NEAR EAST UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF BANKING AND FINANCE
MASTER PROGRAMME

MASTER'S THESIS

THE INTERACTION BETWEEN RENEWABLE ENERGY MARKET AND OIL PRICES

HÜSEYİN İLKER ERÇEN

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SUPERVISOR: ASSIST. PROF. DR. TURGUT TÜRSOY

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We certify the thesis is satisfactory for the award of degree of
Master of Banking & Finance

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DECLARATION

I declare that this dissertation is the product of my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

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ABSTRACT

Second half of 2014 had become a turning point for oil price and energy sector. Increase in the supply of the oil, and decrease in the oil demand which had been supported by the Federal Reserve's statement on interest rates that had strengthens the US Dollar had caused a dramatic decrease (approximately 50%) on the oil price. It was widely accepted that, decreasing oil price would affect the renewable energy sector negatively. But, what about today's renewables with much higher efficiency for much lower cost? In this thesis, five variable vector autoregression models are developed and estimated to investigate the empirical relationship between US Dollar, West Texas Intermediate Oil price, solar index, wind index, and clean energy index. The results show that; there is a cointegration between oil and renewable energy index prices, however unlike to the expectations of a majority, plunged oil price to a 6-year low does not reduce the demand for renewable energy. Research and Development activities on renewable energy had improved the efficiency, and decrease the cost of the products in recent years. This makes renewables an indispensable part of the energy sector. As a result, it can be said that there is an interaction between oil and renewable energy index prices, however today's technological circumstances does not allow the reduction of the demand for renewables, even the oil prices had been shrink by 50%.

ÖZET

2014 yılının ikinci yarısı petrol ve enerji sektörü için bir dönüm noktası olarak nitelendirilebilir. Petrol arzının artması fakat petrol talebinin aşağı yönlü hareketinin yanı sıra, Federal Rezerv Sistemi'nin ileriye dönük faiz oranları ile yaptığı açıklamalar Amerikan Dolar'ını güçlendirirken, petrol fiyatlarının aşağı yukarı 50% seviyesindeki dramatik düşüşüne neden olmuştu. Petrol fiyatlarındaki düşüşün yenilenebilir enerji sektöründe negatif etki yarattığı geniş ölçüde kabul edilir. Peki ya günümüz teknolojisi ile üretilen daha verimli ve daha düşük maliyetli yenilenebilir enerji kaynakları için bu ne kadar geçerlidir? Bu tez, vektör otoregresyonu'nun beş değişkenini kullanarak, ABD Doları, Batı Texas Türü petrol fiyatları, güneş endeksi, rüzgar endeksi, ve temiz enerji endeksi arasındaki ampirik ilişkiyi araştırmayı hedeflemektedir. Sonuçlar, petrol ve yenilenebilir enerji endeks fiyatları arasında bir eşbütünleşmenin varlığını göstermektedir. Fakat, çoğunluğun beklentilerinin aksine, son 6 yılın en düşük seviyelerini gören petrol fiyatları, yenilenebilir enerjiye gösterilen ilgi ve talebi azaltmadı. Yapılan araştırma ve geliştirmeler ışığında son yıllarda ortaya çıkan verimliliği yüksek ve maliyeti düşük yenilenebilir enerji kaynaklarına her geçen gün bu sektöre olan yatırımları artırıyor. Yenilenebilir enerji sektörünün pazar payını artırması ise, onu her geçen gün enerji sektörünün vazgeçilmez bir parçası olmaya doğru yönlendiriyor. Sonuç olarak, petrol ve yenilenebilir enerji kaynakları endeks fiyatları arasında bir etkileşim olduğu, fakat petrol fiyatlarındaki 50% düşüşün yenilenebilir enerji endeks fiyatlarını ve de yenilenebilir enerjiye olan talebi aşağı yönlü etkileyebilmesi için yeterli olmadığı söylenebilmektedir.

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I would like to express my appreciation to my supervisors, Assist. Prof. Dr. Turgut Tursoy, and Assist. Prof. Dr. Nil Gunsel, whose expertise, understanding, and patience, added considerably to my graduate experience. It might not be possible to finish this thesis within the limited amount of time without their continuous support.

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LIST OF ABBREVIATIONS

ADF: Augmented Dickey-Fuller Test

DXY: US Dollar Index

ECO: WilderHill Clean Energy Index

ETF: Exchange-Traded Funds

FED: Federal Reserve System

NASDAQ: National Association of Securities Dealers Automated Quotations.

NYSE: New York Stock Exchange

OECD: Organization for Economic Co-operation and Development

OPEC: Organization of the Petroleum Exporting Countries

PwC: PricewaterhoseCoopers

PP: Phillips-Perron Test

R&D: Research and Development

SOLAR: NASDAQ OMX Solar (GRNSOLAR)

S&P 500: Standard & Poor's 500

VAR: Vector Autoregression

VECM: Vector Error Correction Model

WIND: NASDAQ OMX Wind (GRNWIND)

WTI: Western Texas Intermediate

1. INTRODUCTION

1.1. Motivation to Contribution

This thesis is going to focus on the interaction between oil and renewable energy index prices. The oil prices had shrink approximately 50% to a 6-years low level in very limited amount of time. There is a bias that, reduced oil price have a negative effect on the renewable energy sector and index prices. However, against long odds this thesis is aiming to reveal that, even 50% decrease of the oil prices is not enough to affect the renewable index prices negatively in the light of today's technological development. R&D activities on renewable energy sector during recent years had motivated the author to concentrate on this topic in order to find out place of renewables in energy sector in general, with the support of the innovated renewable products in today's advanced technology.

1.2. Research Hypothesis

The hypothesis that this study seeks to verify is stated as;

H_{0a}: There is no significant impact on renewable energy indexes by the shock of oil prices.

H_{1a}: There is a significant impact on renewable energy indexes by the shock of oil prices.

H_{0b}: Declining oil prices are going to cause decrease in renewable energy index prices.

H_{1b}: Declining oil prices are not going to cause decrease in renewable energy index prices.

1.3. Research Methodology

This thesis is going to study the interaction between oil and renewable energy index prices by using the daily price data, in a date rage from 01 April 2014 to 31 March 2015; US Dollar, WTI Oil Price, NASDAQ OMX Green Energy Solar Index, NASDAQ OMX Green Energy Wind Index, and WilderHill Clean Energy Index

(ECO). Vector Autoregression Model had been applied with an assistance of econometrics software EViews in order to analyze the obtained data series.

1.4. Research Gap

Various researches had been made to find out the correlation between oil and renewable index prices both locally and globally. Mostly, it is possible to observe that, as the researches approaches to present, the findings are changing, and oil and renewables be associated more strictly. The main theme that provides the stronger bonds between these two is actually energy sector in general, and innovations that had been made on renewables. However, none of those researches had experienced the dramatic 50% decrease on the oil price in very limited amount of time. Of course, ups and downs on both oil and renewable index prices had experienced during previous years, but none of the researches had explore the sudden 50% drop in oil prices with high efficiency and lower cost renewable products. In this thesis, author aimed to examine the interaction between renewable energy index and oil prices by using this unique change on the oil prices, and developed renewable energy sector. The thesis is going to analyze the period that witnesses the dramatic decline of oil prices and aiming to find out the impact of unusual dramatic collapse in oil prices to the renewable energy sector. The thesis chose the time period from 01/04/2014 to 31/03/2015 to study because; the WTI Oil prices had decreased from $104.78 down to $44.08 during stated period of time. The loss of oil prices that had been illustrated above is the biggest loss recorded for past 6 years. It had been expected that cheaper oil prices will cause decrease on the demand on the renewables, because cheaper oil will be much more attractive than renewables that has a constant price for last few months. However, technological development that had provided highly efficient renewables for lower costs had improved the importance of renewable energy in energy sector. Neither technology nor renewable energy indexes had remained same during these past 6 years. That is why, it is not possible to efficiently figure out the future of renewable energy sector in financial markets by working on the at least 6 years old researches. The thesis is aiming to figure out the current relationship between oil and renewables in today's financial and technological conditions.

1.5. Introduction

Energy sector has a majestic role on both economy and financial markets. Oil and Gas had been known as the backbones of the energy sector for decades. However, their rival renewable energy sector, especially the solar and wind powers are getting stronger and floury each passing day. On the other hand, oil prices had experienced one of the most dramatic decline that was approximately 50% just before a quarter. Not surprisingly, sharp decline of the oil prices caused biases that low oil prices will affect the other industries that are providing energy. As Oil and Gas and renewable energy address the energy sector, this thesis would like to examine the interaction between oil prices and renewable energy index prices. Many ideas, and researches had been figured through the history that illustrates the relationship between these two. However, all these researches had take place under financially steady conditions. This thesis is going to examine the correlation through the time series, where the oil prices gets its one of the most dramatic shocks.

In order to figure out the relationship, fist of all thesis is going to identify the relationship between US Dollar and oil prices. In financial markets, oil is prices as US Dollars, however not every oil supplying/demanding countries' currency is US Dollar. The logic that lies under the Dollar and oil pricing is going to be examined. Subsequently, importance of the technological development, and how beneficial it is for the renewable energy sector is going to be illustrated. Briefly, it may be said that, technological development had decreased the cost of solar power up to 80% in last 6 years, while efficiency of wind power increased 15 times since the 90's. These innovations in very limited amount of time had provided a stronger background on the renewables while oil prices shrinks to its 6 years low level.

In order to understand the reaction of the financial markets to the oil prices, and find out what exactly had happened to renewable energy indexes through that time series, the thesis is going to examine the daily data of; US Dollar, WTI Oil, Solar Energy Index, Wind Energy Index, and Clean Energy Index for approximately a year. Vector Autoregression Model is going to be applied, and unit root test, cointegration test, granger causality test, impulse response, variance decomposition is going to take place. These econometrics tests are going to be made by the assistance of econometrics software 'EViews'.

2. AN OVERVIEW TO GLOBAL ENERGY SECTOR

Both oil and renewables are the part of the energy sector, and plays significant role on the pricing of energy sector in financial markets, and energy as a product. This chapter is going to introduce the two main components of the energy sector, oil and renewable energies. While introducing those components of energy market, factors that affects the price in the financial markets, such as; R&D, efficiency, demand, and supply are also going to be investigated. After understanding the events that affects their price in the financial market, the relationship between the price of oil and renewable energy stocks are going to be analyzed.

2.1. Oil

Crude oil has been refined since 1850s and plays a significant role in the economics since then. Oil is the most powerful resource that influences the destiny of nations and became the most traded commodity whether it had been measured by the value or the volume (Smith, 2012).

There are three primary standards of crude oil, which are; West Texas Intermediate (WTI), Brent Blend, and Dubai. These benchmarks have different prices in the global oil market, which varies on the location and the quality of the refined product. Crude oil should be examined in the laboratory conditions in order to find out the chemical composition of the product that actually shows the quality of the oil. Oil with different sulphur content, and density needed different refining process that creates the characteristics of the oil, such as its thickness. The refining process and the characteristics of the oil determines the market price of the oil (Adland, 2013, 15). While the price of different benchmarks of oil is not the same, the daily movements on the price of these three benchmarks always have a parallel trend to each other in the financial markets. This thesis is going to use WTI Crude Oil as an indicator.

2.1.1. Determining the Price of Oil

As a commodity that is trading worldwide, the price of the oil is determined by the global demand and supply of the oil. Any expected and unexpected changes such as; supply shortage that caused by rapid increase in demand, decrease on the demand by the stress on the natural environment, and even changing exchange rates have an effect on the demand and supply curve that prices the oil.

2.1.1.1. Demand Factor on the Price of Oil

According to the International Energy Agency's market report (2013, 23) and Grom's article (2013, 17), the main influencers of the price of oil are; Dollar Index (DXY) that represents the strength of US Dollar, strategic petroleum reserve management, and private participants are the key variables of the oil demand.

First of all, let's concentrate on the connection between the oil price and the US Dollar. Unlike the other two influencers, correlation between oil and Dollar is significantly important topic that had to be studied to provide much better understanding on the oncoming chapters of this thesis. Global demand for oil, and oil producers' price setting behavior varies on the fluctuations on the DXY Index (US Dollar exchange rate). Since the international financial markets priced the oil in US Dollar, fluctuations on the exchange rate directly affects the price of oil for the non-Dollar oil demanding countries. Change in the actual price of the oil for non-Dollar countries may lead to increase/decrease on their demand for oil, which is going to respond as higher/lower oil price. By expanding this idea, Grisse (2010, 2) had explained the negative relationship between US Dollar and oil in recent years, and responsiveness of the oil demand to the change in the value of US Dollar successfully. While US generates only a tiny amount of oil imports of oil producers, the oil priced in Dollar, and oil-producing countries principally have export revenue in Dollars. In order to prevent any possible losses, oil-producing countries generally prefer to use the Dollar as their exchange rate, such as; purchasing power that is created by the oil revenues may decrease instantly by the depreciation of the Dollar. This application gives ability to counteract the depreciation of Dollar, and raising oil prices. Oil producers are also able to shift the price of oil by changing the amount of oil supplied. So how does oil price and Dollar affects each other? There are two main reasons, which are; the influence of higher oil prices on the global distribution of trade flows and capital, and the power of higher oil prices on the US and global growth outlook (Killian, 2009, 1058). Price that is denominated in Dollars, and the quantity of oil output occurs by the equilibrium point in the demand/supply curve. Strength of the

Dollar and demand for oil is directly effective on each other. It is possible to explain it with the simple demand/supply formulation in economics. Non-Dollar oil demanding countries have to purchase dollar in order to have valid currency to pay their demand (which means increase in demand, where supply stays stable), Dollar's value starts to appreciate, while other currencies stays constant. Increase in the price of Dollar actually increases the price of oil for foreign investors, and decrease their purchasing power on oil. Decrease on the purchasing power actually decreases the demand on the expensive oil, while the supply (oil production) stays constant. The shift on the oil demand drops the equilibrium point to lower levels in order to sell remaining oil stock. On the other hand, cheap Dollar actually drops the price of oil for non-Dollar countries and seems like a good investment time. Increase in demand and constant supply higher the equilibrium point and increases the price of oil (IEA, 2012, 25).

As thesis had mentioned before, strategic petroleum reserve management is another price influencer by affecting the demand on oil. It states the crude oil stocks held by the country as security for any possible fluctuation on the market. This reserves that held by the country be formed while the oil supply is higher than the demand. By the stocked reserve, country will handle a flexibility to not to demand any oil from oil producers while the demand exceeding supply, lower supply while demand stays constant. This strategy of inventory management may gives direction to the oil prices on the market, while providing a price advantage to the country that had applied the strategy.

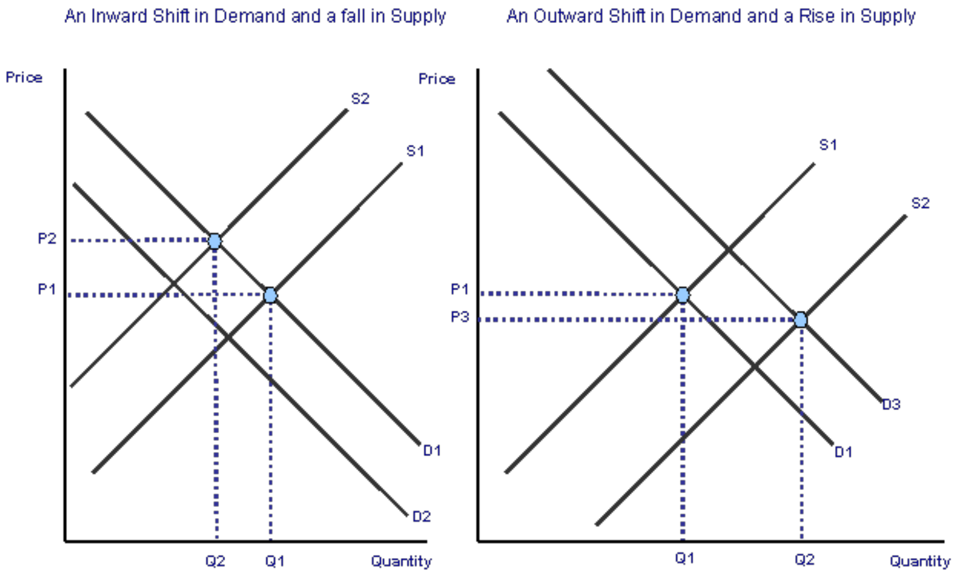
According to the Grom (2013, 18) the last component of price influencers on demand side is private participants. There are two types of private participants; (1) ones who purchase for physical oil, and (2) ones who purchases oil virtually on the stock market. Individuals who purchase physical oil actually follows the same strategy that countries follow as strategic petroleum reserve management. However, there are also individual investors, who also invest on oil directly as a commodity virtually. This method of owning oil may be achieved by purchasing the commodity-based oil exchange-trade funds, also known as 'ETFs'. Trading ETFs on a stock exchange have same process with the stocks. Both ETFs and stocks purchase and sold in the same way. By purchasing an oil commodity, investors actually own a virtual barrel of oil through the energy sector that they had invested on. Profit and loss principles of these commodities are also exactly the same with the stock market's principles. Virtual demand may compose one of the most risky trade volumes in critical time series. As it seems as an investing object, without any correlation with their business, investors always prefer to buy the oil commodity when it's cheap, and sell it on its peak point. These trades may be for both long term and short term. This unexpected demand also has a huge effect on the formation of the global oil prices (Grom, 2013, 16).

2.1.1.2. Supply Factor on the Price of Oil

Without doubt, technological improvements are changing the way we produce in every single sector. Energy and oil sector is one of them as well. By the technological improvements, total supply of oil had increased significantly since 1965 by locating new resources, changes in oil recovery rate, and reaching new resources, which was not able to reach before (OPEC, 2012b, 1). OPEC (Organization of the Petroleum Exporting Countries) had formed by the most important supplier of oil. Their mission is to synchronize and combine the petroleum policies of its members and control the supply of petroleum, and a steady income to producers what also create fair return on capital for petroleum industry investors (OPEC, 2012b, 6). The output decision of OPEC plays an important role on oil industry because, 80% of total global reserves, and 40% of global crude oil is held by OPEC (OPEC, 2012a). Any supply changes that had been made by the OPEC may affect the price of oil dramatically. Changes in demand, supply, and equilibrium point had already been expressed before. Same theory may be examined again by looking at the same figure (Figure 1), and shifting the supply curve instead of demand to see the changes in equilibrium point, quantity, and price.

Figure 1

Demand/Supply Curve



Another influencer of the oil supply is geopolitics. Developing countries that classed as risky countries because they are facing terrorism, political tension, and resource nationalism with large oil reserves are also an affect on changing oil supply.

Increase in carbon dioxide levels triggers the environmental awareness globally. Modern industrial economy fades up the carbon dioxide level, which was constant for many thousands of years. Atmospheric carbon dioxide concentrations have almost risen by 75% during last 140 years (Glick, 2004, 22). Concerns about environment, and the future of our planet actually restrict the available supply by aiming to reduce the refining capacity. Decreasing supply and increasing price encourages the industries to use alternative energies instead of petroleum (Henriques & Sadorsky, 2007, 1000).

2.2. Renewable Energy

Renewable Energy may be defined as; energy that is fully provided by natural resources, such as; sunlight, wind (Aitken and Donald, 2010, 9). This thesis is going to deal with the two most common renewable energy sources in use, which are; Solar

Power and Wind Power. The study of Economist Intelligence Unit (2010, 15) shows that, global energy demand is increasing each passing year by the effect of the population growth. At the present time, this energy demand is providing by both traditional (oil and gas) and renewables generation capacity.

2.2.1. Renewables and Pollution

As the thesis had mentioned before, understanding the causes of pollution, and environmental awareness is significantly growing. The awareness may cause both by ethical thinking, and government's attitude. Increase in energy demand actually triggers the pollution that has a significant impact on human health. In order to reduce the pollution, governments had started to encourage industries to use alternative sources instead of oil and gas (ABARE, 2010, 26). On the other hand, carbon dioxide emission limits that had been applied by governments and cooperation's like GCC (Gulf Cooperation Council) forced states to invest on renewable energy sources that had already been discovered with a reasonable price, instead of investing on new projects to find out a way to decrease the current carbon dioxide output. As renewable energy projects started to apply, confidence and attention on alternatives from both government and investors had increased. As a result of this attention and confidence, investments on renewable energy sector had added $260 billion in average a year worldwide, over the past five years. Investing on renewables through years pave the way of deployment, production and process improvement, and further cost reduction that will increase its popularity globally (University of Cambridge and PwC, 2015, 12).

2.2.2. Generation of Renewables

Rapid upwards movement on the popularity of renewables clearly creates an investment on producer companies, which may be used as financial aid for research and development.

Due to the rapid decrease on the cost of renewables, the finance sector is mostly using the outdated approaches on the related prices of renewable energy supplies and fossil fuel. Moreover, nowadays solar PV has grid unity with fossil fuels in many circumstances and countries.

Although a dramatic fall has been observed ın the price of oil in 2014, that price has always been increased and decreased. In contrast, a steady and rapid decline has been realized in the costs of renewable especially solar PV and on-shore wind. Also, it is believed that this decline will continue, especially at the module and systems level for solar PV, due to ‘learning-by-doing’ enabling continued process improvements in the sector and the entry of large-scale technology providers such as China and US into the global market. According to El New Energy that published the updated data of the fossil fuel break-even prices in February 2015, it is claimed that new build generation on-shore wind and solar PV will stay cheaper in the Middle East comparing to the new oil project prices. Regarding the model of the regional leveled value of energy, the calculations suggest that development of and on-shore wind or utility scale solar PV capacity would be cheaper rather than building a conventional oil plant in the Middle East at any oil price more that US $20/30 bbl over the 25-30 years of a new project. However, considering the existing oil-fired plants in the Middle East the results seems less favorable for renewables that currently account for some 35 percent of the generation mix in the region. Thus, solar PV needs oil prices of more than US$45/bbl in order to compete with a half-depreciated oil-fired plant and over US$60/bbl to expel a fully depreciated one because of the lower running costs. A considerable greater proportion of the investment is front loaded for renewables (University of Cambridge and PwC, 2015, 14). According to the calculations, renewable energy is cheaper than oil and gas when applied to a long-term project. That is why, it is important to lower the oil revenue in order to stay in the game. However, lower revenue will cause some limitations on the amount of the investments on that sector.

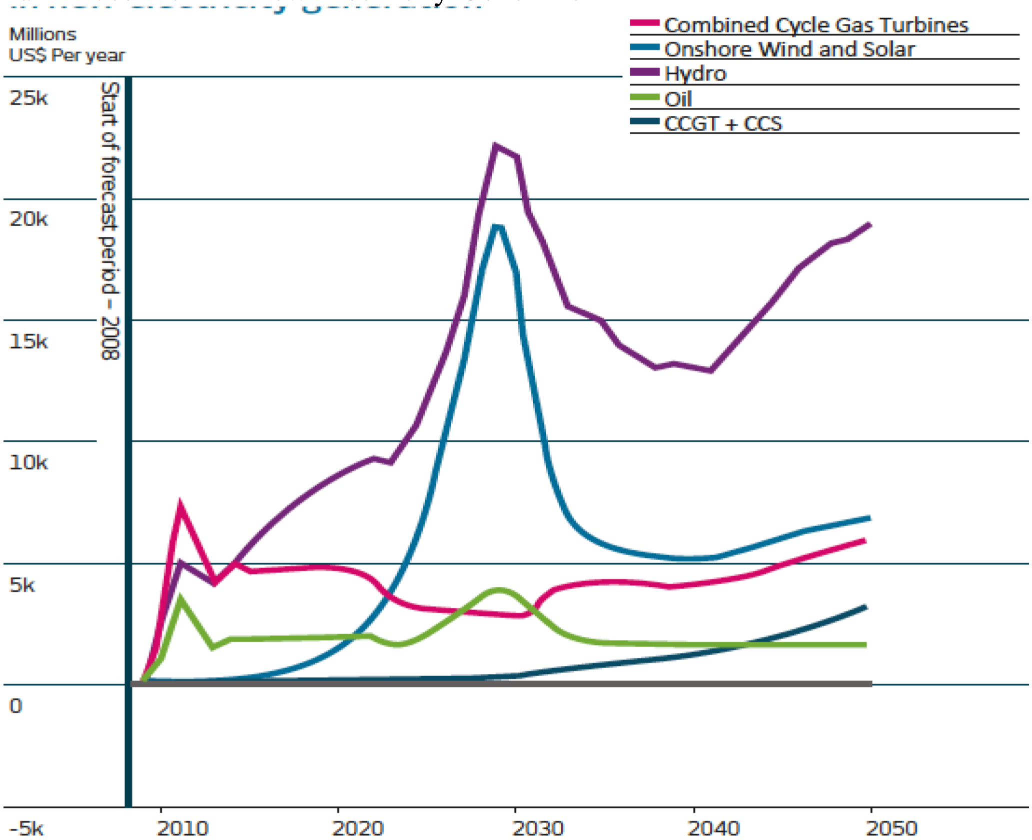
2.2.3. Energy Efficiency

Marginal Abatement Costs that had been take place in Appendix 2 illustrates the improvements of the energy systems and their contribution in economics and environmental scales. From Appendix 2 it may be visibly seen that, solar and wind powers are the most eco-friendly, and cost effective sources of energy that may be used for profit maximization and environmental awareness (McKinsey and Company, 2010, 7).

The innovative scenario of National Bank of Abu Dhabi by the University of Cambridge and PwC (2015) claims that; in order to create low carbon energy for the future of the earth, substantial amount of investment on renewables, and tremendous investment on energy innovation (which mostly includes R&D) is going to be made by year 2050. While enormous investments for renewables is taking place, investments on oil will proceed in a constant movement, not surprisingly. The main reason that lied behind the constant oil investment is of course the carbon intensity. Expected rates of investment on renewables have a power to decrease the carbon intensity by 45% (University of Cambridge and PwC, 2015, 22). The graph of innovative scenario to meet the energy demand may be found under the name Figure 2.

Figure 2

Annual Investment in New Electricity Generation



2.2.4. Innovation and Renewables

By the progression of technology, cost reduction on solar PV modules reached up to 80% in the last six years, and expected to reach 80% of countries around the world in two years time (Grom, 2013, 15). Wind power had utilized from the innovation as well. Nowadays, wind power is cheaper than oil and gas energy in most of OECD nations, and has a capacity to produce energy approximately 15 times more than a single turbine produce in year 1990 (Grom, 2013, 18).

2.2.5. Supply Factor on the Price of Renewable Energy Index

Bloomberg new energy finance (2012, 25) report shows that, the supply of renewable energy had exploded in recent years, while the investments on the sector had break a new record in 2011. The main reason behind the record investment level was the dependency on the renewable energy. The Kyoto Treaty and a binding agreement within the European Union's pressure on its members to reach the 20% of the renewable energy market share by year 2020 had created the dependency.

Another source with huge impact on the supply side is the availability and price of the required raw materials to produce sources of renewable energy. Neodymium is a metal that is essential for the construction of turbines. Silicon is a semi-conductor material, which is the most significant raw material of solar panels. With 97% portion of global production, China is the biggest producer of these raw materials. By holding the biggest proportion of the global production of renewables' raw materials, China has an advantage to control the market availability, and the price of these materials (Milmo, 2010). Because of these reasons, geopolitics plays an important role on the supply of renewable energy, as much as the supply of oil (Reuters, 2013).

Application of renewable energy is highly dependent on the economic development, because it is a long-term investment. Economies that are expecting or struggling with recession may not prefer to invest on renewable energy because of their cost. In long term, they are much more cheaper than other energy sources, but in short term, they are definitely way more expensive. This situation affects the government funding and tax deduction arrangements. That is why; Economic development has a huge impact on the attractiveness of renewable energy (Ernst and Young, 2013, 11).

2.3. The Correlation Between Renewables and Oil at the Present

The cumulative %44 oil price steep decline in June to December 2014 put the oil producers in a very though situation. And this arises a question of continuous alternative energy production? Since these kind of steep declines may occur in the future this will cause in the oil producing companies and countries instabilities. Another point of view tells us that the lower the oil prices more stable the world economy (Kilian, 2015).

The ongoing investment on renewable energy is larger than the investment combined on coal, natural gas and oil. In 2013 the world has new 143 gigawatts of renewable energy plants, which is 2 gigawatts more than fossil fuel energy plants. This was the first time in history that anything that surpass the fossil burning energy power plants. By the year 2030 this difference will 4 times in between renewables and fossil fuels. Solar and wind power producers are making the prices lower and lower every other day. As a result now only %1 of the worlds energy is produced by solar but by the year 2050 solar will be the largest source of energy according to International Energy Agency (Randall, 2015).

Since the crude oil prices are dropping very steeply this arises a new question will the solar energy companies will keep up the prices? US Energy Information Administration says that there is no head to head competition between fossil fuel and renewable energy producing and with the government support clean energy will hold its advantage against all rivals. By 2014 the green house gas emissions will still be increasing despite all the efforts of the President Obama. The highest percent of the electrical energy of USA comes from natural gas and coal so price drops in oil does not directly affect the US. The electric cars are becoming more popular in US so the price drops in crude oil might impact the electrical car companies cause the US residents will turn back to their trucks. But there are many factors affecting the electrical car companies also like the car ownership in US is going down because of the urbanization. Also to sell more cars some of these electrical companies make car-pooling available or free of charge charging (Goldenberg, 2015).

3. LITERATURE REVIEW

The relationship between oil and renewable energy index prices had been an attractant research topic for over fifteen years. However, attainability of renewables and developing technology had always become the key factors that are changing the results of the researches. Technological researches and improvements had change the characteristics of renewable products, and make them much more efficient, for lower costs through the years. Those developments had directly affects the renewable index prices on the stock market, and also their emphasis on the energy sector.

While analyzing the previous researches based on the correlation between oil prices and renewable energy stock indexes, author had especially pay attention to study academic publishes that are belong to different periods of time, especially last 8 years to reach the most efficient results. By analyzing the researches from past to present, author had aimed to examine the changes on both oil and renewables through time, and figure out the progress of renewables' and oil prices. As the thesis is going to concentrate on the global financial impact of oil to renewables, articles on global financial markets had been prioritized in order to find out the most efficient results through the research, because it was possible to misguide by the researches that were concentrated on the local markets.

In order to understand the Oil-Dollar Correlation, Grisse, (2010) article that is called 'What Drives the Oil-Dollar Correlation', which had been published by Federal Reserve Bank of New York had been examined. Christian (2010) defends that; US Dollar and oil prices had used to move together. However, that parallel correlation had turned into a negative relation in recent years. The reason behind this major change is actually the effect of the US Dollar on the demand of oil. Weaker Dollar boosts the oil demand, and increase its price because of stable supply, while stronger Dollar reduce the demand for oil, and decrease its price because of excessing stock. Weekly oil prices, US Dollar exchange rate, and short term US interest rate had been placed into the Vector Autoregression Model to illustrate this relationship.

Atems, Kapper, and Lam, (2015) had also argued that the exchange rates are responding asymmetrically to the oil market shocks, in their 'Do exchange rates asymmetrically to shocks in the crude oil market?' article which has been published in Energy Economics. Unlike to the Grisse (2010), this article had defended that; oil-specific demand shock may also cause the depreciation of the exchange rates. The response of the exchange rates relies on the positive/negative demand and supply shock. Monthly data from 1974 to 2013 on crude oil production, global economic activities, US Dollar exchange rate index, and bilateral exchange rate between the US Dollar and other currencies had been applied to VAR model to illustrate these findings.

Sadorsky, and Henriques, (2007) had concentrated on the 'Oil prices and the stock prices of alternative energy companies' on their article that had been published at Energy Economics. This article had argued that; technology stock prices are strongly influencing the alternative energy stock prices, while oil prices only have a tiny impact on the alternative energy companies' stock prices. Oil prices did not seemed to have a huge impact on alternative energy sector, because during those days investors are classifying renewable energy companies as a technology companies instead of the part of energy sector such as oil. Because of that viewpoint, not so many investors had treated renewables as an energy investment, and that provides a limited response to the oil shocks. Article had preferred to use WilderHill Clean Index (ECO), Arca Tech 100 Index, US West Texas Intermediate crude oil prices, and the interest rate as the data, and applied them in the VAR model to illustrate the findings.

Another research on 'Oil prices and Stock Prices of Alternative Energy Companies' had been made by Haung et al., (2012), that had been take place in Journal of Economics and Management. This paper had concentrated on the date range from 2001 to mid 2010 that had been divided into three time periods, and had investigated the long-term relationship between oil prices and renewables' stock prices. West Texas Intermediate oil price, Brent petrol price, NYMEX Crude Futures, and Wilderhill Clean Energy Index (ECO) had been used as a data in order to reach the research goal. The findings of this article show that there was not any interactive relation between oil and renewable energy prices in the first period. In the second period, the relation between oil prices and renewables started to be formed, and oil prices had started to affect the renewable energy companies' stock prices. Finally, in the third period, oil prices had started to generate a significant impact on the stock prices of renewable energy companies.

'Renewable Energy Opportunities in the Oil and Gas Sector' had discussed by the Switzer, Lovekin, and Finigan (2013). According to their report, it is possible to say that renewable energy technology had started to gain attention of industries and companies. That attention on renewables increased the threat on the oil and gas companies and hydrocarbon fuel business. In light of that idea, they had reached to the conclusion that defends; fossil fuels energy return on energy input rate is increasing, however the R&D that had been made on the renewable energy sector advanced the technology rapidly by reducing the total cost of the product and increased its importance on energy sector.

'The relationship between renewable energy assets and crude oil prices' had also been examined by Grom (2013) as a master thesis in financial economics at Norwegian School of Economics. First of all, thesis had introduced the oil and renewable energy sectors to its readers. The main idea of that chapter is to provide a better understanding of the characteristics of each individual sector, such as; what that sector had actually made of, what are the dependencies of that sector, what decides the price of the ingredients of that sector and what are the key factors that are affecting the demand and supply of each sector. The author had preferred to touch on the differences between the different types of oil (WTI, Brent, and Dubai). Later on, the key influencers of the oil price had been illustrated. The demand and supply had been determined as the most effective influencers of oil prices. Grom (2013) had also argued that, strong US Dollar has a significant effect on the oil prices. This idea had been supported with the idea that, change in the strength of the US Dollar is actually affecting the price of oil for non-Dollar countries and creating differences in their demand. Other strategic investment techniques that are also affecting the demand for oil had also been illustrated. Supply side of the oil had also been examined, and the problems that the industry face, such as; geopolitical effects had been illustrated. Renewable energy sector had also been observed in the same way. First of all, different types of renewable energy had been defined to the readers. Afterwards, the price making factors of renewable energy stocks had been examined. Grom had emphasized the importance of the knowledge and technology on the ascending demand for renewable energy. In order to understand the correlation between oil and renewable energy stock prices, WinderHill Clean Energy Index (ECO), The Ardour Solar Energy Index, The ISE Global Wind Index, S&P GSCI Biofuels Index, and WTI and Brent Oil prices had been selected as the related data. Vector Autoregression Model had applied in order to examine the relation between variables in econometrics way. The thesis had been finalized with the idea that, not all the subsectors of renewable energy had affected by the changes in oil prices, but renewable energy sector had affected in general.

Killian (2015) had concentrated on 'What caused the big fall in oil prices?' in the second half of the 2014. The article had also emphasized the economic stress on both oil and renewable energy sectors. Decreasing oil prices had created an economic stress on oil producers all around the world. Because of the tension that had created on the oil producers by the decreasing oil prices, sustainability of the renewable energy sector had been questioned at the beginning of that stressful time period. After a while, it has been understood that, the stress on the renewable energy sector was only a balloon on the financial sector, and growing concerns on the oil prices and its threats on the economic and political stability had disappeared and had left its place to strength to the global economy.

A report for the National Bank of Abu Dhabi by the University of Cambridge and PwC (2015) called 'Financing the Future of Energy: The opportunity for the Gulf's financial services sector' had meticulously studied. The report had been divided into 4 main chapters. First chapter had based on the scale of the investment opportunity. First of all, the gap between energy supply and demand had been revealed. The energy demand, carbon dioxide emission, and the global population are growing very rapidly. The energy demand is expected to keep growing for at least next twenty years, while the demand will triple todays demand by 2030.For now, it is not possible to construct an energy source that can create that amount of energy, but if the efficiency level of the current energy suppliers will be increased, reaching the demand might be possible. Today, it is necessary to invest on renewables because of the environmental factors. Meeting the aggregate demand mostly with oil and gas is actually boosting the carbon dioxide level, and pollution. That makes both the country and the world a less livable place. In order to prevent the pollution, governments had started to consider the alternative resources to produce energy. Investing on renewables, will accelerate the learning effect of deployment, production and process improvement, and further cost reduction. Descending cost of renewables had increased the market share of renewables in energy sector. The plunged oil prices in 2014, on the other hand, the cost of solar and wind power had also decreased steadily and rapidly. Reduction on the cost of renewables makes them more competitive against fossil fuels. In that case, any oil price that is higher than $20-30/bbl is still unlikely to decrease the demand for renewables. In chapter two, the deeper information had been given about the improvements of renewables through last few years. The reason why oil prices have to decrease down to $20-30 to affect the renewables' demand can be understood in this chapter. In last 6 years, the cost of solar power had decreased a significant 80%, while wind power generates the same amount of electricity for lower prices, because the wind turbine that had been produced in todays technology 15 times efficient than the typical wind turbine that had been built in 90's. Last two chapters had demonstrated the importance of the finance institutions on supporting the industry. Financial perspective had been added to the argument that had been argued in the first two chapters. Required global investments on carbon dioxide levels, R&D, renewables, and fossil fuels had been investigated. As a financial report, this report had also explore the tasks of the finance communities, lenders, governments, and insurance industries to improve the energy sector, and decrease the carbon dioxide level to generate a healthier place to live in.

The battle between fossil fuels and renewables in the recent financial situation had been observed by Randall (2015) on 'Fossil fuels just lost the race against renewables: This is the beginning of the end'. The article had defend that, the renewable energy sector had successfully passed the turning point to achieve the capacity to produce more power than coal, natural gas, and oil combined. From now on, it seems impossible to turn back to old-fashioned energy sources. According to the article, the shift of energy providing sectors had took place in 2013. In 2013, 143 gigawatts of renewable electricity capacity had been added in global based, while burning fossil fuels in the same period of time had produced 141 gigawatts according to the analysis of Bloomberg New Finance annual summit in New York. Renewables energy sources are expecting to be added more than four times by 2030. The cost of electricity that had produced by the renewable sources solar and wind powers are much cheaper than the electricity that is produced by using oil and gas. On the other hand, renewables are much more eco friendly than old-fashioned energy sources. That is why, renewables had already won the battle against the oil by their higher efficiency, lower costs, and eco friendliness.

The most wondered question of the research had been answered by Goldenberg (2015). The name of the article is actually revealing the result of the research; 'Low oil prices won't hurt renewable energy. Says US EIA'. This article had also touched upon the historic decrease of oil prices, and expectations on renewables to not be able to compete with the 6-year low price of oil. The article had give place to the speech of Energy Information Administration's head Adam Sieminski had clarified that government's incentives to increase the demand for renewable energy that aiming to reduce the greenhouse gas emissions, and research and development based creation of new areas based on renewable energy. In 2014, industrial-scaled solar power installations had doubled by the supports of the governments, and also decreasing prices of solar panels. Even the historic reduction of oil prices was not being able to decrease the demand for high efficiency renewables that takes place in the energy market for lower prices ever.

Table 1
Summary Review of the Literature

Study	Methodology	Variables	Results	Countries
Grisse, (2010)	Granger causality Wald tests, Variance decomposition, Impulse response functions	WTI spot price, US Dollar exchange rate, Short-term US interest rates	This study had figured out that, the parallel correlation of US Dollar and oil prices had turned into a negative relation in recent years. It had been observed that, weaker US Dollar is actually increasing the demand for oil, which causes an increase on its price, vice versa and creates a negative correlation between two variables.	Worldwide
Henriques, Sadorsky, (2007)	Unit root test, Granger causality tests, Impulse response functions	WilderHill Clean Energy Index (ECO), The Arca Technology Index (PSE), WTI Crude oil, Interest rate	As a 8 years old study, this paper had figured out that, technology stock prices are strongly influencing the renewable energy stock prices, while oil prices only have a tiny impact on the renewable energy stock indexes, because during those days investors were classifying renewable energy in a technology market instead of energy market.	Worldwide
Huang, et al. (2012)	Unit root test, Johansen cointegration test, Granger causality tests	WTI oil prices, Brent spot prices, NYMEX Crude Futures, WilderHill Clean Energy Index (ECO), Oil Index	This study had worked on the time period from 2001 to 2010. In order to analyse the data, the time period had divided into three periods. In the first period, no interactive relation between oil and renewable prices had been found, while the relation had started to be formed in the second period. In the third period, oil prices had started to generate a significant impact on the stock index prices of renewables'.	Worldwide

Grom, (2013)	Unit root tests, Johansen Cointegration test, Granger causality, Impulse response function, Normality test, Autocorrelation	WTI oil prices, Brent Blend, Dubai, NEW Index, Ardour Global Alternative Energy index, MSCI World Index	This study had figured out that the demand and the supply for the oil is the most effective influencer of oil prices, and US Dollar and oil prices have an asymmetric relation. Developments on renewable energy products by increasing knowledge, and technological development is boosting demand for renewable energy in recent years. As a result it had been found that, renewable energy stock index in general had been affected by the changes in oil prices.	Worldwide
University of Cambridge and PwC, (2015)	A report for the National Bank of Abu Dhabi by the University of Cambridge and PwC	Solar Power (Photovoltaics), Wind Power (On Shore-Off Shore), Coal, Oil, Gas, Nuclear Power, Geothermal, CO2 emissions, US Dollar, Gulf, Population, GDP, Total Primary Energy, Supply, Electricity, Global Investments on R&D, Global Investments, Energy efficiency, Primary energy consumption per capita, Economic vs. environmental performance	In epitome, the report had mentioned that; in order to meet the energy demand in 2030 that is estimated as triple of todays demand, efficiency level of the current energy suppliers has to be increased. While reaching the energy demand, environmental factors have to be considered. That is why; renewables are the future of the energy sector. The bias that plunged oil prices in 2014 is going to provide a competitive advantage on renewables had been rejected in the report. In order to compete with the innovated renewables that their costs had reduced 80% in last 6 years and 15 times more efficient according to the traditional ones, oil prices have to decrease down to $20-30/bbl according to the report.	Worldwide

Atems, Kapper, Lam, (2015)	Unit root test, Variance decomposition, Impulse response function	US Dollar exchange rate index, Australia/US, Canada/US, New Zealand/US, Norway/US, Sweden/US, UK/US, Global crude oil production, CPI, Crude oil prices	This recent study had figured out that, oil-specific demand shock is able to cause the depreciation/appreciation of the exchange rates.	Worldwide
Golden berg, (2015)	Head of Energy Information Administration , Adam Sieminski's speech on Chrisstian Science Monitor	Crude Oil prices, Greenhouse gas emission, Solar power, Wind power	The report had clarified that government's incentives to increase the demand for renewable energy that aiming to reduce the greenhouse gas emissions, and research and development based creation of new areas based on renewable energy. In 2014, industrial-scaled solar power installations had doubled by the supports of the governments, and also decreasing prices of solar panels. Even the historic reduction of oil prices was not being able to decrease the demand for high efficiency renewables that takes place in the energy market for lower prices ever.	United States
Killian, (2015)	Global Economic Prospects, by Worldbank	Crude Oil prices, alternative energy sources	The report had enlightened the stress on the renewable energy sector during the beginning of the period of oil price reduction. The stress on the renewable energy sector was only a balloon on the financial sector, and growing concerns on the oil prices and its threats on the economic and political stability had disappeared and had left its place to strength to the global economy.	Worldwide

Randall, (2015)	BNEF, IEA, Bloomberg New Energy Finance Annual Summit	Price of Solar power, Pricre of Wind power, Power generation capacity of Oil, Gas, Coal, Hydro, Nuclear, Solar, Wind, Biomass, and Geotherm.	The report defends that: from now on, it seems impossible to turn back to old-fashioned energy sources. According to the article, the shift of energy providing sectors had took place in 2013. In 2013, 143 gigawatts of renewable electricity capacity had been added in global based, while burning fossil fuels in the same period of time had produced 141 gigawatts. The cost of electricity that had produced by the renewable sources solar and wind powers are much cheaper than the electricity that is produced by using oil and gas. On the other hand, renewables are much more eco friendly than old-fashioned energy sources.	Worldwide
Switzer, Lovekin, Finigan (2013)	Pembina Institute	Research and Development, Technology, Electricity generation, Heating/Cooling, Renewable energy, Oil Sector, Gas Sector	This report put forth the importance of research and development that had been taking place on renewable energy sector rapidly reduced the total cost of the products while increasing their efficiency. These developments had increased the renewables significance on the energy sector, even when the energy return on the energy input rate of fossil fuels are decreasing.	Worldwide

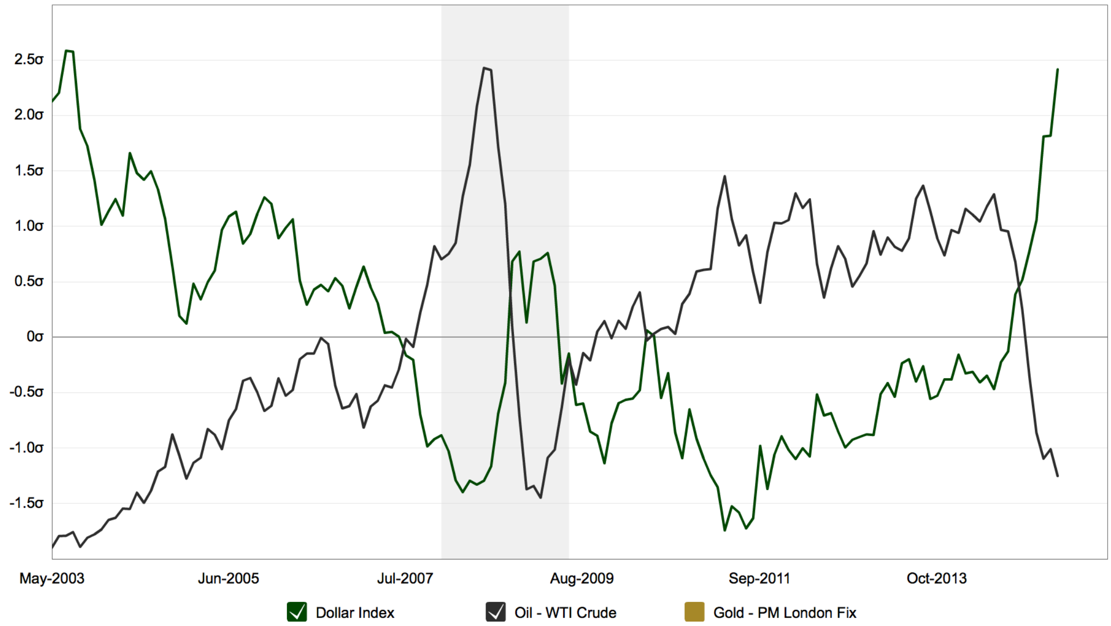
4. DATA AND METHODOLOGY

4.1. Data

Both oil and renewable energy indexes and stock prices were moving constantly. However, August 2014 had been a breaking point for US Dollar and oil prices. Statements of FED (Federal Reserve System) about the future of the interest rate had cause a sudden dramatic upsurge of US Dollar. As the thesis had mentioned in Chapter 2.1 before, there is a negative correlation between US Dollar and oil prices. Oil prices had been negatively affected by the appreciation of US Dollar in August 2014. Because of the continuous upward movement of US Dollar, oil keeps loosing value since May 2015. Correlation of US Dollar and oil price can be seen below (grey column represents recession): Figure 3

Figure 3

Correlation between US Dollar and Oil Prices



http://www.macrotrends.net/chart/1334/dollar-gold-and-oil-historical-chart

So how does actually falling oil price affects the demand on the energy sector? Is it going to reduce the demand for renewable energy? Will excessive demand boost the oil price? How will it affect the financial markets? In order to find the answer of these questions, thesis is going to concentrate on the related indexes and stock prices

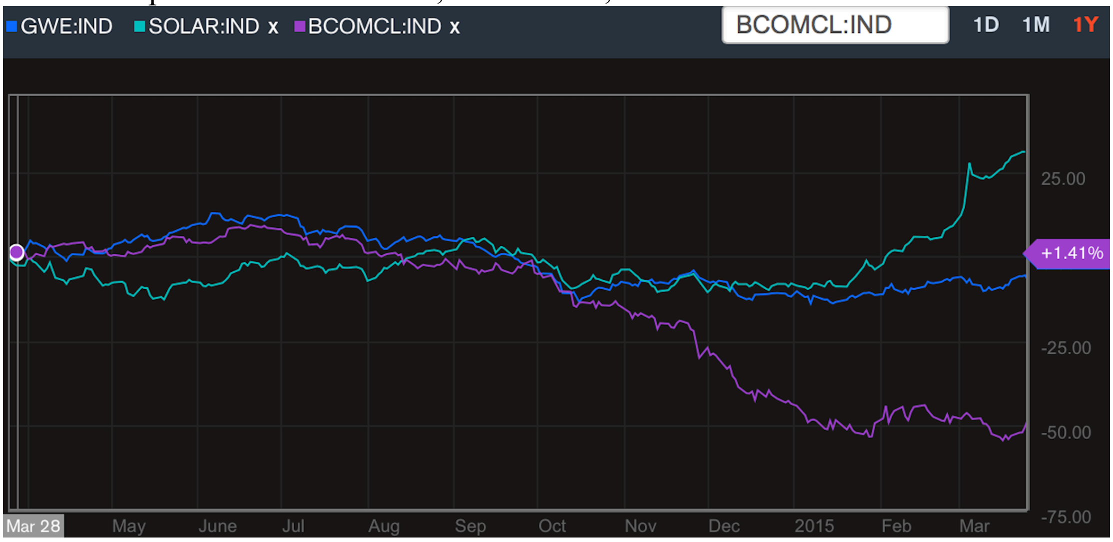
on financial markets.
In order to examine the recent situation in financial markets, thesis is going to study on a yearlong data, from 1st April 2014 to 31st March 2015. In order to find out the instant response of one to another, daily data of prices is going to be analyzed.

In order to introduce the correlation between two main renewable energy sources (solar and wind) and oil, Bloomberg's solar, wind, and oil indexes are going to be illustrated where, solar index had named as; SOLAR:IND, wind index had named as; GWE:IND, and crude oil index had named as; BCOMCL:IND.
The graph above illustrates the relationship between these three. It can be clearly seen that, both three were in a constant movement, until the oil prices gets into a negative trend. At first, both three were trending downwards. However, renewables' decline did not endure for too long. After only a week of decline, renewables' had gather and keep their constant movement. The reason behind the decrease of the renewable indexes was the speculations about the possible changes on the oil demand that may arrive by the decrease of its price. However, the innovative improvement on the renewable technologies that had increased the efficiency and reduce the cost of the renewables that had been identified in Chapter 2.2 disallows the renewable stocks to get a downward direction. Related figure can be found in Figure 4.

On January 2015, solar index price gets away from the constant movement and gets into an upward trend, while oil prices starts to get into a constant mood. What was the reason behind it? Is there an econometric relationship between oil and renewable energy index? Or is it just a random movement? In order to find out the scientific answer to these questions, next chapter is going to examine the datasets in detail with an assistance of econometrics program EViews. But first, thesis is going to introduce the variables on the next subtitle, which is going to be located in the econometric formulas.

Figure 4

Relationship between Solar Index, Wind Index, and WTI Oil Prices



http://www.bloomberg.com/quote/SOLAR:IND

4.1.1. NASDAQ OMX Green Economy Global Benchmark

The NASDAQ OMX Group had announced its green economy index in 22 September 2010. The aim of NASDAQ OMX Green Economy Global Benchmark Index is to provide daily information to investors, who are interested to invest to support clean, renewable and sustainable economic development (Lee and Fried, 2010). The Green Economy Global Benchmark Index aims to encourage economic development and finds sustainable solutions for; more efficient, cost effective, and cleaner energy production, cleaner transportation, better water management and usage, improved land usage, and clean and efficient waste management (NASDAQ OMX, 2015a). NASDAQ OMX Green Economy Global Benchmark Index accommodates five sub indexes. These sub indexes are; NASDAQ OMX Solar, NASDAQ OMX Wind, NASDAQ OMX Global Water, NASDAQ OMX US Water, and NASDAQ OMX Green Economy (NASDAQ OMX, 2015b). As the thesis had concentrated on the two most widely spread and popular renewable energy sectors, which are solar, and wind, NASDAQ OMX Solar, and NASDAQ OMX Wind index are going to be taken into consideration.

NASDAQ OMX Solar Index is a complication of the stocks of solar energy related companies that are actively producing, financing, researching, developing, and supporting the solar energy products and sector. During the next chapter, NASDAQ OMX Solar Index is going to be represented as 'Solar'. The overview information and price history of GRNSOLAR had been taken from the NASDAQ OMX's official website. Further information about GRNSOLAR can be found from: https://indexes.nasdaqomx.com/Index/History/GRNSOLAR

NASDAQ OMX Wind Index is a complication of the stocks of wind energy related companies that are actively producing, financing, researching, developing, and supporting the wind energy products and sector. During the next chapter, NASDAQ OMX Wind Index is going to be represented as 'Wind'. The overview information and price history of GRNWIND had been taken from the NASDAQ OMX's official website. Further information about GRNWIND can be found from: https://indexes.nasdaqomx.com/Index/History/GRNWIND

4.1.2. WilderHill Clean Energy Index (ECO)

WilderHill Clean Index (ECO) had been found in 13 September 1999. It is the first index that had been formed from entirely alternative energy companies' stocks. ECO incorporates 42 clean energy companies. ECO index has mainly formed by these alternative energy sectors: solar power, wind power, hydrogen and fuel cells, bio-fuels, and nuclear. The overview information and price history of the index had been found, and also further information about WilderHill Clean Energy index can be found at WilderHill's official website; www.wilderhill.com. During the next chapter, WilderHill Clean Energy Index is going to be represented as 'ECO'.

In order to examine alternative energy sector efficiently, ECO must be taken into consideration instead of NASDAQ OMX because of their components. ECO is directly rely on alternative energies such as; solar, wind, biofuels, and nuclear and able to give much more efficient result as a whole, while NASDAQ OMX includes water and waste sources. On the other hand, NASDAQ OMX provides much richer source of information on individual sectors of renewable energy indexes such as; Solar and Wind. That is why, author believes that, most accurate result can be achieved by examining ECO for alternative energy sector as whole, and examining the NASDAQ OMX Solar and Wind for most widely spread renewable energy sources Solar and Wind power.

The reason why the thesis includes ECO to the comparison, and examines if any correlation with oil price exists is, to find out if entire alternative energy sector or, only one or few components been affected by the decreasing oil prices.

4.1.3. WTI Crude Oil

As it had been mentioned before, WTI Crude Oil is going to be used as an indicator. WTI Crude Oil is the most common indicator of oil pricing. Cushing, Oklahoma is the main delivery point for the WTI Crude Oil. That is why, it has been considering as a benchmark for US Crude Oil. During the next chapter, WTI Crude Oil is going to be represented as 'Oil'. The price history data had been attained from: http://www.investing.com/commodities/crude-oil-historical-data

4.1.4. US Dollar

As thesis had mentioned before, Dollar is the currency of US, and also preferred to be used as a currency by Non-Dollar oil producing countries. That is why, Dollar can be pronounced as an international currency for oil. In order to examine the Dollar on its very pure value, US Dollar Index (DXY:CUR) is going to be used as an indicator. Any fluctuation on US Dollar can easily be monitored by looking at the DXY Index. During the next chapter, DXY Index is going to be represented as 'Dollar'. The price history data of DXY Index had been attained from: http://www.investing.com/quotes/us-dollar-index-historical-data

4.2. Methodology

In order to examine the relationship between oil and renewable energy, and their performance in stock market in recent past, thesis is going to apply econometrics methods to find out a scientific explanation. Samuelson, Koopmans, and Stone (1954) had defined the econometrics as; "*The integration of economic theory, mathematics, and statistical techniques for the purpose of testing hypotheses about economic phenomena, estimating coefficients of economic relationships and forecasting or* *predicting future values of economic variables or phenomena*".

In this chapter, thesis is going to clarify the econometrics methods that are going to be used briefly. These econometrics methods are; Vector autoregression, unit root test (both Augmented Dickey-Fuller, and Phillip-Perron tests), cointegration, granger causality, and impulse response function. Clarifying these econometrics methods will reduce the complexity, and offers a better understanding on further chapters.

4.2.1. Vector Autoregression

The vector autoregression model (VAR) may be identified as one of the most successful model for analyzing the multivariable time series (Zivot and Wang, 2006, 369). It were popularized by Sims (1980) as a natural generalization of univariate autoregression model to dynamic multivariate time series. System regression model may be illustrated to the appearance of more than one variable. VAR is a system regression model. It had been reflected as a mixture of the univariate time series models and simultaneous equations models (Brooks, 2008, 290). The usefulness of the model on for especially describing the dynamic behavior of economic and financial time series and forecasting had been proven (Zivot and Wang, 2006, 370). Generally, the Vector Autoregression model is a multi-variate way of modeling time series methodology and empowers to test the mutual encouragement of two variables. That's how changes in a particular variable are related to changes in its previous values (lags) and to changes in other variables and their lags. The VAR treats all variables as equally endogenous and does not force any boundaries on structural relationships (Grom, 2013, 30).

The simplest form of the VAR model is the Bivariate Vector Autoregression model. This model is the simplest form because it only contains two variables; y_{1t} and y_{2t}, whose value depend on different combinations of the previous p values (lags) of both variables and error terms:

$$y_{1t} = \beta 10 + \beta 11\, y_{1t-1} + \cdots + \beta 1k\, y_{1t-k} + \alpha 11 y_{2t-1} + \cdots + \alpha 1k\, y_{2t-k} + u_{1t}$$

$$y_{2t} = \beta 20 + \beta 21 y_{2t-1} + \cdots + \beta 2k y_{2t-k} + \alpha 21 y_{1t-1} + \cdots + \alpha 2k\, y_{1t-k} + u_{2t}$$

Both dependent variables are assumed as stationary, where $u1t$ and $u2t$ are uncorrelated white noise disturbance term with $E(u_{it}) = 0$, $(i = 1, 2)$, $E(u_{1t}u_{2t})=0$. This model can be expanded to a multivariate advanced order, where the variables are permitted to influence each other. This could be achieved by expanding the variables up to adding g variables as; y_{1t}, y_{2t}, y_{3t}, . . . y_{gt} to each equation. On the other hand, the model can also be expressed. If the case that had had been illustrated above had taken into account where $k = 1$, each variable is going to depend only upon immediately previous values of y_{1t} and y_{2t}, plus an error term, which can be written as (Brooks, 2008, 290);

$$y_{1t} = \beta 10 + \beta 11 y_{1t-1} + \alpha 11 y_{2t-1} + u_{1t}$$

$$y_{2t} = \beta 20 + \beta 21 y_{2t-1} + \alpha 21 y_{2t-1} + u_{2t}$$

or;

$$\begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \alpha_{11} \\ \alpha_{21} & \beta_{21} \end{pmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-1} \end{pmatrix} + \begin{pmatrix} u_{1t} \\ u_{2t} \end{pmatrix}$$

or even more compact as;

$$\underset{g\times 1}{yt} = \underset{g\times 1}{\beta 0} + \underset{g\times g\, g\times 1}{\beta 1\, y_{t-1}} + \underset{g\times 1}{ut}$$

4.2.1.1. VAR Lag Length Selection

The likelihood ratio (LR) is VARs one of the most essential, serious case, which can only be made by pairwise comparisons. If the lag length had not taken truly, it is not possible to reach the right conclusion. LR test has to be achieved successfully in order to test one set of lags at a time effectively. Information criterion is an alternative approach to select the appropriate VAR length. Information criteria do not require normality assumptions concerning the distribution of the errors. It is possible to add univariate criteria on each equation, however required lag number considered same for each equation (Brooks, 2008, 294). Multivariate form of the information criteria is required, which can be defined as:

$$\text{MAIC}= \log|\hat{\Sigma}| + 2k'/T$$

$$\text{MSBIC}=\log|\hat{\Sigma}| + \frac{k'}{T}\log(\text{T})$$

$$\text{MHQIC}=\log|\hat{\Sigma}| + \frac{2k'}{T}\log(\log(\text{T}))$$

Where $\hat{\Sigma}$ represents the variance=covariance matrix of residuals, T represents the number of observations, and k' represents the total number of regressors in all equations that had been illustrated above. This actually means that, the equations will be equal to $p^2k + p$ for p equations in the VAR system, which is with the k lags of the p variables, plus a constant term in each equation. The values of the information criteria are composed for 0, 1, . . . , $\bar{k}$ lags, and the number of lags that had been chosen is going to be the number that minimizes the value of the given information criterion (Brooks, 2008, 295).

4.2.1.2. Unit Root Test

Unit root test essentially test whether the non-stationary time series are using an autoregressive model. If the series is non-stationary, y_t has to be differenced d times before it had been converted to stationary. It had said to be integrated of order *d*. This can be formulated as: y_t ~ I(*d*). So if y_t ~ I(*d*) then $\Delta^d\ y_t$ ~ I(*0*). The methodology that had been illustrated how to apply the difference operator, Δ, d times, leads to an I(*0*) process, may be illustrative to; a process with no unit roots. Moreover, applying the difference operator more than *d* times to an I(*d*) process will still conclude in a stationary series. An I(*0*) series is a stationary series, while an I(*1*) series contains one unit root (Brooks, 2008, 326).

$$y_t = y_{t-1} + u_t$$

A series with two unit roots demonstrated as I(*2*). I(*2*) has needed to be differentiated twice to persuade stationary. I(*1*) and I(*2*) series can wander a long way from their mean value and hardly cross this mean value. On the other hand, I(*0*) series should regularly cross the mean value. The majority of financial and economic time series contain a single unit root, while some are stationary and some have been claimed to probably contain two unit roots (Brooks, 2008, 326).

$$y_t = 2y_{t-1} - y_{t-2} + u_t$$

In order to examine the unit root (non-stationary time series), Augmented Dickey Fuller (ADF) test, and Phillips-Perron (PP) test is going to be used.

Augmented Dickey Fuller test is an augmented version of Dickey-Fuller test. This is a test for a unit root in a time series, where it tests larger and more complicated set of time series. Negative number is used in the ADF test. The negativity of the number defines the rejection of the hypothesis that indicates the unit root at some point of confidence. As the number gets more negative, the rejection gets stronger. The ADF test adds lagged variables, and also the lags of Δy_t to 'soak up' any dynamic structure that had been presented in the dependent variable, to ensure that u_t is not auto correlated (Brooks, 2008, 329). The Augmented Dickey Fuller test can be formulated as:

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i\, \Delta y_{t-i} + u_t$$

Phillips-Perron test had been developed as a more comprehensive theory of non-stationary unit root. Phillips-Perron test has the same principle with ADF test. However, PP test incorporates an automatic correction to the DF procedure in order to allow auto-correlated residuals. However, non-parametric correction to the t-test statistic had been made by Phillips-Perron test. The test is robust with the respect to indefinite auto correlation it the disturbance procedure of the test equation. Generally, both tests finds out the same result, and mostly experience the same important limitations with the ADF test (Brooks, 2008, 330).

4.2.1.3. Cointegration

Engle and Granger (1987) had defined cointegration as; an econometric method for testing the relationship between non-stationary time series variables. Cointegration of series formed if, each of at least two series have an unit root that is *I(1)*, but a linear combination of them is stationary *I(0)* (Engle and Granger, 1987, 254). This actually means that, a long-term relationship exists, therefore it is possible for the variable to deviate in short-term.

There are two possible types to test the cointegration. These are; Engle-Granger test, which is a two-step test, and Johansen's test. Unlike the Engle-Granger test, the Johansen test allows more than one cointegration relationship, while supporting to include the fact that all variables are treated as endogenous (Grom, 2013, 36).

Johansen's test

In order to test the cointegration, several *I(1)* time series built on the VAR model, a set of *g* variables and *k* lags has to be contained. This can be formulated as;

$$\underset{g\times 1}{y_t} = \underset{g\times g}{\beta 1}\ \underset{g\times 1}{y_{t-1}} + \underset{g\times g}{\beta 2}\ \underset{g\times 1}{y_{t-2}} + \cdots + \underset{g\times g}{\beta k}\ \underset{g\times 1}{y_{t-k}} + \underset{g\times 1}{ut}$$

The VAR that had been illustrated above have to be changed into the VECM (vector error correction model), in order to be able to use the Johansen's test. VECM can be written as (Brooks, 2008, 350);

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t$$

where $\Pi = (\sum_{i=1}^{k} \beta_i) - I_g$ and $\Gamma_i = (\sum_{j=1}^{i} \beta_j) - I_g$

The VAR contains g variables in first differenced from the left hand side, and k−1 lags of the dependent variables from the right hand side, each with a Γ coefficient matrix attached to it. Moreover, the lag length that had been employed in the VECM can affect the Johansen test. That is why; it can be beneficial to select the optimal lag length. The test circles around the examination of the Π matrix. Π can be interpreted as a long-run coefficient matrix, since in equilibrium; all the Δy_{t-i} will be zero, and setting the error terms u_t to their expected value of zero will leave $\Pi y_{t-k} = 0$ (Johansen, 1988, 234).
The test for cointegration between the *y*'s is calculated by looking at the rank of the Π via its eigenvalues. Under the Johansen method, there are two test statistics. These are formulated as:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i)$$

and

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{t+1})$$

where r is the number of cointegration vectors under the null hypothesis and λ! is the estimated value for the *i*th ordered eigenvalue from the Π matrix. Intuitively, the larger λ! is, the bigger and negative ln(1 − λ!) will be, and hence the larger the test statistic. λ max conducts separate tests on each eigenvalue, and has its null hypothesis that the number of cointegrating vectors is r against an alternative of $r + 1$. The distribution of the test statistic is non-standard, and the critical values depend on the value of $g - r$.

The first test involves a null hypothesis of no cointegrating vectors (corresponding to Π with no rank). If this null is not rejected, it would be determined as; there are no cointegrating vectors. Also the testing would be completed. However, if $H_0 : r = 0$ is rejected, the null that there is one cointegrating vector, for example: H_0 : r = 1 would be tested and so on. Thus the value of r repetitively increased until the null is no longer rejected.

Π cannot be of full rank g because this would correspond to the original y! being stationary. If Π has zero rank, then by analogy to the univariate case, Δy! depends only on Δyt-1 not on yt-1 so that there is no long-run relationship between the elements of yt-1. Hence there is no cointegration. For 1 < rank Π < g, there are r cointegrating vectors. Π is then defined as the product of two matrices, α and β', of dimension g x r and r x g.

The β matrix gives the cointegrating vectors, while α gives the amount of each cointegrating vector entering each equation of the VCEM, also known as the 'adjustment parameters'. This matrix can be formulated as (Brooks, 2008, 353):

$$\Pi = \begin{pmatrix} \alpha_{11} \\ \alpha_{12} \\ \alpha_{13} \\ \alpha_{14} \end{pmatrix} (\beta_{11} \quad \beta_{12} \quad \beta_{13} \quad \beta_{14}) \begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{pmatrix}_{t-k}$$

and rewritten as:

$$\Pi \begin{pmatrix} \alpha_{11} \\ \alpha_{12} \\ \alpha_{13} \\ \alpha_{14} \end{pmatrix} = (\beta_{11}y_1 \quad \beta_{12}y_2 \quad \beta_{13}y_3 \quad \beta_{14}y_4)_{t-k}$$

4.2.1.4. Granger Causality

Clive W. J. Granger (1969, 424) had compose the Granger Causality test in 1969 in order to test if one time series can be used to forecast another time series in statistical way. Granger Causality is one of the main forecasting methods that uses the VAR. By using the t-tests and F-tests on lagged values, similarity between two different time series may be determined. Linear Regression models can be used in order to test the Granger Causality (Granger, 1980, 331).

$$X_1(t) = \sum_{j=1}^{p} A_{11,j} X_1(t-j) + \sum_{j=1}^{p} A_{12,j} X_2(t-j) + E_1(t)$$

$$X_2(t) = \sum_{j=1}^{p} A_{21,j} X_1(t-j) + \sum_{j=1}^{p} A_{22,j} X_2(t-j) + E_2(t)$$

There are two variables (X_1 and X_2) in this linear autoregression model. In this formula, *X* represents the Granger Cause time series, *p* represents the number of lags observed, *A* contains coefficients of the model, *E* represents prediction errors for individual time series, and $E(t)$ represents the white Gaussian random vector (Lutkepohl, 2005, 148). By using this test, it can be found if X_1 cause any changes on X_2. In case of causing the lags of other variable, it can be said that X_1 is significant in the equation of X_2. In that situation, it can be said that X_1 Granger-causes X_2, vice versa (Brooks, 2008, 298).

4.2.1.5. Impulse Response and Variance Decomposition

Applying the F-Test to examine the causality gives us an ability to find out the variable that has a significant impact on the other variables in the system. However, F-Test results are not capable to specify the relationship, and the duration of the linked effects that are going to take place. Moreover, the results cannot clarify whether the impact on variables are going to be positive or negative. In order to reach those information, impulse response and variance decomposition of the VAR has to be examined. Impulse response helps us to find out the sensitivity of the dependent variables in the VAR that has an impact on the other variables. Unit shock has to be applied to the error, and its impact on the VAR over time has to be noted for each variable separately. Therefore, the change in the value of the variable can be determined, whether it is a positive or negative impact for a time interval on the other variables (Brooks, 2008, 299). The impulse response that considered the bivariate VAR can be illustrated as:

$$y_t = A_1 y_{t-1} + y_t$$

Where

$$A_1 = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix}$$

This can also be rewritten as:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}$$

The effect of a unit shock to y_{1t} at time $t = 0$

$$y_0 = \begin{bmatrix} u_{10} \\ u_{20} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$y_1 = A_1 y_0 = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0.5 \\ 0 \end{bmatrix}$$

$$y_2 = A_1 y_1 = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix} \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} = \begin{bmatrix} 0.25 \\ 0 \end{bmatrix}$$

Variance Decomposition may be defined as an alternative method to the impulse response function. Variance decomposition regulates the forecast error variance for any variable. Up to a point, variance decomposition and impulse response actually offers identical results. However, tiny differences on the methodology while investigating the VAR system dynamics can be found. Variance decompositions provide the movements in the dependent variables as their own shocks, instead of other variables' shocks. Variable can be affected by any shock on the ith variable. Moreover, not only the variable that had been shocked, but also all the other variables in the system through the dynamic structure of the VAR will also be affected through that shock. The main purpose of the variance decomposition is to identify how much of the s-step-ahead forecast error variance of a given variable is enlightened by innovations to each explanatory variable for s=1,2, . . . In a point of fact, it is frequently observed that shocks that have been made by the series on their own explains most of the forecast error variance of the series in the VAR. The complete component of the errors is qualified slightly randomly to the first variable in the VAR, on the background of a bivariate VAR. The interpretation of the VAR with two variables is the same, while the calculations are more complex in general. Restriction in effect involves an 'ordering' of variables, so that the equation for y_{1t} would be expected first and then that of y_{2t}, a bit like a recursive or triangular system (Brooks, 2008, 301).

5. EMPIRICAL ANALYSIS

In this chapter, thesis is going to investigate the relationship between US Dollar (DOLLAR), WTI Crude Oil (OIL), Solar Power Index (SOLAR), Wind Power Index (WIND), and WilderHill Clean Energy Index (ECO) by using Vector Autoregressive Model. These variables will be represented through each data series as; LDOLLAR, LOIL, LSOLAR, LWIND, and LECO , and DLDOLLAR, DLOIL, DLSOLAR, DLWIND, and DLECO as their first differences in order to reduce unwanted variability. First of all, unit root test is going to take place, which is going to be followed by (Johansen's Cointegration Test, Granger Causality Test, Impulse Response, and Variance Decomposition. These tests are aiming to reveal the connection between oil and renewable energy sector, and how does fluctuation of one affects other in financial market of today.

5.1 Unit Root Test

Table 2 presents the results of unit root test for Dollar Index, WTI Crude Oil, Solar Index, Wind Index, Clean Energy Index, and also S&P 500, NASDAQ, and Dow Jones, which are the most popular American stock market indexes. Unit root had been tested for both short term (from 01.04.2014 to 31.03.2015) and also long term (from 02.01.2013 to 31.03.2015). The integration properties of the data are going to be investigated by using Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests. The lag length in the ADF regression had been selected by using the information criterion. The optimal lag length had also been illustrated in Table 2. Test static is statically significant at the 1%, 5%, or 10% level of significance, which had been denoted by ***, **, *.

Table 2

Unit Root Test

	LAG Length	Levels		First Difference			
Short Term		**ADF**	**PP**	**ADF**		**PP**	
Oil	2	0.279351	0.300687	-9.317336	***	-19.16908	***
Dollar	3	0.963643	1.064306	-6.913846	***	-17.85401	***
ECO	0	-1.806734	-1.806734	-14.32755	***	-14.32755	***
Solar	2	-1.85269	-1.742023	-8.593199	***	-12.77651	***
Wind	0	-1.38541	-1.38541	-15.68586	***	15.68586	***
NASDAQ	0	-0.999152	-0.999152	-15.39628	***	-15.39628	***
S&P500	0	-1.740445	-1.740445	-16.26238	***	-16.26238	***
Dow Jones	0	-1.832543	-1.832543	-17.235678	***	-17.235678	***
Long Term							
Oil	2	-1.710471	-0.828643	-3.90019	**	-5.680329	***
Dollar	0	-0.516072	-0.516072	-9.21051	***	-9.21051	***
ECO	0	-1.403764	-1.403764	-8.328781	***	-8.328781	***
NASDAQ	0	-0.638149	-0.638149	-9.203123	***	-9.203123	***
S&P500	0	-0.681013	-0.681013	-9.161183	***	-9.161183	***
Dow Jones	0	-1.009341	-1.009341	-9.633788	***	-9.633788	***

As it had been mentioned before at Chapter 4.2.1.2, the negativity of the number defines the rejection of the hypothesis that indicates the unit root at some point of confidence. As the negativity of the number increase, the rejection gets stronger. Both of the short term and long term data shows that, the null hypothesis for the ADF and PP tests is that the series has a unit root, and all unit root tests regressions include an intercept. Both of the ADF and PP tests indicates the each variable is integrated of order 1 *I(1)*, because of the non stationary time series. Rejection of null hypothesis allowed by *I(1)* and the test had been repeated with differenced variables. Further information can be found in Appendix 2.

5.2. Cointegration

Johansen's Countegration Test is going to take place in order to test cointegration of several *I(1)* time series. The test results have presented in Table 3. There are two types of Johansen's test, which are; trace test and max-eigenvalue test. The trace test tests the null hypothesis of *r* cointegrating vectors against the alternative hypothesis of *n* cointegrating vectors. If the *r* is equal to zero, this means that there is no relationship among the variables that is stationary. On the other hand, the max-eigenvalue test tests the null hypothesis of *r* cointegrating vectors against the alternative hypothesis of *(r+1)* cointegrating vectors (Ssekuma, 2011, 53). Johansen's test is going to be performed to determine the maximum possible cointegration relationship between five variables, which are; LOIL, LSOLAR, LWIND, LECO, and LDOLLAR.

According to the Trace test, the hypothesis of null hypothesis is rejected at 5% (critical value: 0.05). As it can be seen at the Prob.** column, first three vectors had rejected the hypothesis at the 0.05 level. This actually means that there are at least three cointegration relations between the variables. Max-eigenvalue test had also rejected the null hypothesis at the 0.05 level, and had also find the result that, there are at least three cointegration relation between variables.

Table 3

Johansen's Cointegration Test

Hypothesized	R = 0	R = 1	R = 2	R = 3	R = 4
Trace	0.262142*	0.203719*	0.118596*	0.052944	0.019931
Critical value	88.8038	63.8761	42.91525	25.87211	12.51798
Max-Eigen	0.262142*	0.203719*	0.118596*	0.052944	0.019931
Critical value	38.33101	32.11832	25.82321	19.38704	12.51798

* denotes rejection of the hypothesis at the 0.05 level

Normalized cointegrating coefficient in the equation below had applied to notice the relationship between OIL, SOLAR, WIND, ECO, and DOLLAR. Normalized cointegration equation can be written as;

$$OIL=11.86SOLAR -10.14WIND -7.49ECO -25.88DOLLAR$$

The results of normalized cointegration equation are reversed to enable proper interpretation. Normalized cointegration equation provides the information that; solar is statically significant according to the test results that are shown above. In this case, it can be said that, OIL and SOLAR are positively integrated. On the other hand, WIND, ECO, and DOLLAR are negatively integrated with OIL. Therefore, these variables are cointegrated in the long term. Further information can be found in Appendix 3.

5.3. Granger Causality Test

Identifying whether a time series is a useful instrument in order to forecast the movements of another time series can be achieved by granger causality test. Table 4 represents the granger causality test for OIL, SOLAR, WIND, ECO, and DOLLAR. All the tests are using an intercept with no trend, and the null hypothesis denotes that the series has a unit root. Vector Error Correction Model had applied when two series are cointegrated according to the Table 4 ***, **, * significant at the 1%, 5%, and 10% critical level. VAR is going to be applied on variables' first difference in order to determine the interactive relationship between the variables because, all the variables that had been used are I(1) and not statistically cointegrated. Granger Causality Test results can be found in Table 4, further information can be found in Appendix 8. The lag number for the causality test had been determined as 17. According to the findings by granger causality test, it can be briefly said that, Oil has a great cause on Solar, Wind, and ECO Index prices, but does not cause Dollar. On the other hand, Dollar causes the Oil prices. If the results been examined deeply, it is possible to find out that; Dollar Granger causes Oil at 5% significance level, however Dollar does not Granger causes renewable energy index. On the other hand, Oil Granger causes Solar and ECO Index at 5% significance level, while Granger causes the Wind at 10%

significance level. However, renewable energy sector does not granger cause Oil and Dollar according to the Granger causality test. These findings show that; Granger Causality test supports the relationship between Dollar and Oil prices that had been declared in Chapter 2.1.1. The relationship between variables also confirms that; Oil still dominates the energy industry, however renewable energy sector does not have to wait until a dramatic decrease on the demand for oil in order to reach to a commemorative market share in today's market. Even renewable energy is now gaining that potential to increase its market share, while oil prices are decreasing, by increasing renewable energy products' efficiency, and decreasing their costs. Further information can be found in Appendix 4.

Table 4

Granger Causality Test

Dependent variable: DLOIL				
Excluded	Chi-sq	df	Prob.	
DLSOLAR	31.80198	17	0.0159	**
DLWIND	26.99455	17	0.0581	*
DLECO	27.93403	17	0.0457	**
DLDOLLAR	20.93654	17	0.2291	

Dependent variable: DLDOLLAR				
Excluded	Chi-sq	df	Prob.	
DLOIL	29.24862	17	0.0323	**
DLSOLAR	13.57992	17	0.6966	
DLWIND	13.64674	17	0.6919	
DLECO	17.12945	17	0.4456	

5.4. Impulse Response

The impulse response function is presented in Appendix 9. The main point of the impulse response is to illustrate the response of an asset to the change of other. Responses of the variables; Oil, Solar, Wind, ECO, and Dollar are going to be investigated. Figure 5 shows the response of each variable in the system to a one standardized innovation of each variable in the system. Standard errors that had been calculated analytically are used to construct confidence intervals that are going to gauge the significance of each impulse response. First difference of the variables had selected to be used, and short-term relation between variables had been investigated.

In first place, a one standard deviation shock to the Dollar has a positive and significant impact on itself, however it has a negative and significant impact on all other variables (oil, solar, wind, and eco). The impact of Dollar shock had sustained without an impact for first three lag lengths on oil, solar, and wind. Negative response of oil, and solar to the shock on Dollar can be gauged as a whole afterwards. On the other hand, one standard deviation shock to the oil has a positive but not significant impact on dollar at the first lag, then the impact becomes negative and still not significant, while dollar response positively to the shock of solar stock index. One standard deviation wind stock index price shock has a fluctuating impact on the Dollar. These positive and negative responses to the shocks that had been described above may be associated to the impact of Dollar currency on the demand of energy sector in general, which had been defined in Chapter 2.1.1. The demand on solar power, wind power, or other alternative energy sector that is included in clean energy index may vary both on the local currency, and geographical situation. That is why; Dollar shock may not have a significant effect on solar and ECO index in very short amount of time, while it is affecting wind index.

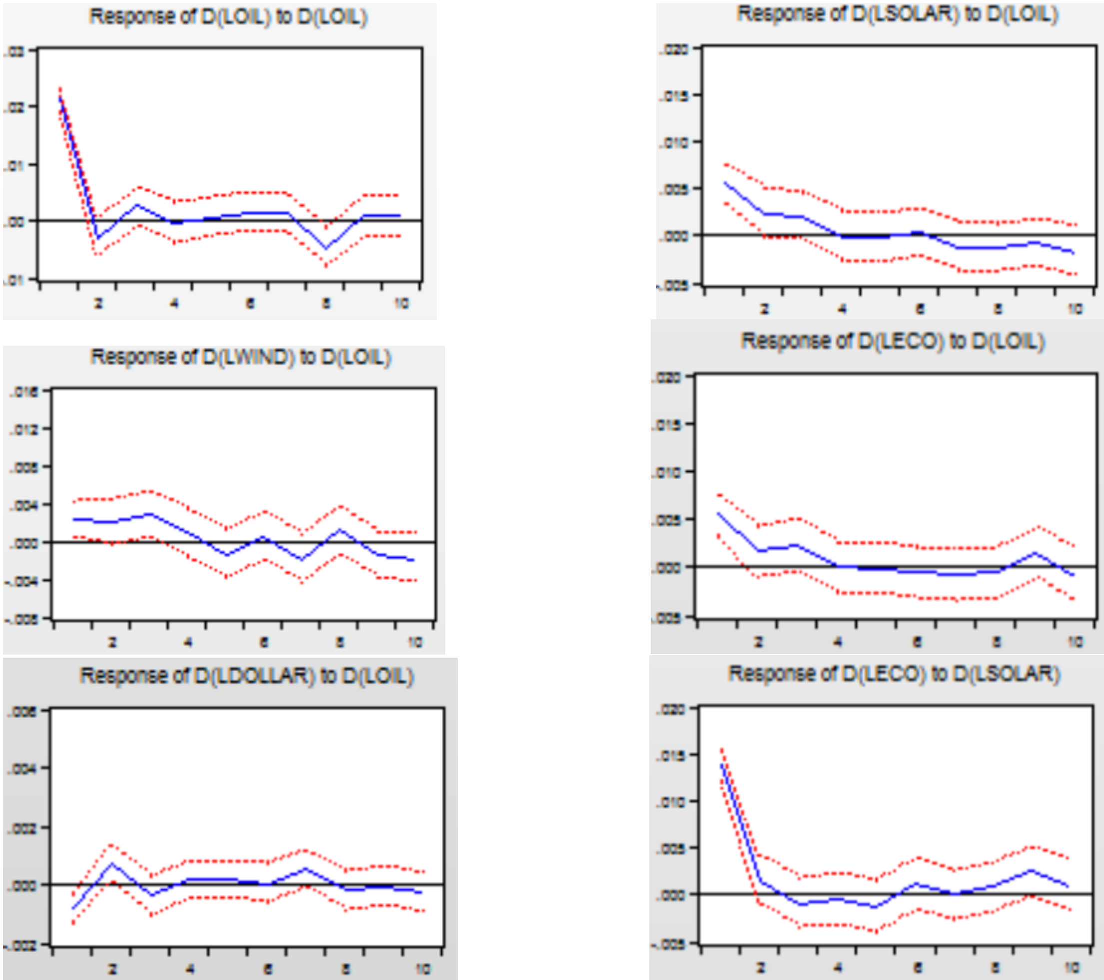
On the other hand, oil has a swift positive response to a shock to itself. A one standard deviation shock to oil prices has a positive and significant impact on solar stock index price for 4^{th} lag length. The response of the solar index to the shock on oil prices actually defines that; solar power had achieved to be a part of energy sector, without any dependency on others failure. The shock to the natural logarithm of oil prices has an impact around 1.005 points on the solar stock index price. It is possible to find out the same positive response to oil shock by the wind stock index, but with lower response, longer lag length and spikier positive and negative changes. Not surprisingly, clean energy index responses positively to the shock on oil as well, with higher than an average value of its two biggest players solar and wind. Clean energy index responses with 1.0056 points at first, and positive impact continue up to 4^{th} lag length. The most important factor that's underlying the positive response of renewable energy index to the shock on oil prices is undoubtedly R&D. Improvements on these technologies that renders them more efficient and cost effective had also increase their market share, and provides a major potential on energy market. On the other hand, a one standard deviation solar stock index and also wind stock index shocks have no statistically significant impact on oil prices. This proposes that, solar stock index and wind stock index shocks are not as important as oil price shocks for energy sector. Not surprisingly, the attitude of oil prices to solar and wind stock index shocks reflects the response of oil to clean energy index shock. It statically has no significant impact on oil prices as well.

So how does solar and wind stock index prices actually responses to a standard deviation shock of the clean energy index? Both solar and wind stock index prices are responding positively and significantly to a standard deviation shock of the clean energy index. However clean energy index does not response to the changes of the wind stock index, while it is responding positively and significant to the changes of the solar stock index price.

As a result, the Appendix 9 had gauge that, shocks to Dollar have a negative impact on both oil and renewable energy sector, shocks to oil price have a positive impact on renewable energy sector, while shocks to renewable energy sector does not have a significant effect on oil prices. Further information can be found in Appendix 5.

Figure 5

Impulse Response



5.5. Variance Decomposition

The variance decomposition signifies information about the contribution of a variable to the other variable in the autoregression. The forecast error variance of each variable by exogenous shocks to other variables can also be identified by variance decomposition. Table 5 represents the variance decomposition for OIL, SOLAR, WIND, ECO, and DOLLAR. The column S.E. is the forecast error of the each variable for each forecast horizon. Other columns with the name of variables give the percentage of the variance due to each innovation.

Appendix 10 shows that, Oil mostly affected by Dollar's shock. On the other hand, the biggest influencer of the Solar Index price is Oil prices. Oil prices are affecting the solar prices up to nearly 16%, while Wind Index has nearly 4%, ECO has nearly

5% and Dollar has nearly 4% during the given period of time. Oil prices does not have that much impact on wind, like it has on the solar, but it is still affecting the wind by 9%. The biggest influencer of the wind prices is its main rival in the renewable energy sector, which is the solar. Solar is affecting the wind prices by nearly 17%. ECO also has a respectable impact on the wind with its 7.5% portion. But which one of them actually sets the price of the ECO? As it might be expected, it is the solar index. Solar power is one of the most advantageous renewable energy source in the market because of its compatibility. As the thesis had mentioned before in Chapter 2.2.5 it is not easy to deliver a huge wind power, and to apply it in a small industries or even on an individuals home, but solar power sources have all those abilities that wind power does not have. Is that really affecting the solar/wind balance on the ECO? The answer is yes. Solar Index has an enormous 56.7% impact on the ECO, while Wind Index is only influencing the price of ECO by 6% which is two times less than the effect of the Oil price.

It is accurate to interpret the result of variance decomposition as; Oil prices has enormously influenced by the Dollar price. Solar Index responses to the oil price shock that had been caused by the Dollar shock. As the biggest player of the renewable industry, responses of the solar index to the oil shocks have a direct impact on the Clean Energy Index. On the other hand, progressive renewable energy sector also has a tiny influence on the oil prices and the Dollar. This actually demonstrates that renewables are getting stronger in the energy market. Further information can be found in Appendix 6.

Table 5

Variance Decomposition

Variance Decomposition of DLOIL:						
Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.02189	100	0	0	0	0
5	0.023945	87.50961	1.455924	1.142821	4.551398	5.340247
10	0.025997	78.73131	4.496332	3.340502	6.563755	6.868103
Variance Decomposition of DLSOLAR:						
Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.016089	12.92867	87.07133	0	0	0
5	0.017566	13.72002	77.51225	1.67453	4.00021	3.092991
10	0.018759	15.63753	72.46693	3.430541	4.893995	3.571003

Variance Decomposition of DLWIND:						
Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.014896	0.374618	10.9806	88.64479	0	0
5	0.017359	5.610259	17.01716	67.14254	6.171027	4.059021
10	0.018563	9.397396	16.8305	61.9223	7.535854	4.313946
Variance Decomposition of DLECO:						
Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.016646	11.03691	67.13104	0.157464	21.67459	0
5	0.018091	11.56468	59.057	3.645989	21.47643	4.255905
10	0.019234	12.07393	56.64651	5.84473	20.42677	5.00807
Variance Decomposition of DLDOLLAR:						
Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.00385	5.238704	5.146326	1.438757	0.003433	88.17278
5	0.004053	8.549397	5.179334	2.8936	2.13394	81.24373
10	0.004459	10.67779	7.207173	3.837022	6.734303	71.54371

6. CONCLUSION

The second half of the 2014 had created an unique experience to explore the most wondered interaction in the energy sector. Sharp shrinkage of oil prices, and its financial effects on the renewable energy indexes had been explored through the thesis. Briefly, the key ideas that underlie the thesis are; US Dollar has a significant effect on the WTI Crude Oil prices. Not every oil supplier/demander country is using dollar as a local currency. Changes on the US Dollar asymmetrically affects the price of oil, because; appreciation of US Dollar, increases the price of oil for non-Dollar countries, and this causes a decline on their demand, vice versa. During the time series that had been takes place in the analysis, asymmetric relationship between Dollar and Oil can be observed. On the other hand, decrease on the index prices of renewable energy was expected, however it was out of unfounded. The R&D that had been taken place through recent years had increased the efficiency of renewables, while decreasing their costs. Through last 6 years, cost of solar power had reduced by 80%, while the efficiency of wind power multiplied with 15 according to the classic 90's turbines. The innovative changes that took place on the renewables, provides a competitive advantage for them on the energy market. The researched had found that, concerns about the affects of reduced oil prices on renewable energy indexes were unwarranted. In terms of todays' cost for renewable energy, WTI Crude Oil prices must fall somewhere between $20-30/bbl to generate a significant effect on the renewable index prices.

In order to understand this interaction, econometric analysis of time series had been made. In light of earlier researches on the identical subject, US Dollar Index (DXY), WTI Crude Oil, WilderHill Clean Energy Index (ECO), NASDAQ OMX Solar Index, and NASDAQ OMX Wind Index had been selected as the key variables of the analysis. The Vector Autoregression Model had tested the variables. Unit root test, Johansen's cointegration test, Granger causality test, impulse response, and variance decomposition took place through the analysis. Unit root test revealed that, all series are I(1), which provides an efficient cointegration test. Through the cointegration test, both Trace test and Max-eigenvalue test had been examined. At least three cointegration, with rejection of the hypothesis at the 0.05 level had been found between variables in both Trace and Max-eigenvalue tests. The 1st Cointegration equation revealed the cointegration equation as;

$$OIL = 11.86SOLAR - 10.14WIND - 7.49ECO - 25.88DOLLAR.$$

The results of Granger causality test indicate that, Solar, Wind, and ECO had granger caused by Oil by 5%, 10%, and 5%. On the other hand, oil had granger caused by Dollar by 5%. The impulse response results show that, Solar, Wind, and ECO is directly responding to the Oil shock, while Oil is directly responding to the Dollar shock. The impact of the oil shock lasts for 3 to 4 lag length for Solar, Wind and ECO.

As a result, it is possible to say that; technological development had increased the market share of renewable energy and renewables had become an indispensable part of energy sector. General demand shocks are affecting the renewable index prices, however declining oil prices won't hurt renewables, specially solar power index prices. Even if all the energy sector indexes fall by the energy demand shock, renewables are able to recover, and get in an increasing trend, while oil still struggles and continues its constant movement.

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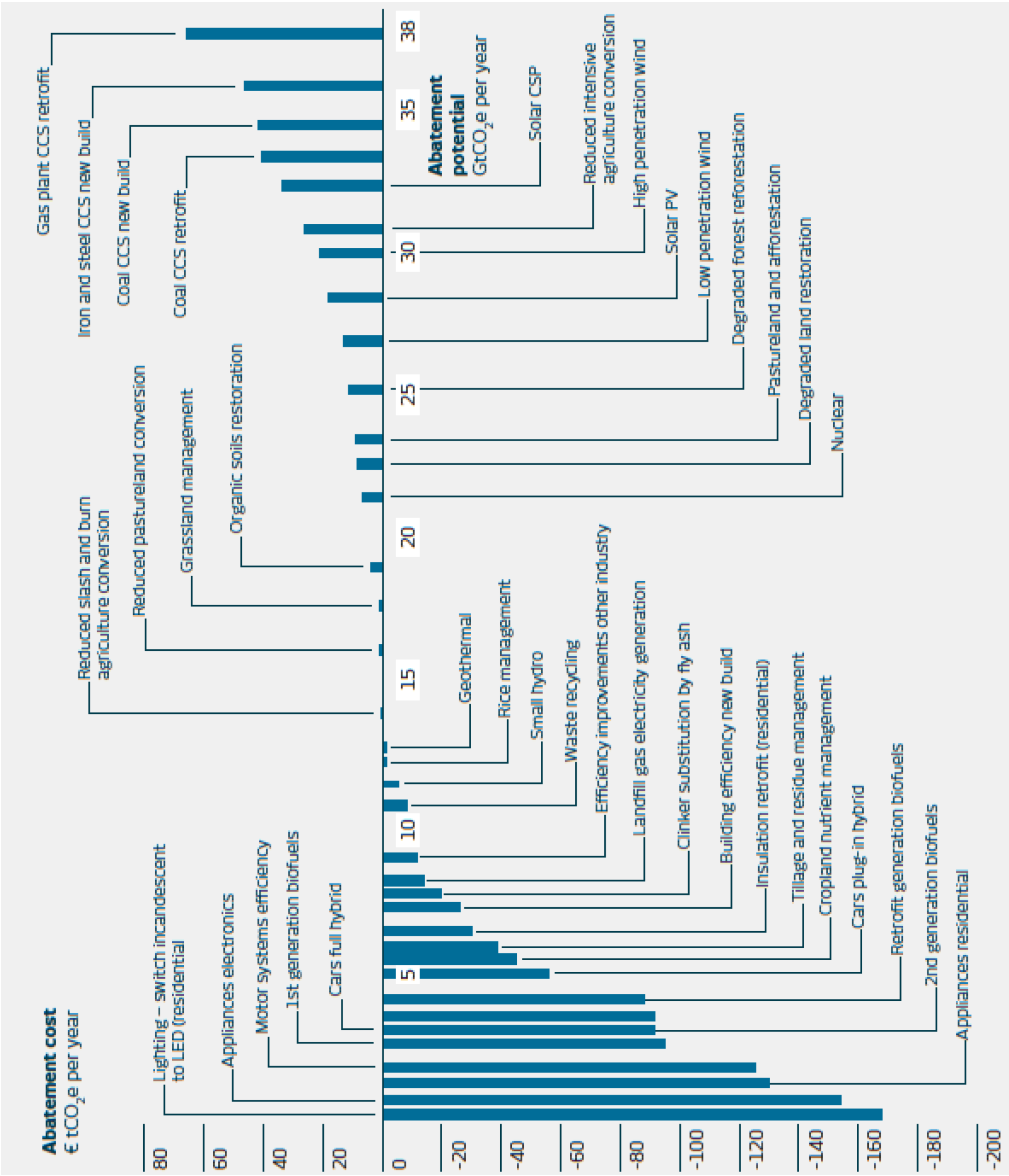
8. APPENDIX

APPENDIX 1

Marginal Abatement Costs to 2030



APPENDIX 2

Unit Root Test

	LAG Length	Levels		First Difference			
Short Term							
		ADF	PP	ADF		PP	
Oil	2	0.279351	0.300687	-9.317336	***	-19.16908	***
Dollar	3	0.963643	1.064306	-6.913846	***	-17.85401	***
ECO	0	-1.806734	-1.806734	-14.32755	***	-14.32755	***
Solar	2	-1.85269	-1.742023	-8.593199	***	-12.77651	***
Wind	0	-1.38541	-1.38541	-15.68586	***	15.68586	***
NASDAQ	0	-0.999152	-0.999152	-15.39628	***	-15.39628	***
S&P500	0	-1.740445	-1.740445	-16.26238	***	-16.26238	***
Dow Jones	0	-1.832543	-1.832543	-17.235678	***	-17.235678	***
Long Term							
Oil	2	-1.710471	-0.828643	-3.90019	**	-5.680329	***
Dollar	0	-0.516072	-0.516072	-9.21051	***	-9.21051	***
ECO	0	-1.403764	-1.403764	-8.328781	***	-8.328781	***
NASDAQ	0	-0.638149	-0.638149	-9.203123	***	-9.203123	***
S&P500	0	-0.681013	-0.681013	-9.161183	***	-9.161183	***
Dow Jones	0	-1.009341	-1.009341	-9.633788	***	-9.633788	***

APPENDIX 3

Johansen's Cointegration Test

Series: LOIL LSOLAR LWIND LECO LDOLLAR
Exogenous series: DUM01 DUM02 DUM03
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 23

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.262142	167.0271	88.8038	0
At most 1 *	0.203719	97.71425	63.8761	0
At most 2 *	0.118596	45.77516	42.91525	0.0252
At most 3	0.052944	16.99274	25.87211	0.4155
At most 4	0.019931	4.590115	12.51798	0.6559

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.262142	69.31287	38.33101	0
At most 1 *	0.203719	51.93909	32.11832	0.0001
At most 2 *	0.118596	28.78242	25.82321	0.0198
At most 3	0.052944	12.40262	19.38704	0.3786
At most 4	0.019931	4.590115	12.51798	0.6559

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Johnsen’s Cointegration Test

1 Cointegrating Equation(s):	Log likelihood	4025.515

Normalized cointegrating coefficients (standard error in parentheses)

LOIL	LSOLAR	LWIND	LECO	LDOLLAR	0.142857143
	-				
1	11.86403	10.13592	7.466873	25.88426	-0.007191
	-2.44986	-1.69418	-2.13152	-5.86079	-0.00321

Adjustment coefficients (standard error in parentheses)

D(LOIL)	0.007822
	-0.01185
D(LSOLAR)	0.006808
	-0.00907
	-
D(LWIND)	0.037569
	-0.00728
D(LECO)	0.005598
	-0.00949
	-
D(LDOLLAR)	0.004226
	-0.00206

APPENDIX 4

Granger Causality Test

VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: DLOIL

Excluded	Chi-sq	df	Prob.
DLSOLAR	31.80198	17	0.0159
DLWIND	26.99455	17	0.0581
DLECO	27.93403	17	0.0457
DLDOLLAR	20.93654	17	0.2291
All	97.14726	68	0.0117

Dependent variable: DLSOLAR

Excluded	Chi-sq	df	Prob.
DLOIL	9.198365	17	0.9338
DLWIND	13.34086	17	0.7131
DLECO	7.54678	17	0.9753
DLDOLLAR	15.61746	17	0.5511
All	46.97189	68	0.9758

Dependent variable: DLWIND

Excluded	Chi-sq	df	Prob.
DLOIL	22.25148	17	0.1752
DLSOLAR	10.60063	17	0.8766
DLECO	17.39661	17	0.4278
DLDOLLAR	19.74582	17	0.2874
All	81.84997	68	0.1207

Dependent variable: DLECO

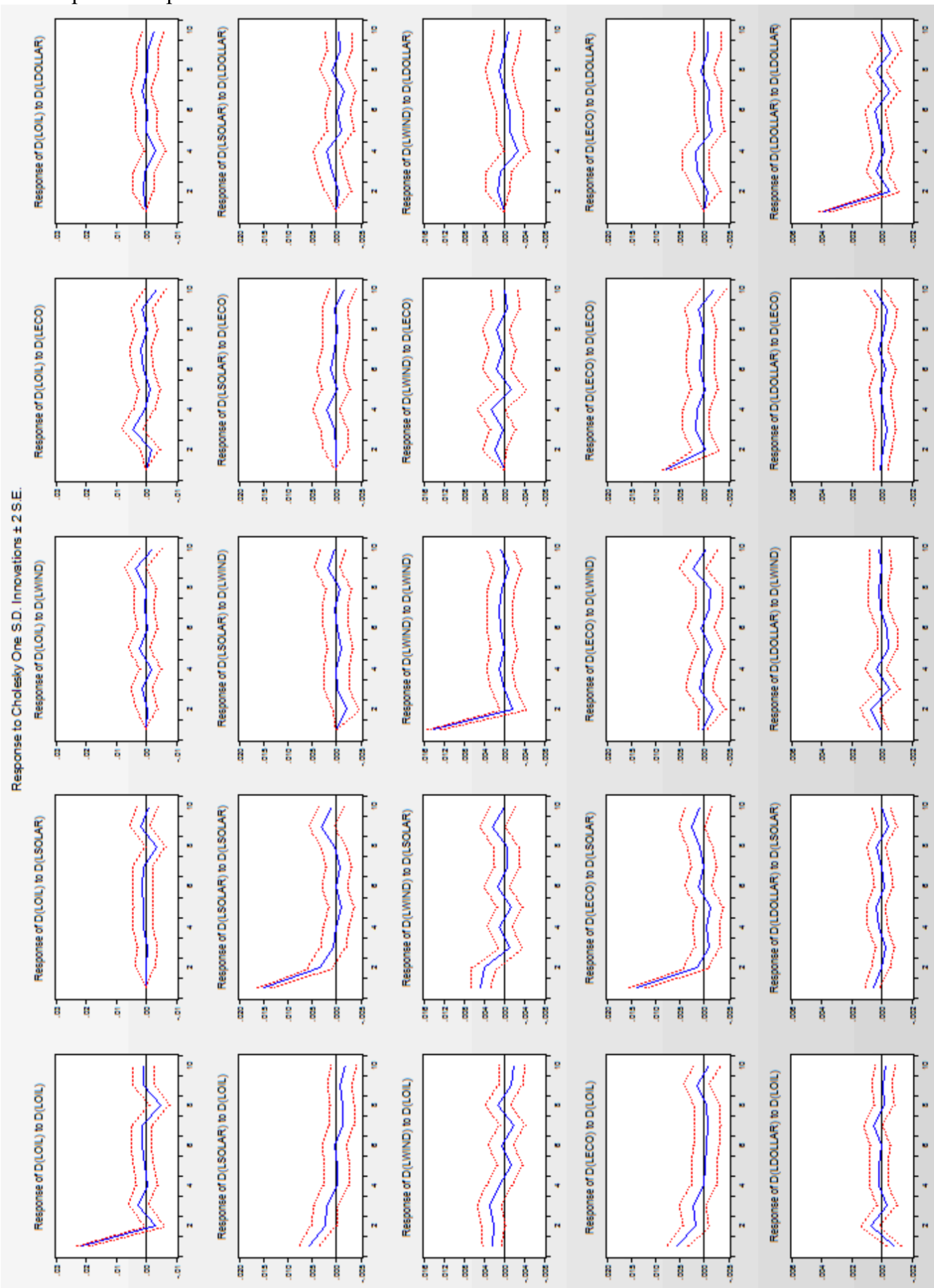
Excluded	Chi-sq	df	Prob.
DLOIL	9.818401	17	0.9111
DLSOLAR	13.49394	17	0.7025
DLWIND	15.04292	17	0.5924
DLDOLLAR	14.73487	17	0.6146
All	46.86208	68	0.9764

Dependent variable: DLDOLLAR

Excluded	Chi-sq	df	Prob.
DLOIL	29.24862	17	0.0323
DLSOLAR	13.57992	17	0.6966
DLWIND	13.64674	17	0.6919
DLECO	17.12945	17	0.4456
All	87.87613	68	0.0528

APPENDIX 5

Impulse Response



APPENDIX 6

Variance Decomposition

Variance Decomposition of DLOIL:

Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.02189	100	0	0	0	0
2	0.022337	99.00835	0.088678	0.00847	0.874734	0.019764
3	0.023049	94.26017	1.036742	0.020047	4.5569	0.126143
4	0.023617	89.94723	1.008403	0.270333	4.419987	4.354046
5	0.023945	87.50961	1.455924	1.142821	4.551398	5.340247
6	0.024201	86.64794	1.678353	1.301319	5.141149	5.231239
7	0.02445	85.12173	2.328627	1.470771	5.953291	5.125581
8	0.025103	83.82725	3.86794	1.66568	5.67304	4.966091
9	0.025492	81.32417	4.333011	3.323384	6.039448	4.979985
10	0.025997	78.73131	4.496332	3.340502	6.563755	6.868103

Variance Decomposition of DLSOLAR:

Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.016089	12.92867	87.07133	0	0	0
2	0.01663	13.62642	84.25992	1.046272	0.597712	0.469678
3	0.016801	14.75699	82.79595	1.045253	0.726891	0.674908
4	0.017161	14.14455	80.12076	1.002411	4.074149	0.658126
5	0.017566	13.72002	77.51225	1.67453	4.00021	3.092991
6	0.017836	14.1044	75.40428	2.319421	4.865374	3.306522
7	0.017936	14.18621	74.95658	2.29398	4.824191	3.739041
8	0.018019	14.75629	74.30456	2.28471	4.900248	3.754196
9	0.01845	14.1227	74.64425	2.771815	4.878337	3.582891
10	0.018759	15.63753	72.46693	3.430541	4.893995	3.571003

Variance Decomposition of DLWIND:

Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.014896	0.374618	10.9806	88.64479	0	0
2	0.015946	2.041901	17.8782	77.36414	2.552715	0.163051
3	0.016254	4.143234	18.01853	74.76967	2.475922	0.592638
4	0.016862	5.395898	16.77553	70.77454	5.381707	1.672331
5	0.017359	5.610259	17.01716	67.14254	6.171027	4.059021
6	0.017707	6.032487	16.98823	64.89404	8.035589	4.049654
7	0.017884	7.249391	16.65346	64.10905	7.933841	4.054263
8	0.017964	7.561668	16.53382	63.56064	8.006154	4.337711
9	0.018315	7.6315	17.28684	63.1873	7.719955	4.174411
10	0.018563	9.397396	16.8305	61.9223	7.535854	4.313946

Variance Decomposition of DLECO:

Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.016646	11.03691	67.13104	0.157464	21.67459	0
2	0.01684	11.12611	65.75452	1.619455	21.37088	0.129035
3	0.01721	12.42751	63.13139	2.088597	21.5807	0.771806
4	0.017517	12.04297	62.26663	2.06654	22.87673	0.747143
5	0.018091	11.56468	59.057	3.645989	21.47643	4.255905
6	0.018423	11.53274	58.06248	4.522557	21.03746	4.844766
7	0.018581	11.39436	57.15602	5.231844	20.92273	5.295048
8	0.01861	11.47886	57.02942	5.334843	20.87775	5.279131
9	0.019104	11.46446	57.19673	5.890259	20.43884	5.009716
10	0.019234	12.07393	56.64651	5.84473	20.42677	5.00807

Variance Decomposition of DLDOLLAR:

Period	S.E.	DLOIL	DLSOLAR	DLWIND	DLECO	DLDOLLAR
1	0.00385	5.238704	5.146326	1.438757	0.003433	88.17278
2	0.003966	7.680472	4.885181	2.801009	0.009719	84.62362
3	0.004011	7.82337	4.796202	2.767429	1.762757	82.85024
4	0.004032	8.147363	4.757614	2.913015	2.101695	82.08031
5	0.004053	8.549397	5.179334	2.8936	2.13394	81.24373
6	0.00415	8.177656	4.97721	3.611112	3.41387	79.82015
7	0.004194	8.5838	4.876948	3.746145	3.402551	79.39056
8	0.004257	8.881868	6.554113	3.986935	3.36693	77.21015
9	0.004335	8.752922	7.482885	3.877642	4.208994	75.67756
10	0.004459	10.67779	7.207173	3.837022	6.734303	71.54371

Cholesky Ordering: DLOIL DLSOLAR DLWIND DLECO DLDOLLAR