.9
France	2001	0.3	24.44	22.528	7
France	2002	0.25	25.02	24.276	6.8
France	2003	0.25	28.83	29.692	6.9
France	2004	0.25	38.27	33.876	6.8
France	2005	0.22	54.52	34.881	6.7
France	2006	0.24	65.14	36.546	6.5
France	2007	0.26	72.39	41.603	6.3
France	2008	0.28	97.26	45.416	6.3
France	2009	0.29	61.67	41.634	6.1
France	2010	0.32	79.5	40.709	6.2
France	2011	0.29	111.26	43.811	5.7
France	2012	0.37	111.67	40.853	5.7
France	2013	0.41	108.66	42.631	5.7
country	year	renewable	oil	gdp	carbon
Italy	1990	0.15	23.73	20.765	7.5
Italy	1991	0.2	20	21.892	7.4
Italy	1992	0.2	19.32	23.175	7.4
Italy	1993	0.2	16.97	18.684	7.3

Italy	1994	0.21	15.82	19.281	7.2
Italy	1995	0.18	17.02	20.604	7.7
Italy	1996	0.21	20.67	23.029	7.4
Italy	1997	0.2	19.09	21.788	7.4
Italy	1998	0.21	12.72	22.261	7.5
Italy	1999	0.23	17.97	21.946	7.6
Italy	2000	0.23	28.5	20.059	8.1
Italy	2001	0.25	24.44	20.409	8
Italy	2002	0.23	25.02	22.206	8.1
Italy	2003	0.23	28.83	27.399	8.3
Italy	2004	0.27	38.27	31.189	8.3
Italy	2005	0.25	54.52	31.974	8.3
Italy	2006	0.26	65.14	33.426	8.3
Italy	2007	0.25	72.39	37.716	7.9
Italy	2008	0.3	97.26	40.66	7.6
Italy	2009	0.34	61.67	36.995	6.8
Italy	2010	0.39	79.5	35.878	6.9
Italy	2011	0.46	111.26	38.365	6.8
Italy	2012	0.54	111.67	34.854	6.8
Italy	2013	0.62	108.66	35.477	6.4
country	year	renewable	oil	gdp	carbon
China	1990	0.03	23.73	3.16	2.1
China	1991	0.02	20	3.31	2.2
China	1992	0.03	19.32	3.65	2.3
China	1993	0.03	16.97	3.76	2.5
China	1994	0.03	15.82	4.72	2.6
China	1995	0.04	17.02	6.08	2.8
China	1996	0.04	20.67	7.07	2.9
China	1997	0.04	19.09	7.79	2.8
China	1998	0.04	12.72	8.26	2.8
China	1999	0.04	17.97	8.7	2.8
China	2000	0.04	28.5	9.55	2.7
China	2001	0.05	24.44	10.47	2.8
China	2002	0.05	25.02	11.42	3
China	2003	0.05	28.83	12.81	3.4
China	2004	0.06	38.27	14.98	4
China	2005	0.07	54.52	17.4	4.4
China	2006	0.08	65.14	20.82	4.9
China	2007	0.09	72.39	26.73	5.2
China	2008	0.11	97.26	34.41	5.8

China	2009	0.12	61.67	38	6.1
China	2010	0.14	79.5	45.15	6.4
China	2011	0.15	111.26	55.74	7
China	2012	0.2	111.67	62.65	7.2
China	2013	0.22	108.66	69.92	7.4
country	year	renewable	oil	gdp	carbon
India	1990	0.02	23.73	3.76	0.8
India	1991	0.02	20	3.1	0.8
India	1992	0.02	19.32	3.24	0.8
India	1993	0.02	16.97	3.09	0.8
India	1994	0.02	15.82	3.55	0.9
India	1995	0.02	17.02	3.84	0.9
India	1996	0.02	20.67	4.11	0.9
India	1997	0.02	19.09	4.27	1
India	1998	0.02	12.72	4.25	1
India	1999	0.02	17.97	4.55	1
India	2000	0.02	28.5	4.57	1
India	2001	0.02	24.44	4.66	1
India	2002	0.02	25.02	4.87	1
India	2003	0.02	28.83	5.65	1.1
India	2004	0.02	38.27	6.5	1.1
India	2005	0.02	54.52	7.4	1.1
India	2006	0.03	65.14	8.3	1.2
India	2007	0.03	72.39	10.69	1.3
India	2008	0.03	97.26	10.42	1.3
India	2009	0.03	61.67	11.47	1.4
India	2010	0.03	79.5	14.17	1.5
India	2011	0.04	111.26	15.03	1.5
India	2012	0.04	111.67	14.81	1.6
India	2013	0.04	108.66	14.87	1.7
country	year	renewable	oil	gdp	carbon
Brazil	1990	0.33	23.73	30.87	1.5
Brazil	1991	0.34	20	26.77	1.5
Brazil	1992	0.34	19.32	25.26	1.5
Brazil	1993	0.35	16.97	27.92	1.5
Brazil	1994	0.36	15.82	35.01	1.6
Brazil	1995	0.37	17.02	48.53	1.7
Brazil	1996	0.39	20.67	51.92	1.8
Brazil	1997	0.4	19.09	53.1	1.8
Brazil	1998	0.41	12.72	51.15	1.9

Brazil	1999	0.41	17.97	34.99	1.9
Brazil	2000	0.42	28.5	37.66	2
Brazil	2001	0.37	24.44	31.62	2
Brazil	2002	0.39	25.02	28.36	1.9
Brazil	2003	0.41	28.83	30.76	1.9
Brazil	2004	0.43	38.27	36.39	2
Brazil	2005	0.45	54.52	47.93	2
Brazil	2006	0.46	65.14	58.88	2
Brazil	2007	0.49	72.39	73.47	2.1
Brazil	2008	0.49	97.26	88.37	2.1
Brazil	2009	0.51	61.67	86.03	2
Brazil	2010	0.53	79.5	113.18	2.2
Brazil	2011	0.57	111.26	132.79	2.3
Brazil	2012	0.56	111.67	121.48	2.4
Brazil	2013	0.56	108.66	119.39	2.6
country	year	renewable	oil	gdp	carbon
Russia	1990	0.25	23.73	34.85	16.5
Russia	1991	0.26	20	34.27	15.5
Russia	1992	0.26	19.32	30.95	14
Russia	1993	0.27	16.97	29.29	13.4
Russia	1994	0.27	15.82	26.63	11.8
Russia	1995	0.27	17.02	26.66	11.8
Russia	1996	0.24	20.67	26.44	11.6
Russia	1997	0.24	19.09	27.38	10.8
Russia	1998	0.24	12.72	18.35	10.7
Russia	1999	0.25	17.97	13.31	11
Russia	2000	0.26	28.5	17.72	11.3
Russia	2001	0.27	24.44	21	11.4
Russia	2002	0.26	25.02	23.75	11.4
Russia	2003	0.25	28.83	29.75	11.9
Russia	2004	0.28	38.27	41.02	12
Russia	2005	0.28	54.52	53.23	12
Russia	2006	0.28	65.14	69.2	12.4
Russia	2007	0.29	72.39	91.01	12.6
Russia	2008	0.27	97.26	116.35	12.5
Russia	2009	0.28	61.67	85.63	11.8
Russia	2010	0.27	79.5	106.75	11.9
Russia	2011	0.26	111.26	133.24	12.5
Russia	2012	0.26	111.67	140.79	12.7
Russia	2013	0.29	108.66	144.87	12.6

country	year	renewable	oil	gdp	carbon
Turkey	1990	0.1	23.73	28	2.8
Turkey	1991	0.09	20	28	2.8
Turkey	1992	0.11	19.32	29	2.8
Turkey	1993	0.14	16.97	32	2.9
Turkey	1994	0.12	15.82	23	2.8
Turkey	1995	0.14	17.02	29	3
Turkey	1996	0.16	20.67	31	3.2
Turkey	1997	0.15	19.09	31	3.4
Turkey	1998	0.16	12.72	44	3.4
Turkey	1999	0.13	17.97	40	3.3
Turkey	2000	0.11	28.5	42	3.6
Turkey	2001	0.09	24.44	31	3.2
Turkey	2002	0.12	25.02	36	3.4
Turkey	2003	0.12	28.83	46	3.5
Turkey	2004	0.16	38.27	59	3.5
Turkey	2005	0.13	54.52	71	3.6
Turkey	2006	0.15	65.14	77	4
Turkey	2007	0.12	72.39	93	4.3
Turkey	2008	0.11	97.26	104	4
Turkey	2009	0.13	61.67	86	4
Turkey	2010	0.19	79.5	101	4.2
Turkey	2011	0.2	111.26	106	4.4
Turkey	2012	0.22	111.67	107	4.5
Turkey	2013	0.24	108.66	110	4.4

APPENDIX B

COUNTRIES' INDEPENDENT AND DEPENDENT VARIABLE SCORES IN NATURAL LOGARITHMS

country	year	renewable	oil	gdp	carbon
US	1990	-0.96	3.17	10.08	2.98
US	1991	-0.96	3.00	10.10	2.96
US	1992	-1.04	2.96	10.15	2.97
US	1993	-0.98	2.83	10.18	2.98
US	1994	-1.04	2.76	10.23	2.99
US	1995	-0.94	2.83	10.27	2.98
US	1996	-0.87	3.03	10.31	3.00
US	1997	-0.86	2.95	10.36	3.01
US	1998	-0.94	2.54	10.40	3.01
US	1999	-0.95	2.89	10.45	3.01
US	2000	-1.05	3.35	10.50	3.03
US	2001	-1.23	3.20	10.53	3.00
US	2002	-1.08	3.22	10.55	3.00
US	2003	-1.06	3.36	10.59	3.00
US	2004	-1.07	3.64	10.64	3.00
US	2005	-1.05	4.00	10.70	2.99
US	2006	-0.98	4.18	10.75	2.97
US	2007	-1.04	4.28	10.78	2.97
US	2008	-0.95	4.58	10.79	2.93
US	2009	-0.86	4.12	10.76	2.84
US	2010	-0.81	4.38	10.79	2.87
US	2011	-0.65	4.71	10.82	2.84
US	2012	-0.65	4.72	10.85	2.79
US	2013	-0.57	4.69	10.88	2.81
country	year	renewable	oil	gdp	carbon
Japan	1990	-1.59	3.17	10.13	2.25
Japan	1991	-1.51	3.00	10.26	2.26
Japan	1992	-1.64	2.96	10.34	2.26
Japan	1993	-1.52	2.83	10.48	2.25
Japan	1994	-1.73	2.76	10.57	2.29
Japan	1995	-1.62	2.83	10.66	2.31
Japan	1996	-1.60	3.03	10.53	2.31
Japan	1997	-1.53	2.95	10.44	2.31
Japan	1998	-1.45	2.54	10.34	2.28
Japan	1999	-1.53	2.89	10.46	2.31

Japan	2000	-1.54	3.35	10.53	2.32
Japan	2001	-1.53	3.20	10.40	2.30
Japan	2002	-1.50	3.22	10.35	2.33
Japan	2003	-1.40	3.36	10.42	2.33
Japan	2004	-1.39	3.64	10.50	2.33
Japan	2005	-1.42	4.00	10.49	2.34
Japan	2006	-1.34	4.18	10.44	2.32
Japan	2007	-1.41	4.28	10.44	2.35
Japan	2008	-1.41	4.58	10.54	2.29
Japan	2009	-1.45	4.12	10.58	2.23
Japan	2010	-1.30	4.38	10.67	2.27
Japan	2011	-1.32	4.71	10.74	2.31
Japan	2012	-1.30	4.72	10.75	2.38
Japan	2013	-1.22	4.69	10.56	2.37
country	year	renewable	oil	gdp	carbon
Canada	1990	0.91	3.17	9.97	2.79
Canada	1991	0.93	3.00	9.98	2.76
Canada	1992	0.95	2.96	9.94	2.77
Canada	1993	0.96	2.83	9.90	2.75
Canada	1994	0.97	2.76	9.89	2.78
Canada	1995	0.98	2.83	9.93	2.79
Canada	1996	1.03	3.03	9.96	2.81
Canada	1997	1.01	2.95	9.99	2.84
Canada	1998	0.95	2.54	9.95	2.84
Canada	1999	0.99	2.89	10.00	2.85
Canada	2000	1.01	3.35	10.09	2.89
Canada	2001	0.94	3.20	10.07	2.86
Canada	2002	0.98	3.22	10.09	2.87
Canada	2003	0.94	3.36	10.24	2.90
Canada	2004	0.93	3.64	10.37	2.88
Canada	2005	0.99	4.00	10.49	2.88
Canada	2006	0.97	4.18	10.60	2.83
Canada	2007	1.00	4.28	10.70	2.89
Canada	2008	1.00	4.58	10.75	2.83
Canada	2009	0.98	4.12	10.62	2.78
Canada	2010	0.95	4.38	10.77	2.79
Canada	2011	1.00	4.71	10.86	2.78
Canada	2012	1.00	4.72	10.87	2.75
Canada	2013	1.02	4.69	10.86	2.75
country	year	renewable	oil	gdp	carbon
UK	1990	-3.71	3.17	9.86	2.33
UK	1991	-3.79	3.00	9.90	2.34
UK	1992	-3.58	2.96	9.93	2.31

UK	1993	-3.59	2.83	9.82	2.27
UK	1994	-3.36	2.76	9.89	2.25
UK	1995	-3.37	2.83	9.97	2.26
UK	1996	-3.48	3.03	10.02	2.28
UK	1997	-3.28	2.95	10.11	2.24
UK	1998	-3.04	2.54	10.17	2.24
UK	1999	-2.94	2.89	10.19	2.22
UK	2000	-2.88	3.35	10.18	2.22
UK	2001	-2.86	3.20	10.16	2.25
UK	2002	-2.70	3.22	10.25	2.22
UK	2003	-2.68	3.36	10.39	2.23
UK	2004	-2.43	3.64	10.55	2.22
UK	2005	-2.21	4.00	10.60	2.22
UK	2006	-2.13	4.18	10.66	2.21
UK	2007	-2.06	4.28	10.79	2.19
UK	2008	-1.95	4.58	10.72	2.16
UK	2009	-1.81	4.12	10.52	2.06
UK	2010	-1.75	4.38	10.55	2.10
UK	2011	-1.48	4.71	10.62	2.02
UK	2012	-1.29	4.72	10.62	2.05
UK	2013	-1.03	4.69	10.64	2.02
country	year	renewable	oil	gdp	carbon
Germany	1990	-2.85	3.17	10.01	2.54
Germany	1991	-3.00	3.00	10.05	2.50
Germany	1992	-2.82	2.96	10.18	2.44
Germany	1993	-2.73	2.83	10.15	2.43
Germany	1994	-2.64	2.76	10.21	2.41
Germany	1995	-2.53	2.83	10.36	2.40
Germany	1996	-2.60	3.03	10.33	2.42
Germany	1997	-2.51	2.95	10.20	2.39
Germany	1998	-2.35	2.54	10.21	2.38
Germany	1999	-2.23	2.89	10.19	2.34
Germany	2000	-1.99	3.35	10.07	2.34
Germany	2001	-1.89	3.20	10.07	2.36
Germany	2002	-1.68	3.22	10.13	2.34
Germany	2003	-1.60	3.36	10.32	2.35
Germany	2004	-1.37	3.64	10.44	2.35
Germany	2005	-1.24	4.00	10.45	2.31
Germany	2006	-1.08	4.18	10.50	2.33
Germany	2007	-0.85	4.28	10.64	2.30
Germany	2008	-0.78	4.58	10.73	2.33
Germany	2009	-0.75	4.12	10.64	2.28
Germany	2010	-0.65	4.38	10.64	2.29

Germany	2011	-0.45	4.71	10.73	2.27
Germany	2012	-0.29	4.72	10.69	2.30
Germany	2013	-0.23	4.69	10.74	2.32
country	year	renewable	oil	gdp	carbon
France	1990	-1.50	3.17	9.99	1.93
France	1991	-1.44	3.00	9.99	1.99
France	1992	-1.27	2.96	10.08	1.96
France	1993	-1.33	2.83	10.02	1.90
France	1994	-1.15	2.76	10.07	1.88
France	1995	-1.22	2.83	10.21	1.90
France	1996	-1.32	3.03	10.20	1.93
France	1997	-1.35	2.95	10.10	1.91
France	1998	-1.38	2.54	10.13	1.96
France	1999	-1.22	2.89	10.12	1.94
France	2000	-1.29	3.35	10.02	1.93
France	2001	-1.20	3.20	10.02	1.94
France	2002	-1.38	3.22	10.10	1.92
France	2003	-1.40	3.36	10.30	1.93
France	2004	-1.40	3.64	10.43	1.91
France	2005	-1.51	4.00	10.46	1.90
France	2006	-1.41	4.18	10.51	1.87
France	2007	-1.33	4.28	10.64	1.85
France	2008	-1.26	4.58	10.72	1.85
France	2009	-1.25	4.12	10.64	1.81
France	2010	-1.13	4.38	10.61	1.82
France	2011	-1.24	4.71	10.69	1.74
France	2012	-1.01	4.72	10.62	1.74
France	2013	-0.88	4.69	10.66	1.74
country	year	renewable	oil	gdp	carbon
Italy	1990	-1.87	3.17	9.94	2.01
Italy	1991	-1.63	3.00	9.99	2.01
Italy	1992	-1.61	2.96	10.05	2.00
Italy	1993	-1.62	2.83	9.84	1.99
Italy	1994	-1.56	2.76	9.87	1.98
Italy	1995	-1.69	2.83	9.93	2.04
Italy	1996	-1.58	3.03	10.04	2.00
Italy	1997	-1.59	2.95	9.99	2.01
Italy	1998	-1.56	2.54	10.01	2.02
Italy	1999	-1.45	2.89	10.00	2.03
Italy	2000	-1.45	3.35	9.91	2.09
Italy	2001	-1.38	3.20	9.92	2.08
Italy	2002	-1.46	3.22	10.01	2.09
Italy	2003	-1.45	3.36	10.22	2.12

Italy	2004	-1.32	3.64	10.35	2.11
Italy	2005	-1.39	4.00	10.37	2.11
Italy	2006	-1.34	4.18	10.42	2.11
Italy	2007	-1.37	4.28	10.54	2.07
Italy	2008	-1.21	4.58	10.61	2.03
Italy	2009	-1.07	4.12	10.52	1.91
Italy	2010	-0.93	4.38	10.49	1.93
Italy	2011	-0.78	4.71	10.55	1.91
Italy	2012	-0.61	4.72	10.46	1.91
Italy	2013	-0.47	4.69	10.48	1.85
country	year	renewable	oil	gdp	carbon
China	1990	-3.68	3.17	5.76	0.75
China	1991	-3.71	3.00	5.80	0.79
China	1992	-3.67	2.96	5.90	0.83
China	1993	-3.53	2.83	5.93	0.90
China	1994	-3.44	2.76	6.16	0.94
China	1995	-3.29	2.83	6.41	1.03
China	1996	-3.34	3.03	6.56	1.05
China	1997	-3.29	2.95	6.66	1.04
China	1998	-3.24	2.54	6.72	1.05
China	1999	-3.27	2.89	6.77	1.02
China	2000	-3.19	3.35	6.86	1.01
China	2001	-2.98	3.20	6.95	1.03
China	2002	-2.95	3.22	7.04	1.09
China	2003	-2.97	3.36	7.16	1.23
China	2004	-2.76	3.64	7.31	1.39
China	2005	-2.65	4.00	7.46	1.48
China	2006	-2.56	4.18	7.64	1.58
China	2007	-2.45	4.28	7.89	1.65
China	2008	-2.25	4.58	8.14	1.75
China	2009	-2.16	4.12	8.24	1.80
China	2010	-1.95	4.38	8.42	1.86
China	2011	-1.87	4.71	8.63	1.94
China	2012	-1.63	4.72	8.74	1.97
China	2013	-1.54	4.69	8.85	2.00
country	year	renewable	oil	gdp	carbon
India	1990	-4.05	3.17	5.93	-0.28
India	1991	-3.97	3.00	5.74	-0.23
India	1992	-4.04	2.96	5.78	-0.21
India	1993	-4.04	2.83	5.73	-0.19
India	1994	-3.94	2.76	5.87	-0.15
India	1995	-3.99	2.83	5.95	-0.10
India	1996	-4.09	3.03	6.02	-0.06

India	1997	-4.08	2.95	6.06	-0.04
India	1998	-3.93	2.54	6.05	-0.04
India	1999	-3.95	2.89	6.12	0.01
India	2000	-4.02	3.35	6.12	0.02
India	2001	-4.08	3.20	6.14	0.01
India	2002	-4.14	3.22	6.19	0.04
India	2003	-4.11	3.36	6.34	0.05
India	2004	-3.90	3.64	6.48	0.11
India	2005	-3.76	4.00	6.61	0.13
India	2006	-3.59	4.18	6.72	0.19
India	2007	-3.50	4.28	6.97	0.24
India	2008	-3.52	4.58	6.95	0.28
India	2009	-3.50	4.12	7.04	0.35
India	2010	-3.42	4.38	7.26	0.39
India	2011	-3.26	4.71	7.32	0.40
India	2012	-3.27	4.72	7.30	0.47
India	2013	-3.18	4.69	7.30	0.50
country	year	renewable	oil	gdp	carbon
Brazil	1990	-1.12	3.17	8.03	0.38
Brazil	1991	-1.08	3.00	7.89	0.40
Brazil	1992	-1.07	2.96	7.83	0.40
Brazil	1993	-1.04	2.83	7.93	0.42
Brazil	1994	-1.02	2.76	8.16	0.44
Brazil	1995	-0.99	2.83	8.49	0.50
Brazil	1996	-0.95	3.03	8.55	0.57
Brazil	1997	-0.92	2.95	8.58	0.61
Brazil	1998	-0.89	2.54	8.54	0.62
Brazil	1999	-0.89	2.89	8.16	0.64
Brazil	2000	-0.87	3.35	8.23	0.68
Brazil	2001	-0.99	3.20	8.06	0.68
Brazil	2002	-0.94	3.22	7.95	0.66
Brazil	2003	-0.88	3.36	8.03	0.63
Brazil	2004	-0.84	3.64	8.20	0.68
Brazil	2005	-0.80	4.00	8.47	0.67
Brazil	2006	-0.78	4.18	8.68	0.68
Brazil	2007	-0.71	4.28	8.90	0.72
Brazil	2008	-0.72	4.58	9.09	0.76
Brazil	2009	-0.67	4.12	9.06	0.69
Brazil	2010	-0.63	4.38	9.33	0.80
Brazil	2011	-0.56	4.71	9.49	0.84
Brazil	2012	-0.57	4.72	9.40	0.89
Brazil	2013	-0.59	4.69	9.39	0.94
country	year	renewable	oil	gdp	carbon

Russia	1990	-1.37	3.17	8.16	2.80
Russia	1991	-1.36	3.00	8.14	2.74
Russia	1992	-1.34	2.96	8.04	2.64
Russia	1993	-1.32	2.83	7.98	2.60
Russia	1994	-1.32	2.76	7.89	2.47
Russia	1995	-1.31	2.83	7.89	2.47
Russia	1996	-1.45	3.03	7.88	2.45
Russia	1997	-1.42	2.95	7.91	2.38
Russia	1998	-1.41	2.54	7.51	2.37
Russia	1999	-1.40	2.89	7.19	2.40
Russia	2000	-1.37	3.35	7.48	2.43
Russia	2001	-1.30	3.20	7.65	2.44
Russia	2002	-1.36	3.22	7.77	2.44
Russia	2003	-1.40	3.36	8.00	2.47
Russia	2004	-1.27	3.64	8.32	2.49
Russia	2005	-1.29	4.00	8.58	2.48
Russia	2006	-1.28	4.18	8.84	2.52
Russia	2007	-1.26	4.28	9.12	2.54
Russia	2008	-1.33	4.58	9.36	2.53
Russia	2009	-1.27	4.12	9.06	2.47
Russia	2010	-1.32	4.38	9.28	2.48
Russia	2011	-1.34	4.71	9.50	2.53
Russia	2012	-1.34	4.72	9.55	2.54
Russia	2013	-1.25	4.69	9.58	2.54
country	year	renewable	oil	gdp	carbon
Turkey	1990	-2.33	3.17	7.93	1.02
Turkey	1991	-2.36	3.00	7.92	1.02
Turkey	1992	-2.22	2.96	7.96	1.04
Turkey	1993	-1.99	2.83	8.07	1.06
Turkey	1994	-2.11	2.76	7.73	1.04
Turkey	1995	-1.97	2.83	7.97	1.11
Turkey	1996	-1.86	3.03	8.02	1.18
Turkey	1997	-1.90	2.95	8.05	1.22
Turkey	1998	-1.84	2.54	8.39	1.21
Turkey	1999	-2.05	2.89	8.30	1.19
Turkey	2000	-2.18	3.35	8.35	1.27
Turkey	2001	-2.44	3.20	8.03	1.17
Turkey	2002	-2.13	3.22	8.18	1.21
Turkey	2003	-2.10	3.36	8.43	1.25
Turkey	2004	-1.85	3.64	8.68	1.26
Turkey	2005	-2.01	4.00	8.87	1.29
Turkey	2006	-1.91	4.18	8.95	1.38
Turkey	2007	-2.11	4.28	9.14	1.46

Turkey	2008	-2.16	4.58	9.25	1.40
Turkey	2009	-2.05	4.12	9.06	1.38
Turkey	2010	-1.67	4.38	9.22	1.43
Turkey	2011	-1.62	4.71	9.27	1.48
Turkey	2012	-1.50	4.72	9.27	1.51
Turkey	2013	-1.44	4.69	9.30	1.48

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