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**ENERGY AND ITS IMPACT ON ECONOMIC SECTORS
AND THE ENVIRONMENT**



**DOCTOR OF PHILOSOPHY
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**ENERGY AND ITS IMPACT ON ECONOMIC SECTORS AND THE
ENVIRONMENT**

By

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UUM
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**Thesis Submitted to
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in Fulfillment of the Requirement for the Degree of Doctor of Philosophy**



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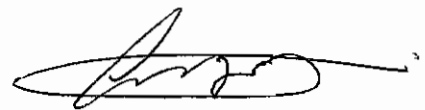
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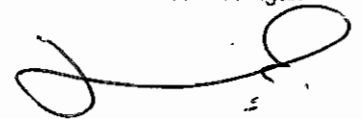
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ABSTRACT

The issue of energy has come to the fore since the proliferation of studies on the effects of its consumption on the environment. A vast array of empirical evidence related to this issue has lent credence to the environmental Kuznets curve (EKC) that economic growth causes greater environmental degradation at the early stages but improves the environment at the final stages. Therefore, this study endeavours to investigate the effects of energy (electricity, gas and oil) consumption on sectorial output and CO₂ emission in Malaysia from 1990 to 2014. Panel data analysis methods (namely, Fully Modified Ordinary Least Square, Pooled Mean Group and Mean Group) are employed in this study. The results show that, in the long run, aggregate output hinges on energy consumption. In the short run, energy consumption does not contribute to any change in output. It is found that gas consumption can have an influence on output in the industrial and transportation sectors but oil and electricity consumption does not have any impact on all sectorial output in Malaysia. The findings show that the consumption of electricity, gas and oil can have detrimental effects on the environment in the long run. However, in the short run, only oil consumption can be hazardous to the environment. Oil consumption in the agricultural and transportation sectors has a significant effect on CO₂ emission. Gas consumption in the transportation sector can also cause pollution albeit a little. Electricity consumption in the transportation sector has a favourable effect on the environment as it can reduce CO₂ emission. The results show that increasing aggregate output can inflict pollution only in the long run. Enhancing output in the agricultural, transportation and industrial sectors does not trigger any environmental issue. Therefore, the consumption of non-renewable energy such as oil, gas and electricity should be reduced in order to conserve the environment.

Keywords: energy consumption, sectorial, output, CO₂ emission, panel data analysis

ABSTRAK

Isu mengenai tenaga semakin mendapat perhatian semenjak terdapat percambahan kajian berkenaan kesan penggunaan tenaga terhadap alam sekitar. Banyak bukti empirik berkaitan dengan isu ini telah menyokong keluk persekitaran *Kuznets (EKC)* bahawa pertumbuhan ekonomi menyebabkan peningkatan kerosakan alam sekitar pada peringkat awal tetapi alam sekitar menjadi bertambah baik pada peringkat akhir. Oleh itu, kajian ini cuba mengkaji kesan penggunaan tenaga (penggunaan minyak, gas dan elektrik) ke atas output sektor dan pelepasan CO₂ di Malaysia dari tahun 1990 hingga 2014. Kaedah analisis data panel (iaitu *Fully Modified Ordinary Least Square, Pooled Mean Group and Mean Group*) digunakan dalam kajian ini. Dapatan kajian menunjukkan bahawa output agregat bergantung kepada penggunaan tenaga dalam jangka panjang. Dalam jangka pendek, penggunaan tenaga tidak menyumbang kepada sebarang perubahan dalam output. Penggunaan gas didapati mempengaruhi output sektor perindustrian dan sektor pengangkutan tetapi penggunaan minyak dan penggunaan elektrik tidak mempunyai sebarang kesan terhadap output dalam semua sektor di Malaysia. Dapatan kajian juga menunjukkan bahawa penggunaan elektrik, gas dan minyak boleh membahayakan alam sekitar dalam jangka panjang. Walau bagaimanapun, hanya penggunaan minyak yang boleh membahayakan alam sekitar dalam jangka pendek. Penggunaan minyak dalam sektor pertanian dan sektor pengangkutan boleh memberi kesan yang signifikan terhadap pelepasan CO₂. Penggunaan gas dalam sektor pengangkutan juga menyebabkan pencemaran meskipun sedikit. Penggunaan elektrik di dalam sektor pengangkutan memberi kesan yang baik terhadap alam sekitar kerana ia dapat mengurangkan pelepasan CO₂. Dapatan kajian menunjukkan peningkatan output agregat menyebabkan pencemaran hanya dalam jangka masa panjang. Peningkatan output dalam sektor pertanian, pengangkutan dan perindustrian tidak akan mencetuskan sebarang isu alam sekitar. Justeru itu, penggunaan tenaga yang tidak boleh diperbaharui seperti minyak, gas dan elektrik perlu dikurangkan untuk memelihara alam sekitar.

Kata kunci: penggunaan tenaga, output, sektor, pelepasan CO₂, analisis data panel

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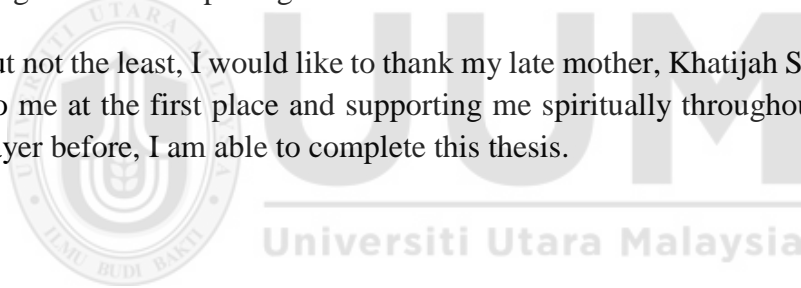


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Abbreviations

ARDL	Autoregressive Distributed Lag
CO ₂	Carbon Dioxide
DOLS	Dynamic Ordinary Least Squares
ECM	Error Correction Model
EKC	Environmental Kuznets Curve
FDI	Foreign Direct Investment
FMOLS	Fully Modified Ordinary Least Squares
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GHG	Green House Gas
GMM	Generalized Method of Moment
GNP	Gross National Produce
GWh	Gigawatt Hour
ktoe	Kiloton of Oil Equivalent
LMDI	Logarithmic Mean Divisia Index
MENA	Middle East and North Africa
MG	Mean Group
OECD	Organisation For Economic Co-Operation And Development
OLS	Ordinary Least Squares
PMG	Pooled Mean Group
STSM	Structural Time Series Technique
TJ	Terajoule
UEDT	Underlying Energy Demand Trend
VAR	Vector Auto-Regression
VECM	Vector Error Correction Model

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

The relationship between national output and energy consumption has attracted many researchers. This is because developing an economy highly requires energy and energy is the main factor of production in every country (Stern & Cleveland, 2004; Hou, 2009; Imran & Sidiqqi, 2010). Energy is consumed to generate various economic activities especially in industries, agriculture, and transportation. Therefore, adequate energy supply is indispensable to ensure that national output can be increased. However the supply of energy is unpredictable as energy sources such as oil, gas and coal can be exhausted.

The scarcity of energy is a great challenge to all countries in deciding how to manage the limited energy resources efficiently. Zaleski (2001) highlighted that although energy acts as a catalyst for a desirable change in the economy, its supply is uncertain. This is because the process of their formation takes billions of years. The rising demand for energy especially in developing countries which rely substantially on energy for development can be met by alternative energy sources. However, the alternative energy sources are costly for example the use of renewable energy. Therefore, the supply cannot meet the rising demand.

In Malaysia, several policies on energy consumption have been implemented to make sure the supply of energy is adequate in order to attain desirable economic performance with minimum adverse effect on the environment. However, these policies appear to be ineffective. This is because carbon dioxide (CO₂) emission always increased in Malaysia (Ghadimzadeha et al., 2015). Malaysia recognized that an appropriate energy policy is important to balance economic development and the environment conservation.

Therefore, the Malaysian government has formulated and implemented various plans and programs. According to Mohamed and Teong (2004), the National Energy Policy that was introduced in 1979, National Depletion Policy (1980) and Fuel Diversification Policy (1981 & 1991) were designed in an effort to conserve energy resources for sustainable development. The Eighth Malaysian Plan has highlighted the energy policy especially the use of renewable energy to ensure that the environment can be preserved. In this plan, biomass was focussed and claimed as the fifth fuel in the Malaysia fuel diversification program (Yusoff & Kardooni, 2012). The government and energy producers have incorporated policies to ensure energy security and environmental sustainability.

There are three objectives of Malaysia's National Energy Policy, namely, to sustain energy supply and make sure that Malaysia can enjoy cost-effective energy supply, to promote efficient utilization of energy and eliminate wasteful and non-productive usage and to minimize negative impacts on the environment. According to Yatim, Mamat, Mohamad-Zailani and Ramlee (2016), the main focus of the policy was to ensure energy efficiency, security and environmental sustainability for future energy

supply and good practice on energy utilization. The first objective of this policy is to make sure that the sustainable energy could be attained by enhancing renewable energy. The next objective is to ensure that energy can be efficiently consumed, thus leading to less waste of energy. The last objective is to ensure environmental protection in energy consumption and production.

The production and consumption of energy can be detrimental to the environment through air and water pollution. Energy comprises coal, oil, gas and electricity. These types of energy can produce hazardous emissions, such as CO₂ and carbon monoxide. Energy processing, such as burning, are harmful to our environment because it involves chemical reactions with oxygen in the air. These processes release CO₂ in the air and thus affect the environment, ensuing global warming.

The increasing level of CO₂ emissions indispensably occur in newly industrialized countries. These countries consume more energy compared to industrialized countries. Therefore, it results in a reduction of snow and sea ice, raising the sea level which leads to coastal flooding. A warmer climate causes extinction of many animal species living on earth. The increase in global temperatures also affects human as it triggers risks of health such as mental illness and cancers (Cover, 2010).

1.1.1 Types of Energy

According to Ahmed and Ahmed (2016), energy can be categorized into primary or secondary energy, commercial or non-commercial energy, and renewable or non-renewable energy. Primary energy is the type of energy that is not converted into another form of energy. Examples of primary energy are oil, natural gas and coal. It is

found generally in nature and used to form secondary energy. Secondary energy is the primary energy that has been changed into better feature of energy for instance electricity. Commercial energy refers to the energy sources that can be found in the market at a definite price.

Various types of commercial energy such as coal, oil, and natural gas have great economic value and are consumed for numerous economic activities such as transportation, services, agriculture, and industry. However, they leave deleterious effects on the environment. Non-commercial energy is traditional energy and it is not counted in energy evaluation. Examples of non-commercial energy are cow dung and firewood. Non-commercial energy is different from commercial energy as it is not available in the market for example cow dung, charcoal, firewood and agricultural waste.

Renewable energy can be extracted from several sources. The supply of this energy can be sustained over a significantly long period of time. This can be used as an alternative energy for non-renewable energy. Renewable energy includes power obtained from wind, solar, nuclear, geothermal, tidal, and hydroelectric. Renewable energy is good for the environment as it causes least pollution compared to other types of energy. The consumption of renewable energy has been widely discussed, as it is eco-friendly and produces a low level of carbon emission (Panwar, Kaushik, & Kothari, 2011). Nonrenewable energy is produced from fossil fuels such as coal, crude oil, natural gas and uranium. This type of energy may produce carbon that is harmful to the environment.

1.1.2 Energy Mix in Malaysia

The oil crisis which occurred in 1970s had caused negative impacts on the Malaysian economy, therefore, the country has reduced oil consumption (Manan, Baharuddin & Chang, 2015) and moved towards energy diversification. This was to ensure that the country was not highly dependent on oil. Table 1.1 shows electricity generation mix in Malaysia from 1994 to 2013. The table suggests that Malaysia was highly dependent on gas from 1994 to 2013 in electricity generation. The use of natural gas exhibited a steady increase and became the main energy source now.

Hence, oil source started to be reduced and it exhibited a steady decrease from 1994 to 2013 as seen in Table 1.1. The increase in energy demand for various economic activities has motivated the government to expand its energy mix. Solar and hydro energy are the most convenient and environment-friendly energy and are the best alternative sources of energy.

Table 1.1
Electricity Generation Mix in Gigawatt Hour (GWh) 1994 – 2013

Year	Hydro	Gas	Coal	Oil	Diesel	Others	Total
1994	6483	17491	4081	8756	988	-	37799
1999	7552	45988	4522	4220	747	-	63029
2004	5573	61363	22627	1130	729	-	91422
2009	6890	63370	37644	1041	685	132	109762
2013	11799	71174	53663	1571	1741	1318	141266

Sources: Malaysia Energy Statistic Handbook, 2015

1.1.3 Energy Demand by Various Economic Sectors in Malaysia

Malaysia consumes a large amount of energy in order to keep pace with the development of various economic sectors, such as industrial, agricultural,

transportation, and services. Energy consumption is perceived to be inextricably connected with economic growth (Shahiduzzaman & Alam, 2012).

Table 1.2
Energy Demand by Various Sectors (ktoe)

Year	Final Energy Demand by Sectors (ktoe)				
	Industrial	Transport	Agriculture	Non-Energy	Residential and Commercial
2005	15492	15384	101	2173	5134
2006	15248	14825	253	2809	5429
2007	16454	15717	281	2958	6196
2008	16205	16395	287	2876	6205
2009	14312	16119	211	3868	6336
2010	12928	16828	1074	3696	6951
2011	12100	17070	916	6377	6993
2012	13919	19757	1053	7494	7065
2013	13496	22357	1051	7277	7403
2014	13162	24327	1045	6217	7458

Source: Malaysian Energy Information Hub, 2014

Table 1.2 shows the final energy demand in kiloton of oil equivalent (ktoe) by various sectors in Malaysia from 2005 to 2014. The energy demand in the industrial sector has been declining while the energy demand in the transport and agriculture sectors has been increasing. This is because Malaysia slipped into recession in 2009 and this caused the industrial sector to move slowly. Furthermore, the share of the sector in the Malaysia's GDP has declined as the country moved to the service sector (see Table 1.1)

In 2007, the energy demand in the industrial sector was the highest. It dropped by 15.4% from 2007 to 2012 and this allowed the transportation sector to surpass it. After the economic crisis in 2008, energy demand in the transportation sector has become the highest. In 2009, the agricultural, industrial, and transportation sectors exhibited a decrease in the demand for final energy. The agricultural sector contributed the least

share of energy demand among the sectors. Energy demand in the non-energy sector has been increasing except for 2008 and 2010.

Table 1.3 shows the various types of energy that are used by sectors in Malaysia. Numerous types of energy including coal were used in the industrial sector. However, coal was not used in other sectors such as transportation sector and agricultural sector. The agricultural sector was highly dependent on two types of energy, namely, electricity and oil. Electricity was mostly used in the commercial and public services sector. Oil was mostly used in the transportation and industrial sectors.

Figure 1.1 shows the gross domestic product (GDP) breakdown by sector in 2014. The figure exhibits that service sector contributed the largest share (42%) to Malaysia's GDP. Electricity is predominantly used in the service sector. The industrial sector captured the second largest share of GDP with 31%. This sector required various types of energy such as oil, gas, electricity and coal. Among the various types of energy, electricity makes the largest contribution to the industrial sector. The transport sector contributed the lowest share of GDP (8%).

Based on all the tables and figure, it can be learnt that the industrial sector, which accounts for the second largest share of total GDP, consumes the second largest amount of total energy in Malaysia. The agricultural sector, which contributes the second smallest share of total GDP, consumes the smallest amount of total energy in Malaysia. It is obvious that energy is not only important in economic growth as a whole but it is also important in every economic sector. Therefore, the larger the amount of energy is consumed, the higher the output is produced.

Table 1.3
The Use of Primary Energy Sources in Various Sectors (2014)

Various Sectors	Coal (kt)	Electricity (GWh)	Natural Gas (TJ)	Oil (1000 tonnes)	Renewable and Waste (GWh)
Industry	2711	63205	226506	1477	n/a
Transport	n/a	256	12840	20998	317
Residential	n/a	27284	47	595	25702
Commercial and Public Services	n/a	41473	1023	822	n/a
Agriculture	n/a	419	n/a	975	n/a
Non-Energy Use	n/a	n/a	208037	1059	n/a

Source: International Energy Agency, 2014

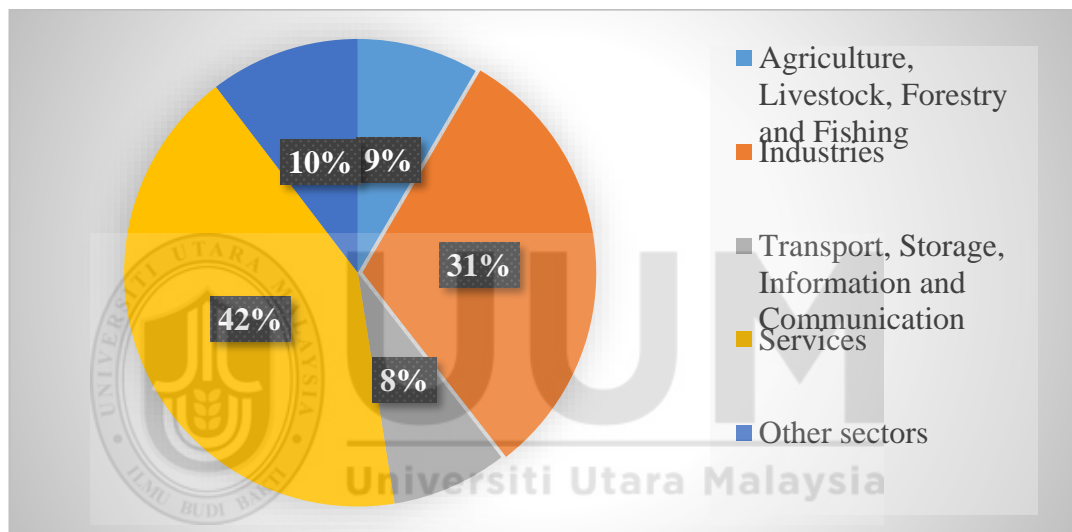


Figure 1.1
Gross Domestic Product (GDP) by Sector 2014
 Source: Department of Statistics, Malaysia, 2014

1.1.4 Energy Consumption and Environmental Effect

Energy consumption is inextricably connected with environmental issues (Jalil & Mahmud, 2009). Our environment can be affected by the production or consumption of energy. Pursuing sustainable economic growth and protecting natural environment pose a great challenge to any country. Table 1.4 shows the coal, oil and natural gas

consumptions in Malaysia from 2005 to 2013. The trend shows that the consumption of all energy sources has increased over the years.

Malaysia consumed the largest amount of natural gas in 2010. Natural gas is the cleanest fossil fuel that alleviates the effects of pollution and conserves the environment compared to other energy sources such as coal and oil. Oil and coal sources produce a higher level of hazardous emissions such as CO₂ and sulphur dioxide. Natural gas produces relatively less CO₂ compared to oil and coal (about 29% and 44% respectively). Table 1.4 shows that gas consumption has increased from 2005 to 2012 with the exception of 2009 and 2011.

Coal is an important source of energy in Malaysia, especially in the production of electricity. Table 1.4 exhibits an increasing trend in coal consumption in Malaysia. The highest consumption of coal was recorded in 2011. Emission of harmful substances such as CO₂, sulphur dioxide, and mercury can occur because of coal burning and the acidic water can flow out of abandoned underground mines.

Table 1.4
Energy Source in Malaysia from 2005 to 2013

Year	Oil	%	Gas	%	Coal	%
2005	522	(n/a)	914	(n/a)	12049	(n/a)
2006	534	2.30	940	2.84	12269	1.83
2007	574	7.49	997	6.06	15861	29.28
2008	568	-1.05	1131	13.44	16101	1.51
2009	611	7.57	1100	-2.74	18600	15.52
2010	631	3.27	1145	4.09	25222	35.60
2011	675	6.97	1081	-5.59	28662	13.64
2012	670	-0.74	1115	3.15	27468	-4.17
2013	680	1.49	1125	0.90	28160	2.52

Source: World Bank, 2015

It is undeniable that oil plays an important role in the transportation sector. Table 1.4 shows that oil consumption has continuously increased during the period (2005-2013) except for 2008 and 2012. In 2008, oil consumption decreased from 574 to 568 thousand barrels per day while in 2012, it decreased from 675 to 670 thousand barrels per day. The drop in oil consumption was due to the oil price increase. The largest volume of oil consumption (680 thousand barrels per day) was recorded in 2013. Malaysia consumed the lowest amount of crude oil in 2005 with 522 thousand barrels per day.

Table 1.5
CO₂ Emission by Different Sectors of Malaysia from 2006 to 2013

Sector	Year							
	2006	2007	2008	2009	2010	2011	2012	2013
Residential buildings and commercial and public services (%)	2.79	3.38	2.85	2.94	2.95	2.67	2.29	2.18
Electricity and heat production (%)	49.61	48.83	51.46	54.53	56.52	58.17	56.86	54.90
Manufacturing industries and construction (%)	23.62	24.56	22.85	17.57	16.16	15.02	16.69	14.04
Agriculture (%)	0.49	0.46	0.44	0.34	1.72	1.45	1.65	1.52
Transport (%)	23.49	22.76	22.41	24.61	22.65	22.69	22.51	27.36

Source: World Bank, 2015

Table 1.5 shows the share of CO₂ emission from various sectors from 2006 to 2013. There are electricity and heat production sector, transportation sector, manufacturing industries and construction sector, buildings and commercial and public services sector, and agricultural sector. The electricity and heat production sector contributed the most of CO₂ emission in every year and thus suggested that the sector is most harmful to the environment in Malaysia.

Electricity generation involves fossil fuel combustion which can be the main source of greenhouse gas emissions. The agricultural sector accounted for the smallest share of CO₂ emission in Malaysia over the period. However, it exhibited a steady increase from 2006 to 2013. It indicated that the sector is least harmful to the environment. The share of CO₂ emission from the residential buildings and commercial, and public services sector continued to decrease from 2009 to 2013.

1.1.5 Energy Consumption, Economic Growth and CO₂ Emission

The exhibition of the same trend in CO₂ emission and energy consumption in Malaysia have attracted this current study to explore the effects of energy consumption and economic growth on CO₂ emission. This situation seems to suggest that the environment is inextricably related to energy consumption in Malaysia. Table 1.6 shows the trend in energy use, economic growth and CO₂ emission in Malaysia. Energy consumption in Malaysia was recorded at 2580.514 kt of oil equivalent per capita in 2005 and decreased by 1.19% in 2006. In the following years, energy use shows a steady rise until 2008. CO₂ emission was recorded at 174486.9 kt in 2005 and plummeted by -3.89% in the next year.

In 2007, CO₂ emission revived and was recorded at 184816.8 kt. The trend in economic growth in Malaysia was uncertain from 2005 to 2013. In 2005, economic growth in Malaysia was 5.33%, and increased to 5.9% in 2006. Economic growth escalated and reached 6.3% in 2007 and dropped to 4.83% in 2008. However, in 2009, energy use, CO₂ emission and economic growth showed the same decreasing trend. In this year, Malaysia slip into recession, economic activities were slow and the use of energy was

reduced as well as CO₂ emission. The years after the recession, on the other hand showed that energy use, CO₂ emission and economic growth rose again.

Table 1.6
Energy Consumption, CO₂ Emission, and GDP Growth in Malaysia, 2005-2013

Year	Indicator				
	Energy use (kg of oil equivalent per capita)	Percentage (%)	CO ₂ Emissions (kt)	Percentage (%)	GDP growth (%)
2005	2580.514	n/a	174486.9	n/a	5.33
2006	2549.698	-1.19	167702.9	-3.89	5.58
2007	2742.5	7.56	184816.8	10.20	6.3
2008	2818.864	2.78	204031.9	10.40	4.83
2009	2637.675	-6.43	198802.7	-2.56	-1.51
2010	2648.531	0.41	218476.2	9.90	7.43
2011	2717.4	2.60	220405	0.88	5.19
2012	2724.224	0.25	218707.2	-0.77	5.47
2013	3019.819	10.85	236510.5	8.14	4.71

Source: World Bank, 2015

1.1.6 Energy Policy

There are several energy policies that have been implemented in Malaysia. For example the National Depletion Policy introduced in 1980, The Four-fuel Energy Policy implemented in 1981 and The Five Fuel Diversification which was established in 1991 (Mohamed & Teong, 2004). The policies aimed to ensure that Malaysia has adequate energy to generate economic activities, hence Malaysia diversified the energy sources and was not dependent on oil production alone. The National Depletion Policy focussed on alternative energy use in order to control and reduce the consumption of oil. Therefore, oil has been reduced from 8756 GWh in 1994 to 1571 GWh in 2013 (Malaysia Energy Statistic Handbook, 2015).

In Malaysia, the energy mix strategy based on the Four-fuel Energy Policy was implemented. This strategy was adopted following the international oil crisis in 1973. This strategy aimed to balance the energy consumption and production in Malaysia as well as to ensure the conservation and sustainability of energy. The Malaysian Fuel Diversification policy aims to balance the energy resource and maintain security and sustainability.

The diversification of energy is called the energy mix, containing the various sources of energy for example hydro, coal, oil and natural gas. The multiple sources of energy are the key for Malaysia to meet higher energy requirement in the future and to protect the environment. The increasing trend in economic development requires more energy consumption; therefore, policies on energy consumption remain complex as policy makers have to consider both economic growth and the environment.

The Five-fuel Diversification Policy was to ensure sustainable energy use and protection of the environment from greenhouse gas (GHG) emissions. This policy attempted to incorporate renewable energy that is not harmful to the environment as the fifth fuel. This program aimed to generate electricity from hydroelectric sources, which reached 5% in 2005. Renewable energy in Malaysia is still sparsely used and the government has formulated several policies to encourage its use. In 2000, the Eighth Malaysian Plan replaced the Four-fuel Diversification Policy with the Five-fuel Diversification Policy (Abdul & Lee, 2004).

1.2 Research Problem

Energy consumption has been argued to be a determinant of national output. Hence, energy is as important as other factors of national output such as labour and capital. Several studies suggested that energy consumption can influence national output (Apergis & Danuletiu, 2012; Adhikari & Chen, 2012; Odularu & Okonkwo, 2009; etc.). Cassim, Akinboade, Niedermeier, Sibanda and Jackson (2004) stated that energy is used for economic development as it generates economic activities. Ozturk, Aslan, and Kalyoncu (2010) found that in upper and lower-middle income countries, energy consumption is the determinant of national output. Thus, a rise in energy can expand the economy. Ighodaro (2010) used several types of energy sources such as oil and electricity as the proxy of energy and determined which energy will influence national output. It was found that national output hinges on several sources of energy. Therefore, exhaustion or reduction of any type of energy can disrupt national output.

Although energy consumption is important, it can be detrimental to the environment. The environmental problem emerges when a country consumes more energy. This is because the use of more energy can produce more CO₂ emission and thus affect the air quality. According to a report released by the Malaysian Department of Environment (2010), CO₂ emissions contribute the largest share of the greenhouse effects and subsequently, cause global warming. Humans can be exposed to many risks such as cancers and mental illness. Climate change can also threaten the economy. Agriculture and tourism will be affected by climate change.

Therefore, these issues have attracted many researchers to study it in order to find solutions. Several studies have documented the effects of energy consumption on the

environment such as Farhani and Rejeb (2012), Dritsaki and Dritsaki (2014), and Menyah and Wolde-Rufael (2010). Jalil and Mahmud (2009) acknowledged that the environmental sustainability cannot be attained as excessive energy is used. Lin and Lin (2011) stated that energy consumption, which contributes to national output, also contributes to the environmental degradation. If national output increases with less CO₂ emission, then increasing national output is good as it can create green technology and energy efficiency.

Previous studies have also mentioned the importance of energy in the economy (Stern 1993, 2000; Shahiduzzaman & Alam, 2012; Peng & Sun, 2010). Nevertheless, its consumption can create environmental problems as it can produce CO₂ emissions. Therefore, a policy to reduce energy consumption as well as CO₂ emission should be formulated with much attention on both economic development and the environment. Wei, Yaoguo and Xia (2009) found that coal and other low-quality energy consumption should be limited in order to preserve the environment as their consumption can have deleterious effects on the environment. Therefore, the consumption of energy should be reduced to conserve the environment. However, this reduction can pose damaging effects on national output.

According to Belke, Dobnik and Dreger (2011), policies to reduce energy are complex if the results show that national output hinges on energy. In addition, Begum, Sohag, Abdullah and Jaafar (2015) stated that increasing more energy to enhance national output can have an unfavourable effect on the environment as it can cause CO₂ emission to escalate. Ighodaro and Ovenseri-Ogbomo (2008) stated that energy

conservation policies can be formulated if energy consumption has no effect on the economy.

The expansion of economy can usually have undesirable effects on the environment especially in less developed countries where people in those countries are more concerned about national income rather than the environment. Nevertheless, it is not necessary to have aggravating environmental degradation as national output intensifies. In most developed countries, people are more concerned about the environment. The government imposes strict environmental regulations on firms, causing them to move their plants to less developed countries.

In addition, green technology is also used in developed countries. Thus, national output can reduce environmental degradation. Apergis and Ozturk (2015) stated that at the beginning, as per capita income is on the rise, the environmental problems worsen and subsequently it starts to decrease as income per-capita increases. Jebli, Yousef and Ozturk (2016) supported that the increasing consumption of renewable energy can reduce pollution. Therefore, national output can intensify without increasing environmental degradation.

As mentioned in the background of the study, Malaysia is aware of the environment and several policies have been enacted in series such as the National Energy Policy, Four Fuel Energy Policy and Energy Diversification Policy. These policies are to ensure that Malaysia can increase national output and conserve the environment in tandem. However, these policies seem to be ineffective as CO₂ emission is always on the rise. The factor that contributes to the inexorable increase in CO₂ emission in

Malaysia is still not clear. Therefore, it is crucial to highlight factors, namely, energy consumption and economic sectors in this study.

Numerous studies such as Maddison and Rehdanz (2008), Azomahou, Laisney and Van (2006), Stolyarova (2009) as well as Azlina, Law and Mustapha (2014) have examined the linkage among energy consumption, national output and CO₂ emission. However, the findings of the studies are mixed. A few studies were interested in investigating the impacts of sectorial energy on CO₂ emission such as Norlaila and Khalid (2013) who explored the impacts of Malaysian industrial energy use on CO₂ emission. However, their study highlighted the contribution of economic sectors to emissions only in a single year. In addition, the study did not explore the long-run effects of energy and economic sectors on emission.

Apart from that the study did not consider many years as Malaysian energy policies have been formulated since 1980. The study also did not explore which sector is reducing emissions and which sector is increasingly or decreasingly dependent on energy sources. In addition, Shaari, Razak and Basri (2017) investigated both short- and long-run effects of energy consumption in various sectors but the study did not divide energy into several types of energy such as oil, gas and electricity. If those problems are not explored, we might not be able to formulate the right policies to reduce the sectorial energy type that increases emission. Therefore, this current study is important to fill the gap and is better at shedding light on energy policies.

In Malaysia, the transportation sector is the largest energy consumer compared to other sectors in 2012 (Malaysian Energy Information Hub, 2014). If there is a reduction in

energy consumption, it can hinder the transportation sector in Malaysia, thus disrupting the national output. The industrial sector is an important sector in Malaysian gross domestic product (Department of Statistics, Malaysia, 2014). This sector relies on various types of energy sources (International Energy Agency, 2014). Any reduction in energy consumption definitely affects this sector and thus can dampen the economy as this sector makes up the second largest share of gross domestic product.

The agricultural sector consumes relatively less amount of energy (Malaysian Energy Information Hub, 2014), but it is still an important sector as it contributes to large employment especially in rural areas (Istikoma, Qurat-ul-Ain, & Dahlan, 2015). In addition, Malaysia still needs this sector for food security and supply of essential food as it is still not self-sufficient. Therefore, all of these sectors are indispensable for the economy. Sufficient energy consumption is important to ensure that Malaysia can be developed by the year 2020.

However, the transportation, industrial and agriculture sectors, which consume oil, gas, and coal can generate pollution (International Energy Agency, 2014). These sectors also emit CO₂. Therefore, this current study will consider sectorial energy and CO₂ emission for a long period so that it will be clear to reduce energy source from which sector if the energy source can be detrimental to the environment without affecting the sectorial output. Careful formulation of policies is important to ensure that Malaysia can achieve economic sustainability and environmental improvement.

In summary, this study attempts to investigate the effects of energy consumption on economic sectors encompassing agriculture, transportation and industry. Energy

consumption will be split into several energy types, particularly, oil, gas and electricity. Besides, this study also embarks on an investigation into the effects of those energy types and those economic sectors on CO₂ emission in Malaysia.

1.3 Research Questions

- i) To what extent is output dependent on energy consumption in the short and long runs?
- ii) To what extent is CO₂ emission dependent on output in the short and long runs?
- iii) To what extent is CO₂ emission dependent on energy sources?

1.4 Research Objectives

The general objective of this study is to examine the effects of energy consumption on output.

The specific objectives:

- i) To investigate the effects of energy consumption on output in the short and long runs.
- ii) To explore the effects of energy on CO₂ emission in the short and long runs.
- iii) To examine the impacts of output on CO₂ emission in the short and long runs.

1.5 Significance of the Study

This study can contribute to the literature in energy consumption and its effects on the economy; it becomes crucial to address the policy issue that has been proposed by previous studies. This study is to propose policies on energy consumption and the

methods employed by them. Therefore, this study aims to shed light on the effects of energy consumption on sectorial output and the environment in Malaysia.

Previous studies proposed several energy policies. However, their studies are still lacking as they focus more on economic growth rather than sectorial output. Therefore, this research aims to fill the gap in research by assessing the impact of sectorial energy on output and the environment in Malaysia.

This study represents an attempt to examine the linkage among several types of energy consumption (oil, gas and electricity), sectorial output (industrial, transportation, and agriculture) and CO₂ emission in Malaysia. This study will help government formulate policies on energy consumption since it may harm the environment. Energy consumed in various economic sectors can produce carbon emission which can affect the environment and human health. It is also important to understand which sectorial output produces the largest environmental pollution.

Based on the results, the government will be able to focus on appropriate energy consumption for various economic sectors. Therefore, economic growth and environment can be balanced to ensure sustainable development in the country. Apart from that, this study will also fill the gap by focussing on sectorial output and sectorial CO₂ emission. It is crucial to ascertain the effects of sectorial energy on sectorial output and emission as we can only reduce energy types in certain sectors without reducing total energy in all sectors.

1.6 Scope of the Study

This study will focus on the Malaysia's economy. The annual data from 1990 to 2014 will be obtained for oil consumption, gas consumption and electricity consumption, which are the proxy for energy consumption. The period from 1990 to 2014 is selected because of the availability of the data. These three energy types are selected on grounds of their contribution to Malaysia's economic sectors. Most of the economic sectors in Malaysia hinge on those three types of energy. The annual data is sufficient as this study employs panel data analysis and annual data is better as it can respond to the government policies on the environment. The sectorial outputs, particularly agriculture, industrial and transportation sectors will be explored. These three sectors will be addressed in this study on account of their intriguing patterns of energy consumption in Malaysia. The industrial sector was the largest energy consumer in 2007. Somehow, after the year, the transportation sector has surpassed the industrial sector in energy consumption. Despite the fact that the agricultural sector consumes the smallest share of total energy, its inevitable contribution to CO₂ emission should also be taken into account so that we can discover whether or not the smallest consumer of energy can exacerbate environmental degradation. Lastly, data on CO₂ emission in those sectors are also collected. The data is explained in chapter 3.

1.7 Organization of the Study

The remainder of this thesis is organised as follows. The theoretical framework which explains the theory of production and the EKC will be discussed in the following chapter. Besides, the previous studies on the relationship between energy consumption and national output will be critically reviewed based on several perspectives (the

effects of energy consumption on national output, as well as the effects of energy consumption and national output on the environment).

Chapter 3 underlines the methodology that will be used in this study. The model specifications based on two functions, namely, the Cobb-Douglas production function and the EKC function will be described in that chapter. Apart from that, the panel unit root, panel co-integration, panel estimations based on FMOLS, PMG and MG are also discussed.

With the methodology used, the findings are obtained and discussed based on the objectives of this study (to investigate the effects of energy consumption on output in the short and long runs, to explore the effects of energy on CO₂ emission in the short and long runs, and to examine the impacts of output on CO₂ emission in the short and long runs). In addition, the findings are also discussed in respect of several sectorial classifications: industrial output, transportation output, and agricultural output.

Chapter 5 concerns the recapitalisation of findings, policy implication, limitation of the study, and future study. The recapitalisation of findings is discussed based on the previous four chapters. The policy implication explains several policies that the government should consider to cushion the negative effects of energy consumption. Despite the fact that this study achieves the objectives, there are also several limitations in conducting this study and thus several suggestions are also included in the final chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Chapter two intends to bring the discussion pertaining to relevant literature on energy consumption and national output. It is organised in two parts. The first presents the underpinning theory of the present study, namely the theory of production and Environmental Kuznets Curve (EKC). The second part presents a review of previous findings from relevant studies in which the relationship between energy consumption and national output, and the effects of energy consumption on environment are discussed. In particular, the review tries to illuminate the gap in the body of literature that paves to the objectives of this study.

2.2 Theoretical Framework

Scholars have long argued on the importance of maintaining the quality of the environment while achieving successful economic growth. With that intention, several theories are being proposed. Naming a few, the theory of production and the Environmental Kuznets Curve (EKC) are among the profound theories that prevail when the economic growth and environment are being argued. The theory of production shows the relationship between input and output and the EKC indicates the relationship between per-capita income and output. These theories can serve as the building block for the present study. Thus, in the succeeding sections, these theories are elaborated and given thought.

2.2.1 Theory of Production

Production refers to the process of transforming inputs into outputs. Inputs are factors of production which include land, capital, entrepreneur, and labour. Outputs refer to finished goods such as computers, cars, and services. The theory of production describes the decision of firms on how many outputs that can be produced and sold, and the best combination of inputs that firms need to employ to produce outputs. In order to describe the relationship between inputs and outputs, economists use a tool known as the production function. A simple production function which focuses on only two inputs can be written as follows:

$$Q = F(K, L), F_K > 0, F_L > 0, F_{KK} < 0, F_{LL} < 0, F_{KL} > 0$$

where Q is the amount of output, K is the amount of capital and L is the amount of labour. The symbol $F_K > 0$ ($F_L > 0$) indicates that the marginal product of capital (labour) is positive. The symbol $F_{KK} < 0$ ($F_{LL} < 0$) indicates that there is a diminishing marginal product with respect to capital and labour, respectively. Finally, the symbol $F_{KL} > 0$ indicates that adding capital (labour) increases the marginal product of labour (capital).

In empirical work, there is a need to employ a specific form of production function. One of the most frequently employed forms is known as the Cobb-Douglas production function, which was named after its originators, Charles Cobb and Paul Douglas (Cobb & Douglas, 1928). Basically, this production function can be specified as follows:

$$Q = K^\alpha L^\beta \tag{2.1}$$

where α and β are the labour and capital elasticity of output respectively. Consistent with the assumption of the general production function, each of α and β is assumed to be a positive fraction: $0 < \alpha, \beta < 1$. Furthermore, it is assumed that the sum of α and β can be either greater than, equal to, or less than unity. If $\alpha + \beta$ is greater than one (less than one), then the production function is said to exhibit increasing return scale (decreasing return to scale). Finally, if $\alpha + \beta$ is equal to one, then the production function is said to exhibit a constant return to scale.

2.2.2 Environmental Kuznets Curve (EKC)

The Kuznets curve was introduced by Kuznets (1955) to see the relationship between unequal distribution of income and economic development in a country. It measures the economic development on the horizontal axis and unequal distribution of income on the vertical axis. Per capita income is usually used as a proxy of economic development. According to Kuznets, the inverted U-shaped curve depicts a common phenomenon in developing an economy. This is because at the early stages, the gap between high-income groups and low-income groups is small as the economy is dependent on the agricultural sector. However, when economic development has become better, moving towards the industrial sector, the gap grows larger. At the final stages, the large gap will become smaller as economic growth is still on the rise.

The Kuznets curve was then expanded by Grossman and Krueger (1995), which adapted the curve to see the relationship per-capita income and the environment. The EKC portrays the relationship between per-capita income and environmental degradation. The relationship can be depicted as an inverse U-shaped curve (see Figure 3.1). Grossman and Krueger (1995) believed that, at the early stage of economic

development, a rise in per capita income can contribute to greater environmental degradation. However, at the second stage, a steady increase in per capita income can reduce environmental degradation.

At the early stage, the per capita income increases and it suggests that people are more interested in enhancing outputs, obtaining jobs and earning money without having adequate awareness of the effects of their economic activities on the environment. This situation usually transpires in middle-income countries as economic prosperity comes first. They are apathetic about their environment. Therefore, the positive relationship between environmental degradation and per capita income is exhibited.

After the turning point, the negative relationship between per capita income and environmental degradation can be observed. It implies that the country starts having an alleviating environmental degradation without causing any disruption to economic activities. This is due to the policy of striking a balance between economic growth and the environment. When income rises, the country tends to have policies and regulations to ensure that the environmental degradation can be alleviated and the pollution level can be reduced. It shows that people have a higher awareness of the environmental value. Thus, the country starts to manage their environment efficiently.

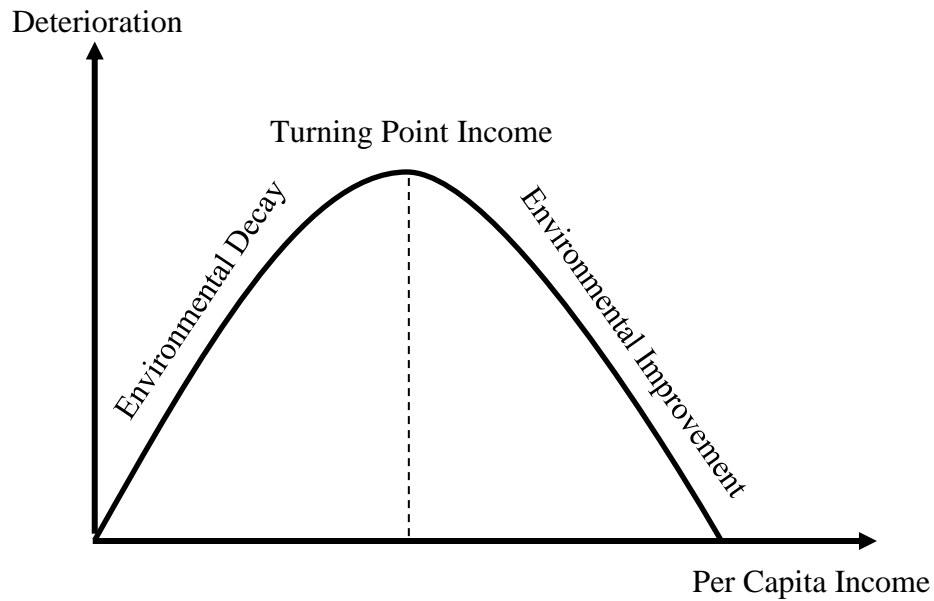


Figure 2.1
Environmental Kuznets Curve (EKC) for Environment Condition View
 Sources: Kuznets, 1955

This EKC can be explained using the econometric equation. The equation is as follows:

$$E_{it} = (\alpha + \beta_i F_i) + \delta Q_{it} + \varphi(Q_{it})^2 + k_t + \varepsilon_{it} \quad (2.2)$$

E is environmental degradation, Q represents per capita income, F is country-specific effects, k represents a linear time trend, i represents country and t is year. Suppose that $\delta > 1$ and $\varphi < 1$, it means that we can have an inverted U-shaped EKC. An increase in per capita income can cause environmental degradation to increase at the early stages, however, at the final stages, a continuous increase in per capita income can reduce environmental degradation. If $\delta < 1$ and $\varphi > 1$, it means that we can have a U-shaped EKC. An increase in per capita income can cause environmental degradation to decrease at the early stages. At the final stages, a steady increase in per capita income can exacerbate environmental degradation.

2.3 Empirical Studies

For decades, studies on energy consumption, economic growth, CO₂ emission and relevant variables have proliferated across the globe, signifying the increased interest among economic analysts and researchers. This topic has fuelled many debates in the literature, hence fortifies the body of knowledge that in turn could benefit the humankind. Thus far, most studies touched on the linkage between energy consumption and economic variables such as GDP, industrial output, and manufacturing.

In a parallel development, as the topic of environment sustainability is becoming a raised concern among global citizens, the debate on the extent that the national output affects the quality of life is ubiquitous. Nevertheless, studies that could provide sound information on the extent to which the economic sector jeopardises the environment are still sparse. Due to deterioration of the air quality that we are living in now, the concerns on the emission of CO₂ due to the economic activity has become an interesting topic. Thus, there is an alarming need for additional knowledge about the current issues that could be informed by research.

2.3.1 Energy Consumption and National Output

The debate pertaining to the association between energy consumption and national output has long been addressed by energy analysts and economists all over the countries (see Kraft & Kraft, 1978; Stern, 1993, 2000; Ghali & El-Sakka; 2004; Peng & Sun, 2010; Shahiduzzaman & Alam, 2012). Exemplifying such studies are the ones conducted in the United States by Kraft and Kraft (1978), Stern (1993, 2000) and Ghali

and El-Sakka (2004) using different analyses; namely the co-integration analysis, Vector Error Correction Model (VECM) and Vector Auto-regression (VAR).

Kraft and Kraft (1978) first investigated the connection between energy input and GNP in the United States in the period 1947 to 1974. Based on the Sims causality test, the findings showed that a rise in GNP causes energy consumption to rise simultaneously. However, GNP does not include all outputs produced within the country, as it does not consider output produced by foreign labour. Instead, it includes all output produced by the country's citizens regardless of where they are.

The lacking premise in the work of Kraft and Kraft (1978) has paved Stern (1993) to explore the connection between GDP and energy consumption in the United States in the period 1947-1994. Employing the VAR model and treating labour and capital as other factors of national output, the preliminary results showed that any change in energy consumption does not affect GDP. However, when energy consumption was adjusted for changing fuel composition, the results indicated that energy consumption affects GDP.

Seven years later, employing the Johansen co-integration method, Stern (2000) extended his previous study by exploring the connection between national output and energy consumption using GDP as the proxy for national output in the same period (ie from 1947 to 1994). The study achieved similar results to his previous findings. In the same demeanour, Shahiduzzaman and Alam (2012) also assessed the linkage between national output and energy consumption for the Australian country in the period 1960-2009. They used labour and capital as other factors of national output. The study,

which used Johansen and Toda-Yamamoto causality tests analysis, found that energy consumption is as important as capital and labour in determining real GDP.

Meanwhile, in China, Peng and Sun (2010) explored the consumption of energy and its effects on economy allowing for structural breaks within the period of 1953-2007, employing Johansen co-integration approach. Focusing on demand and production sides, they advocated that there is a connection between national output and energy consumption. When the VECM was used, the findings showed that total energy consumption has an influence on GDP in the short run. Therefore, energy reservation can be detrimental to national output in China. Zhang, Li, Zhou, and Mu (2011) explored the efficiency of energy consumption in national output in China within 1980-2006. Using a method known as the Logarithmic Mean Divisia Index (LMDI), the study found a support for the importance of energy consumption in output.

Cheng (1999) investigated the connection between national output and energy consumption in India within 1970-1990 and the analysis was based on the co-integration, ECM and Granger causality. The study found that national output can influence energy consumption without feedback.

Several studies found a mutual connection between national output and energy consumption such as Lise and Montfort (2007), and Paul and Bhattacharya (2004). Lise and Montfort (2007) assessed the connection between GDP and energy consumption in Turkey within 1970-2003. The co-integration and Granger causality tests were performed and the findings showed that energy consumption can change GDP with feedback in Turkey. Paul and Bhattacharya (2004) examined the association

between national output and energy consumption in India within 1950-1996. The analysis was based on the co-integration and Granger causality and the study found that energy consumption can affect national output with feedback in India.

Belke et al. (2011) explored the connection between national output and energy consumption. The study considered the panel data from 25 OECD countries using the data from 1981 to 2007 and included energy prices in the model. The analysis was based on panel Johansen co-integration, dynamic ordinary least squares (DOLS) and panel Granger causality. The findings indicated that energy consumption can affect national output with feedback in 25 OECD countries. Apart from that, there is a mutual connection between energy price and energy demand.

Besides interests on the relationship between energy consumption and national output, it is noted that these studies have different interest on the types of energy (oil, biomass, gas, and electricity). For instance, the work by Ighodaro (2010) who examined the linkage between national output and several types of energy and in Nigeria using the data from 1970 to 2005. Employing the Johansen co-integration, he found that the long run linkages between oil, gas, biomass and electricity consumptions and national output do exist. When the Granger causality test was employed, the results indicated that national output is dependent on gas consumption, electricity consumption, and oil consumption. Interestingly, however, only oil consumption is affected by national output.

While, Shaari, Hussain and Ismail (2012) explored the linkage between national output and energy consumption in Malaysia from 1980 to 2010. Using the same analysis

approach, namely, the Johansen co-integration and Granger causality test, but adding another type of energy source which is coal, the findings revealed that national output is not affected by oil and coal consumption and vice versa. In particular, they found that national output can influence electricity consumption without feedback and national output cannot influence coal consumption with feedback.

Whereas in Pakistan, a group of researchers, Qazi, Ahmed and Mudassar (2012), examined the linkage between the industrial outputs and disaggregate energy type within 1972-2010. The analysis was based on the Johansen co-integration method. The results showed that gas consumption has no connection with the industrial output. The results also explained that oil consumption can affect the industrial output with feedback and electricity consumption can affect the industrial output without feedback. Besides, the industrial output can have an impact on coal consumption, and gas consumption does not affect industrial output.

All of the studies mentioned above only focused on the linkage between national output and aggregate energy consumption. While some of them used GDP as a proxy for national output and other studies used GNP. However, most of the previous studies did not highlight the sectorial outputs such as industrial, agriculture and transportation sectors although these sectors consume energy with different patterns. Among the studies that highlighted the sectorial outputs, it is noted that most of them did so for the industrial sector (as this sector is highly dependent on energy) at the expense of other sectors such as the agricultural.

Several studies explored the relationship between a single type of energy and output (Yazdan & Hossein, 2012; Hodges, Stevens & Rahmani, 2010; Adom, 2011). Based on the review of relevant literature, energy consumption can be divided into several energy types such as oil consumption, gas consumption, coal consumption and etc. Some previous studies focused on only a single type of energy consumption, for example oil, gas, biomass, electricity and coal, as a proxy for energy to explore the relationship between energy consumption and output.

2.3.1.1 Oil Consumption

Several previous studies have been carried out to assess the association between national output and oil consumption employing various approaches. For example, Yazdan and Hossein (2012) and Kasgeri, Etesami and Chemazketi (2014) explored the connection between GDP and oil consumption in Iran within 1980 to 2010 as it is well known that the Iranian economy relies substantially on oil production. Using techniques such as co-integration, ECM and Granger causality, both of the studies indicated that there is a significant connection between national output and oil consumption in which an intensification of national output can increase oil consumption temporarily and vice versa. Nevertheless, the relationship was found in the short run only.

The results of the above studies are slightly different from those of the study conducted by Aktas and Yilmaz (2008) in Turkey, who explored the linkage between GNP and oil consumption. Using the same approach and the data for the period 1970-2004, the study found that there is a mutual relationship between GNP and oil consumption in the long as well as the short run. Therefore, a rise in oil consumption can contribute to

national output and national output also can increase the consumption of oil. The difference of the results was due to the different economic conditions.

The existence of the relationship between oil consumption and GDP was also examined by Zikovic and Dizdarevic (2011) in European countries. The study used the ECM approach and the data from 1980 to 2007 for developed countries and 1993 to 2007 for developing countries. The results showed that, for the developed countries category, only Austria show a relationship between oil consumption and national output while other countries, show relationship between GDP and oil consumption. In developing countries, the results are mixed.

The linkage between national output and oil consumption has also been explored by Olusegan (2007) in Nigeria. The study used the Ordinary Least Squares (OLS) method and the data on crude oil consumption, export and GDP from 1970 to 2005. The study found that crude oil consumption and export can contribute to national output in Nigeria.

Lin and Xie (2013) extended the investigation of the relationship between oil consumption and national output by including oil price and labour productivity in the automobile industry. The study analyzed the data in China from 1980 to 2010 using the Johansen co-integration technique and ECM. The study found that the relationship among the variables used such as energy consumption, GDP, labour productivity in the automobile industry and oil price exist in the long run. Hence, GDP, labour productivity and oil price can determine oil consumption.

Naser (2011) investigated the connection between national output and oil consumption in emerging and industrialized countries using the data from 1965 to 2010. The analysis was based on the Toda and Yamamoto tests and the study indicated the existence of various directional relationships between national output and oil consumption. The findings showed that GDP does influence oil demand in France, China and South Korea, while GDP is dependent on oil consumption in Japan. A unidirectional connection, moving from GDP to oil consumption, was found in France, China, South Korea, Japan, Canada, USA and India. Apart from that, the causal relationship running from oil consumption to GDP does not exist in Canada and Russia. But in the USA and India, bidirectional relationship does exist.

Several studies investigated the correlation between oil consumption and sectorial outputs as oil consumption also plays an important role in several economic sectors. This statement has been supported by Bedi-uz-Zaman, Farooq, and Ullah (2011), Mushtaq, Abbas, Abedullah, and Ghafoor (2007) and Leung (2009). Bedi-uz-Zaman et al. (2011) explored the sectorial oil consumption in Pakistan using data from 1972 to 2008. The Johansen co-integration, VAR model, ECM and Granger causality tests were performed to achieve the objective. The findings showed that there are positive effects of oil consumption on four major sectors in Pakistan such as transportation, power generation and industry. However, there are negative effects of oil consumption on minor sectors such as household, government and agriculture. There is a one direction of the relationship which is moving from GDP, the transportation sector and industrial sector to the power sector.

However, the previous studies discussed above did not explore the effects of sectorial oil consumption on sectorial output. In addition, presumably, to some extent, there might be some differences, in how each type of energy source influences the national output or in how each type of energy source influences different sector. In other words, there is a gap in the body of knowledge pertaining to the influence of different source of energy consumption on sectorial output. This gap signifies the need to embark on further study.

2.3.1.2 Biomass Consumption

There has been a great deal of international interest in understanding how biomass consumption relate to national output. For example, this question has been addressed by Hodges et al. (2010) in Florida, Yildirim, Sarac and Aslan (2012) in the United States and Zhao (2014) in China, on top of efforts done by numerous scholars by comparing the data on groups of countries (see for example Operinde, 2010; Bildirici and Ozaksoy, 2013). These scholars used different approaches in determining the relationship between biomass consumption and national output. For instance, Hodges et al. (2010) used the Input-Output/Social Accounting Matrix approach to evaluate the potential effects of biomass consumption on national output in Florida in 2007. They found that a rise in biomass consumption can result in an increase in GDP, employment and the state government revenue in Florida.

With similar objective but different approaches, Zhao (2014) focused his study on agricultural, in particular, the biomass consumption in farmers' income in China for the period 1996 to 2007. Using the grey model comprising the grey correlation analysis approach, grey prediction method, grey statistics and evaluation method, the study

found the presence of a positive relationship between biomass consumption and farmers' income in China. The study concluded that farmers could benefit from escalated biomass consumption.

Yildirim et al. (2012) examined the connection between biomass consumption and national output in the United States. The time period was divided into three spans: 1949-2010 and 1960 -2010. The study employed the Toda-Yamamoto procedure and Bootstrap-corrected causality tests and found that only biomass waste derived from energy consumption can affect national output.

Bildirici and Ozaksoy (2013) attempted to ascertain the association between biomass consumption and national output in 10 countries from 1960 to 2010. The study performed the ARDL and VECM tests and the findings were divided into three directional relationships. Firstly, biomass consumption affects national output was found in Austria and Turkey. Secondly, national output affects biomass consumption was discovered in Hungary and Poland. Finally, biomass consumption affects national output with feedback in France, Spain and Sweden.

Operinde (2010) explored the existence of environmental Kuznets curve (EKC) in 132 countries, considering biomass consumption instead of total energy consumption. The study employed the OLS method to analyse the data from 1971 to 2004. The results revealed that income per capita can have a negative effect on biomass consumption but a positive effect on the health status.

2.3.1.3 Electricity Consumption

Previous studies showed various findings concerning the directional relationship between electricity consumption and national output. Some results showed that higher national output requires more electricity consumption. For example, Adom (2011) investigated the connection between economic enhancement and the need of electricity in Ghana in the period 1971 to 2008. The analysis was based on the Toda-Yomamoto causality test and the results showed that national output can increase the need of energy in Ghana. Therefore, higher national output can prompt an increase in electricity consumption.

Ciarreta and Zarraga (2010) examined the linear and nonlinear relationship between national output and the consumption of electricity for the country of Spain for the period 1971-2005. With the same method used by Adom (2011), the study found the existence of a linear connection moving from national output to the consumption of electricity and no existence of nonlinear connection moving from electricity consumption to national output.

Pemptzoglou (2014) also examined the linear relationship between electricity consumption in various sectors and national output in Turkey. The study was based on the data from 1945 to 2006 and the linear Granger causality test was performed. The findings indicated that national output is dependent on electricity consumption in the residential and commercial sector, and electricity consumption in the industrial and other sectors are dependent on national output.

Several studies explored the linkage between electricity consumption and sectorial output. For example, Wang, Mu, Kang, Song and Ning (2010) analyzed the determinants of electricity consumption in the industrial sector in China within 1998-2007. The study was based on the Logarithmic Mean Divisia Index and found that the manufacturing of raw chemical material and products, the manufacturing of non-metal mineral products, the smelting and pressing of ferrous and non-ferrous metals, and the production and supply of electric power and heat power are the determinants of electricity consumption among industrial subsectors in China.

Masduzzaman (2012) investigated the linkage between national output and electricity consumption in Bangladesh to formulate policies on electricity consumption. The data from 1981 to 2011 were collected and the results from the Johansen co-integration test showed that the elasticity of electricity consumption is higher in the long run than in the short run. Therefore, an increase in electricity consumption can trigger higher national output in the long run rather than in the short run. Apart from that, an increase in electricity consumption can enhance national output and the quality of life.

Atif and Siddiqi (2010) assess the connection between electricity consumption and national output in Pakistan within 1971-2010. The Engle-Granger co-integration, standard Granger causality, and Modified Wald test were performed and the findings showed that electricity consumption is an important determinant of national output. Javid, Javid, and Azwan (2013) also pinpointed the linkage between national output and electricity consumption in Pakistan within 1971-2008. The study employed the Engle-Granger co-integration and VECM approaches and found the same results in

which electricity consumption can influence national output but national output cannot influence electricity consumption.

Qazi et al. (2012) explored the connection between electricity consumption and output in Pakistan but the study focused on the industrial output over the period 1972 to 2010. Using the Engle-Granger co-integration and Toda-Yamamoto Granger causality, the study found the unidirectional causality running from electricity consumption to industrial output.

Chouaibi and Abdessalem (2011) investigated the connection between electricity consumption and national output in Tunisia during the period 1971 to 2007. The analysis was based on the Granger causality and the findings suggested that the relationship between electricity consumption and national output does exist in the long run. However, there is a relationship running only from electricity consumption to national output in the short run. Akinwale, Jesuleye, and Siyanbola (2013) also examined the relationship between electricity consumption and national output in Nigeria using the data period 1970 to 2005. The analysis was based on the VAR and ECM methods and it was reported that a rise in electricity consumption can help develop economies in the future.

Several studies found a bidirectional relationship between electricity consumption and national output. For example, Aytac and Guran (2011) examined the relationship between national output and energy consumption as well as energy price in Turkey using the data for the period 1984 to 2007. The analysis was based on the VAR approach and the results indicated that electricity consumption can affect national

output and vice versa. It is also noted that national output can influence the price of electricity.

Bayar and Ozel (2014) examined the relationship between electricity consumption and national output in emerging economies using the panel data from 1970 to 2011. The analysis was based on the panel Johansen co-integration, FMOLS, DOLS and panel Granger causality and the results revealed the existence of a bidirectional relationship between national output and electricity consumption in the short run and long run.

Nyamdash and Denny (2010) examined the relationship between national output and electricity consumption at the aggregate and disaggregate levels; i.e. residential, commercial or industrial electricity consumption in Ireland for the period 1960 to 2007. The VECM test was performed and the results showed that national output can affect electricity consumption at disaggregate level with feedback, and at the aggregate level without feedback.

Muhammad and Abdul (2013) investigated the relationship between national output and electricity consumption as well as the real price of electricity and the underlying energy demand trend (UEDT) at the aggregate and sectorial levels, namely, the residential, commercial, industrial, and agricultural sectors in Pakistan for the period 1972 to 2010. The analysis was based on the Structural Time Series Technique (STSM) and ARDL and the results showed that electricity consumption shows an upward slope in the commercial, agricultural and residential sectors in Pakistan.

Bildirici, Bakirtas and Kayikci (2012) explored the causal relationship between national output and electricity consumption using data on the price and income elasticity of total electricity consumption and industrial demand in several countries such as the United Kingdom, the United States, China and South Africa from 1978 to 2010. The study applied the ARDL approach and the results showed that there is a directional relationship moving from electricity consumption to real GDP in the United States, China, Canada and Brazil. However, the results were different for other countries, as it was found that there is a unidirectional relationship moving from GDP to energy consumption. The findings also showed that the industrial sector is dependent on electricity consumption. Therefore, an increase in the industrial sector can cause electricity consumption to escalate. Apart from that, the opposite directional and bidirectional relationship were also confirmed in some countries.

Squalli and Wilson (2006) investigated the relationship between income and electricity consumption in six Gulf Cooperation Council (GCC) countries using data from 1980 to 2003. The study employed the ARDL based on the unrestricted ECM, Modified Wald test based on Toda and Yamamoto and non-causality approaches. The results revealed that income affects electricity consumption positively and electricity consumption affects income negatively in Bahrain and KSA. In Kuwait and Oman, however, income was found to have a positive effect on electricity consumption without feedback. Other than that, there is a positive effect of income on electricity consumption with positive feedback in Qatar but there is no significant relationship in UAE.

However, there is limited literature that examines the linkage between sectorial output and electricity consumption. The one found thus far, is the attempt to relate manufacturing and services sectors with electricity consumption. Exemplifying this is the work done by Tang and Shahbaz (2013) who examined the linkage between sectorial output and electricity consumption in Pakistan using the data for the period 1972-2010. The analysis was based on the Johansen co-integration and the study found that the manufacturing and services sectors are dependent on the use of electricity. Nevertheless, there is no connection between output and electricity consumption found in the agricultural sector.

Besides, Atakhanova and Howie (2007) examined the dependency of the sectorial output on the electricity in Kazakhstan for the period 1999-2003. The study also included data on population and the real electricity price. The Generalized Method of Moment (GMM) was applied to both the aggregate and sectorial models. The findings showed that the price elasticity of demand is low in all sectors, implying that electricity demand is relatively insensitive to the price change. It is also found that the income elasticity of demand is low in all sectors, indicating that electricity demand is relatively insensitive to the business cycles.

2.3.1.4 Gas Consumption

A few studies found that natural gas consumption is related to national output. For instance, Shahbaz, Chandran and Pervaiz (2011) examined the relationship between the two variables and other control variables such as capital and labour in Pakistan from 1972 to 2009. The ARDL bound test was performed and the results showed that there is a positive effect of gas consumption on national output. Shahbaz, Lean and

Farooq (2012) extended the study by including real export with a premise that it plays an important role in determining production. The data from 1972 to 2010 were analyzed by using the ARDL bound test and the results showed that the natural gas consumption is connected with the national output.

Shahbaz, Farhani and Rahman (2013) used the Cobb-Douglas production function to underline their study in France. Their study included export, capital and labour in the factor of production and examined the connection between national output and gas consumption within 1970-2010. The ARDL bounds test was employed and the results showed the existence of a relationship between national output and gas consumption in the long run. In addition, the VECM-based causality test was performed to see the directional relationship and the findings showed that gas consumption does affect national output without feedback.

2.3.1.5 Coal Consumption

A few previous studies found that there is no connection between economic development and coal consumption. For example, Ocal, Ozturk and Aslan (2013) examined the relationship between economic enhancement and the consumption of coal in Turkey within the period 1980-2006. The analysis was based on the asymmetric causality test and the findings indicated that national output does not affect coal consumption and coal consumption also does not affect national output.

Kumar and Shahbaz (2010) also investigated the relationship between coal consumption and national output in Pakistan using the data period from 1971 to 2009.

The study employed the ARDL bounds test and the results indicated that coal consumption can generate income.

Satti, Hassan, Mahmood and Shahbaz (2014) also investigated the relationship between coal consumption and national output in Pakistan using different data period (1974 to 2010). The study extended the previous analysis by using other determinants of national output and coal consumption such as unemployment, urbanization, fiscal deficit and real services value added. The VECM causality test was also conducted and the results revealed that there is a relationship between coal consumption and national output.

Bloch, Rafiq and Salim (2011) investigated the relationship between coal consumption and income in China using both supply-side and demand-side framework during the period 1966 to 2002. The co-integration and VECM were conducted and the study found that there is a unidirectional causality running from coal consumption to output in the short and long run in China. Therefore, an increase in coal consumption can cause the national output to increase.

Nasiru (2012) also examined the relationship between national output and coal consumption for the Nigerian country for the period 1980-2010. The two-step-residual-based approach to co-integration and Granger causality tests were conducted and the findings revealed that there is one direction of the relationship from national output to coal consumption. Therefore, an expansion of the economy in Nigeria can increase coal consumption.

Apart from that, Shahbaz and Dube (2012) included capital and labour as the controlled variables and examined the relationship between national output and coal consumption in Pakistan within the period 1972-2009. The VECM causality test was employed and the findings suggested that there is a bidirectional connection between national output and coal consumption in Pakistan.

There were mixed results found by Li and Li (2011) who examined the relationship between coal consumption and national output in China and India using the data from 1965 to 2006. The study employed the co-integration and Granger causality approaches and the results revealed that national output does Granger-cause coal consumption without feedback in China but coal consumption does Granger-cause national output in India without feedback. Therefore, policies to conserve coal can be formulated in China as it does not give any impact to national output but the policies can be a stumbling block to achieving sustainable development in India.

Tian and Cul (2013) examined the relationship between coal consumption and national output in China using the data ranging from 1978 to 2010. The Johansen co-integration and Granger causality tests were conducted and the study supported the finding that coal consumption does not Granger-cause national output in China.

In addressing the issue of energy consumption, the role of FDI in enhancing the economy and at the same time require more energy has been increasingly mooted by several studies. For example, Omri and Kahouli (2014) extended the previous studies by investigating the relationship among FDI, energy consumption and national output in 65 countries for the period 1990–2011. The panel dynamic simultaneous-equation

model was employed based on the conventional growth model framework and the findings showed that there is a mutual connection between energy consumption and national output, economic enhancement and FDI in low income groups.

Other than that, FDI can affect energy consumption without feedback in middle-income countries and energy consumption can affect FDI without feedback in low-income countries. For the full sample of countries, the findings confirmed that there is a bi-directional causal relationship between national output and energy consumption, and between national output and FDI inflows, and there is a uni-directional causal relationship running from FDI to energy consumption. A bi-directional causal relationship between FDI inflows and national output was also found in the four sub-samples of countries.

Nasreen and Anwer (2014) examined the dynamic relationship among energy consumption, national output and trade openness in 15 Asian countries, the area of the world's largest economies, using the panel data for the period 1980 to 2011. The panel Johansen co-integration, FMOLS and DOLS estimation were employed and the findings confirmed that an increase in energy consumption can cause the economy to burgeon. In addition, the results from the panel Granger causality tests indicated that there is a bidirectional relationship between energy consumption and national output, and a bidirectional relationship between trade openness and energy consumption.

The population is also an important variable in addressing the issue of energy consumption. Hence Shaari, Rahim, and Rashid (2013) explored the existence of a linkage among energy consumption, national output and population in Malaysia within

1991-2011. The Johansen co-integration was employed to examine the long-run relationship and the results indicated that there is an interconnection among population, national output and energy consumption in Malaysia. The Granger causality was then performed and the findings showed that population can contribute to higher energy consumption and subsequently energy consumption can boost national output in Malaysia.

All the studies aforementioned investigated the relationship between coal consumption and national output or certain sectorial output. However, they did not investigate and provide the relationship between coal consumption and environmental degradation. In the attainment of sustainable development, environmental degradation must be taken into account since coal consumption can be deleterious to the environment.

2.3.2 Energy Consumption and Environment

National output and environmental quality have become a current topic for policy makers to debate. Some argued that national output will lead to environmental degradation while others said that environmental problems can be mitigated by having more rapid national output. Numerous researchers were interested in studying the relationships among energy consumption, national output and CO₂ emission in various countries (Maddison & Rehdanz, 2008; Azomahou et al., 2006; Stolyarova, 2009). However, their results were mixed and remained complex for policy formulation.

Azomahou et al. (2006) investigated the relationship between national output and environmental degradation based on EKC in 100 countries using the data from 1960 to 1996. The non-parametric panel data analysis was performed and the results showed

that GDP per capita can influence CO₂ emission. The findings were supported by Stolyrova (2009) who also examined the relationship between CO₂ emission and national output in 93 countries for the period 1960-2008. The dynamic panel data and within models were also estimated and the results showed that national output can have a deleterious effect on the environment.

The investigation of the association between national output and environmental degradation has also been conducted in more than 100 countries by Maddison and Rehdanz (2008) using the data from 1990 to 2005. The panel co-integration and panel homogeneous and heterogeneous non-causality tests were conducted and the results showed that the significant relationship between national output and environmental problems is dependent on the sub-group of countries. In several countries, such as the Asian countries, no relationship was found between national output and environmental degradation.

Apergis and Payne (2010) examined the relationship among energy consumption, national output and CO₂ emissions using the data in 11 Commonwealth of Independent States (CIS) countries from 1992 to 2004. The study employed the panel VECM and the results showed that most of the countries rely on several energy sources such as oil, coal, and natural gas. Therefore, it remains a challenge for policy makers to reduce CO₂ emissions in the countries. Energy consumption can be harmful to the environment in the long run as it can exacerbate CO₂ emissions and CO₂ emissions will escalate owing to higher national output.

Asici (2011) investigated the relationship between national output and the environmental degradation using the panel data of 213 countries from 1970 to 2008. The data on the environmental degradation (which was measured by pressure on nature, net forest depletion and CO₂ emission) and income per capita was analyzed using the fixed effects model and the results indicated that an increase in income per capita can have an adverse effect on the environment. The findings also suggested that high-income countries will increase CO₂ emission and pressure of forests more slowly compared to the middle-income countries.

Li, Dong, Li, Xiang and Yang (2011) investigated the same relationship in collective 30 provinces in China covering the period from 1985 to 2007. The analysis was based on the panel co-integration method and the findings indicated that there is a positive relationship between real GDP per capita and energy consumption in the long term. Therefore, a rise in real GDP per capita can engender larger energy consumption and higher CO₂ emission in China.

Silva, Soares and Pinho (2012) attempted to examine the effects of increasing dependency on renewable energy sources and national output on CO₂ emission in several countries (namely, the United States, Portugal, Spain and Denmark) for the period 1960 to 2004. The structural VAR model was employed and the findings revealed that intensifying RES can have a bad impact on national output but reduce CO₂ emission. Therefore, it is necessary to formulate environmental policies to ensure sustainable development in those countries.

Cherniwchan (2012) investigated the effects of the industrial output on environmental degradation using the panel data of 157 countries from 1970 to 2000. The panel co-integration was employed and the results showed that an increase in the industrial output can worsen environmental degradation.

Farhani and Rejeb (2012) examined the linkage among energy consumption, national output and environmental degradation in 15 Middle East and North Africa (MENA) countries and the data from 1973 to 2008 were used. Using the panel co-integration approach. The results showed that there is a relationship among energy consumption, national output and environmental degradation. Energy consumption can affect national output and environmental degradation but without any feedback for both variables in the short run. The study also employed the individual and panel test of OLS, FMOLS, and DOLS and the results indicated that national output hinges on energy consumption.

Dritsaki and Dritsaki (2014) investigated the causal relationship between energy consumption, national output and CO₂ emissions in Southern Europe, namely, Greece, Spain, and Portugal for the period 1960 to 2009. The panel co-integration, FMOLS, DOLS and panel causality tests were applied and the findings showed that there is an existence of a long-run relationship between the three variables. The results from FMOLS and DOLS tests showed that an increase in energy consumption can result in a rise in CO₂ emissions in the countries. For the individual test of OLS and DOLS, the results confirmed the existence of a strong positive relationship between energy consumption and national output in Greece and Spain. Based on the causality test,

there is a bidirectional relationship among energy consumption, national output and CO₂ emissions in the short run.

Several studies were conducted based on a single nation instead of many countries. For example, Chebbi and Boujelbene (2008) explored the relationship among national output, energy consumption and CO₂ emission in Tunisia from 1971 to 2004. The Johansen co-integration and VECM tests were performed and the results showed that there is a long-run relationship among those variables. However, the results for the short run suggested that an increase in national output can result in higher demand for energy.

Bozkurt and Akan (2014) also examined the relationship among energy consumption, national output and CO₂ emission in Turkey covering the period from 1960 to 2010. The same methods were employed and the study found that energy consumption can affect national output positively, while CO₂ emission can affect national output negatively. Therefore, policies to have more effective and efficient energy consumption are necessary to be formulated.

In Bangladesh, Alam and Huylenbroeck (2011) examined the connection between national output and environmental degradation in Bangladesh from 1972 to 2006. The study employed the ARDL and VECM approaches, and the results supported that Bangladesh is a country dependent on energy whereby a shock in energy consumption can have a negative effect on national output and thus affecting the environmental quality in Bangladesh.

Amin, Ferdous and Porna (2012) also examined the relationship between the two variables in Bangladesh using the data from 1976 to 2007. The Johansen co-integration approach was employed and the results showed a significant long-run relationship between national output and environmental degradation. The Granger causality test was then conducted for the examination of the directional relationship and the results indicated that national output can affect energy consumption as well as CO₂ emissions without feedback.

Menyah and Wolde-Rufael (2010) and Alkathlan, Alam, and Javid (2012) employed the ARDL approach in their studies in the United States and Saudi Arabia, respectively. Menyah and Wolde-Rufael (2010) examined the relationship among renewable and nuclear energy consumption, CO₂ emission and national output using the data from 1960 to 2007. Using the modified version of the Granger causality test, the results showed that there is a unidirectional relationship moving from nuclear energy consumption to environmental degradation and there is no relationship moving from renewable energy consumption to environmental degradation. Apart from that, it was also found that nuclear energy consumption can reduce environmental degradation.

Alkathlan et al. (2012) investigated the short-run and long-run relationships among CO₂ emissions, energy consumption and national output in Saudi Arabia over the period 1980 to 2008. Using the ARDL and VECM approaches, the empirical results showed that there is an existence of a long-run relationship between energy consumption and national output. The results from the Granger causality test also showed that national output does not Granger-cause CO₂ emission. In light of this

result as well as the fact that Saudi Arabia is the largest oil exporter and producer in the world and, at the same time, the 14th largest producer of CO₂ emission in the world, the policy for energy consumption is proposed for the Saudi Arabia case.

Zhang and Cheng (2009) examined the relationship among energy consumption, national output and CO₂ emissions in China using the time series data from 1971 to 2007. The study employed the Johansen co-integration and VAR Granger causality approaches and the findings showed that CO₂ emission affects energy consumption positively but CO₂ emission affects GDP negatively. Therefore, an increase in energy consumption can increase CO₂ emission and national output.

Tiwari (2011) investigated the relationship between energy consumption, national output and CO₂ emissions in India over the period 1971 to 2005. The causality test based on VECM analysis was employed and the results showed that there is no relationship running from energy consumption to national output. However, CO₂ emission was found to have a negative effect on national output in India.

Most previous studies focused on total energy consumption rather than energy consumption in various sectors. However, Shaari et al. (2017) extended the previous studies by investigating the effects of energy use in the agricultural, industrial and transportation sectors on CO₂ emission from 1990-2014. The study employed a panel data analysis consisting of Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS), Pooled Mean Group (PMG) and Mean Group (MG). The results show that output can reduce CO₂ emission in the long run but not in the short run. Energy consumption was found to have an effect on CO₂

emission in the long run. In the short run, energy consumption in the transportation and industrial sectors was found to have an effect on CO₂ emission.

Pao and Tsai (2010) added FDI as the factor of environmental degradation and used VECM and fixed effect model to examine the effects of national output on environment degradation in multiple countries (namely, Brazil, Russian Federation, India, and China) over the period 1992-2007 and found that there are four bidirectional relationships between CO₂ emissions and FDI, CO₂ emissions and output, energy consumption and FDI, and energy consumption and output in the short run. In the long run, FDI can affect CO₂ emissions with feedback but there is a unidirectional relationship moving from energy consumption to real output.

Using the same variables, Hassaballa (2014) conducted a similar study on 23 developing countries based on the data from 1971 to 2010 and the results showed that the relationship between FDI inflows and emissions does exist in both the short and long run. Similarly, Hitam and Borhan (2012) investigated the relationship between FDI and environmental degradation in Malaysia over the period 1965 to 2010. Using the Johansen co-integration approach, the study supported the finding that an increase in FDI can cause CO₂ emission to escalate.

Next, Lee (2013) investigated the contributions of FDI to clean energy use, carbon emission and national output in 19 nations of the G20 over the period 1971-2009. Using the panel co-integration test and fixed effect model, the results showed that FDI limits the impact of CO₂ emissions. The elements that have been found to limit the

impact of CO₂ emissions include using energy efficiently, developing renewable energy and introducing new technologies to reduce carbon energy.

Ren, Yuan, Ma and Chen (2014) conducted a study to examine the interaction between FDI, international trade and CO₂ emissions in China using the data from 2000 to 2010. The study applied the input-output analysis and the GMM-based regression model and found that the increase in CO₂ emission is rooted in higher trade surplus and larger FDI inflows. The results also suggested that an increase in the industrial income per capita can intensify CO₂ emission in China. Therefore, the country must control FDI inflows and trade surplus in order to curb an increase in environmental degradation.

The previous studies have investigated the effects of energy consumption on national output and some of them included its effect on the environment quality. However different countries produced different results, and thus different policies should be formulated. If energy consumption was found not to influence national output but influences the environment, thus energy consumption should be reduced. However, the formulation of energy can be better if we look into sectorial output and sectorial CO₂ emission. This will reduce only certain types of energy consumption in certain sectors. Therefore, it can post minimal effects on the environmental problem.

2.4 Summary and Remarks

Throughout the review, it is noted that numerous studies have already examined the relationship between energy consumption and national output and that some of them included CO₂ emission in their studies while some did not. Even though, there are a few studies that revealed the effect of manufacturing and transportation sector on CO₂

emission, they did not, however, focus on the short- and the long-run effects of CO₂ emission, which is somewhat lacking in understanding the sustainability better.

In addition, previous studies did not provide empirical evidence as to which sector depends highly on energy demand and which sector mostly contributes to CO₂ emission. This has created a knowledge gap in the body of literature thus signals the needs to address the alarming issue of CO₂ emission to the environment. Furthermore, lack of information to evaluate the existence of EKC by sectors in Malaysia served as one of the motive to embark on a further investigation.

In figuring out the methods for the study, it is noted that previous studies employed various methods such as panel co-integration, FMOLS, Pooled Mean Group (PMG) and Mean Group (MG) to explore the causal relationship between energy consumption, national output and CO₂ emission. This is because the panel data analysis contains more degree of freedom and more sample variability. Therefore, this study will adopt the approaches employed by previous studies. Next chapter will explain the methodology in details.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the production theory and the EKC. The production theory shows the relationship between inputs and outputs, while the EKC describes the effects of income per capita on the environmental degradation. This chapter also discusses the methods that will be employed in details and tries to achieve every objective of this study. Several tests will be performed in this study such as the panel unit root, panel co-integration, panel estimation (FMOLS), Pooled Mean Group (PMG) and Mean Group (MG).

3.2 Research Methodology

Energy is used to ensure that output can be produced in economic sectors such as industrial, transportation and agriculture. Therefore, this study is important to address these two issues (increasing economic sectors and reducing environmental degradation in tandem). This study will use panel data on some variables from 1990 to 2014. This method is based on two models, particularly the Cobb-Douglas production function and the EKC function. Data on oil consumption, gas consumption, electricity consumption and CO₂ emission are extracted from International Energy Agency (2014) while data on sectorial output are obtained from Department of Statistics, Malaysia (2014).

3.2.1 The Cobb-Douglas Production Function

The Cobb-Douglas production function is to show the relationship between inputs such as capital and labour and production and the equation is as follows.

$$Q = K^\alpha L^\beta \quad (3.1)$$

Due to its simplicity, however, the above production function omits energy consumption as an important input. Energy is used to ensure that output can be produced in economic sectors such as industrial, transportation and agriculture. Therefore energy is a catalyst for sectorial productivity. Adding this variable to equation (3.1) yields the following:

$$Q = K^\alpha L^\beta EC^\gamma \quad (3.2)$$

where EC is energy consumption while γ is the energy elasticity of output. Like other parameters, γ is assumed to be a positive fraction, $0 < \gamma < 1$. In order to ensure that this model is linear in parameters, there is a need to take logarithms for each variable. Doing so and adding the error term u as well as the time subscript t , the model becomes as follows:

$$\ln Q_t = \alpha \ln K_t + \beta \ln L_t + \gamma \ln EC_t + u_t \quad (3.3)$$

This equation represents the baseline model in estimating the effect of capital, labour and energy consumption on output.

3.3.2 The EKC

For the effects of energy consumption and economic sectors on carbon dioxide emission, this study applies the EKC model. The model which was introduced by Grossman and Krueger (1995) shows a non-linear relation between economic growth and carbon dioxide emission. The inverse U-shaped curve can be empirically specified as follows:

$$\ln E_t = \varphi \ln Q_t + \theta \ln Q_t^2 + v_t \quad (3.4)$$

where E is environmental degradation, Q is per capita income, v is the error term, and φ and θ are parameters such that $\varphi > 0$ and $\theta < 0$.

However, energy consumption also plays an important and direct role in determining environmental degradation. Therefore, this study includes energy consumption as another determinant of environmental degradation. Using carbon dioxide emission as a proxy for environmental degradation (since it constitutes the largest share of environmental degradation), the model in equation (3.4) can be expanded to be

$$\ln CO_{2t} = \varphi \ln Q_t + \theta \ln Q_t^2 + \delta \ln EC_t + \varepsilon_t \quad (3.5)$$

where CO_2 is carbon dioxide emission, ε_t is the error term and δ is a parameter which is assumed to be positive, $\delta > 0$.

3.3 Model Specification

In the preceding section, the analysis is assumed to be applicable to the national economy where output, energy consumption and environmental degradation are measured at the national level. In this study, all of these variables are measured at the sectorial level. Given the two theories and previous studies, two model specifications can be derived. The first model specification is to answer the first objective of this study (i.e. to investigate the effects of energy consumption on output in the short and long runs).

The second model specification is to achieve the second and third objective (i.e. to explore the effects of energy on CO₂ emission in the short and long runs, and to examine the impacts of output on CO₂ emission in the short and long runs). Several energy sources are used as proxies for energy consumption. These energy sources are electricity consumption (E), oil consumption (O) and gas consumption (G). Therefore, two models are specified to investigate the effects of a) energy consumption on output, and b) output and energy on CO₂ emission, respectively:

$$\ln Q/P_{it} = \alpha_0 + \alpha_1 \ln EC_{it} + \alpha_2 \ln K_{it} + \alpha_3 \ln L_{it} + \mu_{it} \quad (3.6)$$

$$\ln CO_{2it} = \beta_0 + \beta_1 \ln(Q/L)_{it} + \beta_2 \ln EC_{it} + v_{it} \quad (3.7)$$

where Q is sectorial output (industrial, agriculture and transportation), Q/L is sectorial output per labour. Sectorial output per labour is used in the second model to avoid multicollinearity as sectorial output has been used as a dependent variable in equation 3.6 and independent variable in equation 3.7. CO₂ is sectorial carbon dioxide emission, EC is energy consumption which consists of oil consumption, gas consumption,

electricity consumption, coal consumption, k is capital, L is labour, u and v are the error terms, i is sector, t is year and α 's and β 's are parameters.

3.3.1 Variables

With the adaptation of two functions (the Cobb-Douglas production function and the EKC function), this study comes out with several important variables to achieve the objectives of this study. The list and explanation on the variables are shown in Table 3.1. Labour, capital, oil consumption, gas consumption and electricity consumption are treated as independent variables while industrial output, agricultural output and transportation output are considered dependent variables in the first model specification. The same proxy for energy consumption in the first model is also included in the second model. With the exclusion of labour and capital, the second model treats sectorial output per labour as one of the independent variables instead of a dependent variable and CO₂ emission as a dependent variable.

Table 3.1
Definition and Measurement for Energy Consumption Variables.

Variables	Definition	Units of Measurement
Labour (L)	Labour is the total employment who contributes their physical skill to produce goods and services in each sector (industrial, agricultural and transportation). Labour is the controlled variable	Number of people.
Capital (K)	Capital is measured by the value of fixed assets owned as at the end of the year. Fixed assets include machinery, building, land and furniture. Capital is the controlled variable, which is very important in determining output.	Ringgit Malaysia (RM)
Output (Q)	Output is measured by the value of real gross domestic product in three sectors: i) Industrial sector is the secondary sector that produces goods. This sector takes raw material from	Ringgit Malaysia (RM)

	<p>primary sectors to process to be output. The industrial sector includes manufacturing and construction. This sector consumes various types of energy.</p> <p>ii) Agricultural sector is the primary sector which includes growing crops, raising animals, and harvest fish and other animals from a farm, ranch or their natural habitats. This sector contributes the least of emission in Malaysia</p> <p>iii) Transportation sector is the tertiary sector which includes truck, bus, airline and etc. Transportation sector is highly dependent on oil products. If the price of oil increases, it can affect the performance of this sector.</p>	
Output per labour (Q/L)	Output is measured by the value of real gross domestic product per labour in three sectors (industrial, agricultural and transportation)	Ringgit Malaysia (RM)
Sectorial CO ₂ Emissions (CO ₂)	Sectorial CO ₂ emissions is the emissions produced by separate sectors; industries, transport and agriculture. This emission contributes to the largest share of greenhouse gasses. When we need energy, it is unavoidable to burn oil, coal and gas, and therefore CO ₂ will be emitted into the air. This emission can be harmful to the environment.	Metric tons
Sectorial Natural Gas Consumption (G)	Sectorial natural gas consumption is the consumption of natural gas in several sectors, particularly, industries, transportation and agriculture. Natural gas includes is composed of mostly methane and little hydrocarbon liquids and non-hydrocarbon gases.	Terajoule (TJ).
Sectorial Oil Consumption (O)	Sectorial oil consumption is the consumption of oil in each sector of industries, transportation and agriculture. This type energy can contribute much of CO ₂ emission.	Thousand tonnes of oil equivalent (ktoe).
Sectorial Electricity Consumption (E)	Sectorial electricity consumption is the consumption of electricity in every sector, namely, transportation, industries and agriculture. This type energy is actually generated by several primary energy such as hydro, gas, coal and oil	Gigawatt Hour (GWh).

Source: World Bank, 2015

3.4 Panel Analysis

The panel data analysis outperforms the time series data analysis because it can overcome the problem of estimation techniques for a single time series (Chen & Huang, 2013). The time-series data analysis has two problems, namely, seriously low power tests and low degree of freedom on account of short time period data. Low degree of freedom becomes more serious if the study uses many independent variables. This situation may provide wrong statistical inference. Therefore, the use of the panel method can increase the power of tests and degrees of freedom through the combination of time-series and cross-section information. Next, the panel analysis allows researchers to improve the efficiency of estimators.

There are three tests that will be performed in this study, namely, panel unit root test to see the stationarity of the data, panel co-integration test to see the co-integrating relationship between the variables, panel estimation to see the long-run relationship and thus answer all the objectives (i.e to investigate the effects of energy consumption on output in the short and long runs, to explore the effects of energy on CO₂ emission in the short and long runs, and to examine the impacts of output on CO₂ emission in the short and long runs), and PMG and MG test to see the directional relationship and also short run effects, thus answering all the objectives of this study.

3.4.1 Panel Unit Root Tests

The panel unit root test will be performed before panel co-integration test and panel estimation. The panel unit root tests will be performed for all selected variables. The test is conducted to ensure that there is no tendency for spurious regression when using panel data (Im, Pesaran & Shin, 1997; Levin, Lin & Chu, 2002). The main reason that

the panel unit root test is performed is to solve the low power problem when ADF is applied.

Campbell and Perron (1991) and Ramirez (2007) stated that the reliability of the estimation can be questioned as the unit root test has low power when the number of observations used in time-series studies is less than 50. The use of the panel unit root test can overcome this problem as it has more power and standard asymptotic distribution. Therefore, reliable evidence can be provided by the test. Moreover, as stated by Levin, Lin and Chu (2002), the panel unit root test is more efficient compared to time series unit root test.

Several methods were employed in this test such as Levin, Lin and Chu (2002) (LLC), Breitung (2000), Im, Pesaran and Shin (1997) (IPS), and Maddala and Wu (1999) (MW). These methods have been widely used in previous studies on energy consumption such as Chen and Huang (2013); Li et al. (2011); Farhani and Rejeb (2012); and Akin (2014). Based on the previous studies, this study will use the IPS panel unit root test, LLC and Breitung. Kim, Oh and Jeong (2005) stated that the IPS test is more important than LLC test because it is more appropriate for unit root regressive heterogeneity under the alternative hypothesis.

3.4.1.1 Levin, Lin and Chu (LLC)

Based on LLC, the hypothesis of panel unit root test is as follows:

H_0 : each time series contains a unit root

H_1 : each time series is stationary

The null hypothesis is $H_i = 0$ which suggests that there is a unit root, while the alternative hypothesis is $H_i < 0$ which indicates that there is no unit root. LLC proposed a three-step procedure. Firstly, the ADF regression is needed and its value must ensure that the residual is not related along the analysis period. Secondly, the ratio of long-run to short-run innovation standard deviation must be estimated for each individual. The first and second steps must be performed for each individual. Finally, the pooled t-statistic is computed.

The ADF regression is as follows:

$$\Delta Y_{i,t} = \delta_i Y_{i,t-1} + \sum_{j=1}^p \vartheta_{ij} \Delta Y_{i,t-j} + \varepsilon_{it} \quad (3.8)$$

The lag order from ϑ can be differentiated for each individual. The process of lag order selection can be done as P can be maximized. Subsequently, t-statistic for \hat{P} can be observed to see whether the order of the smaller lag is suitable or not [t-statistics have a standard normal distribution in a null hypothesis ($\hat{P} = 0$) when $\varphi = 0$ or $\varphi < 0$]. Once we have selected the order of autoregression, we can generate two auxiliary regressions to obtain orthogonalised residuals. The regression $\Delta Y_{i,t}$ and $Y_{i,t}$ on $\Delta Y_{i,t-L}$ ($L= 1, \dots, p$) can be performed and residuals $\hat{\varepsilon}_{i,t}$ and $\hat{\nu}_{i,t-1}$ can be obtained. The model is presented as follows:

$$\hat{\varepsilon}_{i,t} = \Delta Y_{i,t} - \sum_{j=1}^p \vartheta_{ij} \Delta Y_{i,t-j} \quad (3.9)$$

$$\hat{\nu}_{i,t} = Y_{i,t} - \sum_{j=1}^p \vartheta_{ij} Y_{i,t-j} \quad (3.10)$$

The normalization of $\hat{e}_{i,t}$ and $\hat{v}_{i,t-1}$ through standard error regression can be done by LLC in order to avoid heterogeneity among individuals. The equation for the normalization is as follows:

$$\tilde{e}_{i,t} = \frac{\hat{e}_{i,t}}{\hat{\sigma}_{\varepsilon,t}}, \quad \tilde{v}_{i,t-1} = \frac{\hat{v}_{i,t-1}}{\hat{\sigma}_{\varepsilon,t}} \quad (3.11)$$

where $\hat{\sigma}_{\varepsilon,t}$ is the standardized error from estimation of equation (3.12). This value can also be computed from regression $\hat{e}_{i,t}$ on $\tilde{v}_{i,t-1}$.

$$\hat{\sigma}_{\varepsilon,t}^2 = \frac{1}{T-p_i-1} \sum_{i=p+2}^T (\hat{e}_{i,t} - \hat{\Phi}_i \hat{v}_{i,t-1})^2 \quad (3.12)$$

Then, the ratio of long-run to short-run standard deviation can be estimated and the model is as follows:

$$\hat{\sigma}_{y,t} = \frac{1}{T-1} \sum_{i=2}^T \Delta Y_{i,t}^2 + 2 \sum_{L=1}^{\bar{K}} W_{K,L} \left[\frac{1}{T-1} \sum_{i=2+L}^T \Delta Y_{i,t} \Delta_{i,t-L} \right] \quad (3.13)$$

where w refers to weights. The truncation lag parameter \bar{K} depends on data. For each individual i , LLC defines the ratio of the long-run standard deviation to innovation standard deviation as:

$$S_i = \frac{\sigma_{y,i}}{\sigma_{\varepsilon,i}} \quad (3.14)$$

The average standard deviation is $S_N = \left(\frac{1}{N}\right) \sum_{i=1}^N S_i$ and is estimated as $\hat{S}_N = \left(\frac{1}{N}\right) \sum_{i=1}^N \hat{S}_i$. Two things must be completed first before the third step can be taken.

Firstly, $\hat{\sigma}_{y,i}$ must be estimated for the null hypothesis which is $\hat{\sigma}_{\varepsilon,i}^2 / (1 - \sum_{i=1}^{p_i} \hat{p}_{i,t})^2$ and after the estimation the result is $\hat{\sigma}_{\varepsilon,i}$ which is constant for $\hat{\sigma}_{\varepsilon,i}^2$ for the null hypothesis. Then, the estimation of \hat{S}_i can be performed according to $[1 - \sum_{i=1}^{p_i} \hat{p}_{i,t}]$. Secondly, the first difference of the estimation of the long variance can cause the feature of size and power for the panel unit root to be larger. Schwert (1989) stated that the first difference of a long-run estimation can be less biased with a limited sample rather than a long-run variance based on residuals in level.

The third step is the estimation of coefficient Φ and the calculation of the t-statistic. With the combination of all cross section and times series, the model can be written as follows:



$$\tilde{e}_{i,t} = \Phi \hat{v}_{i,t-1} + \tilde{\varepsilon}_{i,t} \quad (3.15)$$

where the total observations is $N\tilde{T}$, where $\tilde{T} = T - \bar{g} - 1$ represents the average number of observations per individual in the panel, and $\bar{p} = \frac{1}{N} \sum_{i=1}^N p_i$ represents the average interval for individual ADF regression. The conventional t-statistic to test $\Phi = 0$ is:

$$t_{\Phi} = \frac{\hat{\Phi}}{STD(\hat{\Phi})} \quad (3.16)$$

where

$$\hat{\Phi} = \frac{\sum_{i=1}^N \sum_{t=2+p_i}^T \tilde{v}_{i,t-1} \tilde{e}_{i,t}}{\sum_{i=1}^N \sum_{t=2+p_i}^T \tilde{v}_{i,t-1}} \quad (3.17)$$

$$STD\hat{\Phi} = \sum_{i=1}^N \sum_{t=2+p}^T \tilde{v}_{i,t-1} \quad (3.18)$$

$$\Phi_{\tilde{\varepsilon}}^2 = \left[\frac{1}{N\tilde{T}} \sum_{i=1}^N \sum_{t=2+p}^T (\tilde{\varepsilon}_{i,t} - \hat{\Phi}\tilde{v}_{i,t-1})^2 \right] \quad (3.19)$$

With the null hypothesis $\Phi=0$, a normal distribution for the ADF model without intercept and trend can be found from the regression of t-statistic (t_{Φ}). However, the t-statistic is skewed to the left for the ADF model with intercept and trend, in which case the coordinated t-statistic

$$t_{\Phi}^* = \frac{N\tilde{T}\hat{\sigma}_{\tilde{\varepsilon}}^{-2}STD(\hat{\Phi})\mu_{m\tilde{t}}^*}{\sigma_{m\tilde{t}}^*} \quad (3.20)$$

needs to be computed, where tabulated mean value is adjustment for $\mu_{m\tilde{t}}^*$ and standard deviation is provided by LLC with a deterministic specification ($m=1,2,\dots$) and time series dimension \tilde{T} . The normal tabulation is $N \rightarrow \infty$ and $T \rightarrow \infty$ with $\sqrt{N}/T \rightarrow 0$ or $N/T \rightarrow 0$, depending on our model specification.

3.4.1.2 Im, Pesaran and Shin (IPS)

Im, Pesaran and Shin, or IPS (1997), introduced a test for the stationary data in panel. The test combines information from the time series dimension with that from the cross section dimension under the condition that time series dimension is smaller for the test to have power. We can use IPS as it has superior test power; then IPS can be ensued with specifying a separate ADF regression for each cross-section with individual effects and no time trend:

$$\Delta y_{it} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \quad (3.21)$$

where $i = 1, \dots, N$ and $t = 1, \dots, T$

This test is based on ADF and it provides separate unit root tests for the N cross-section units. Therefore, the average of the t -statistic for ρ_i from the individual ADF regressions, $t_{iT}(\rho_i)$:

$$\bar{t}_{NT} = \frac{1}{N} \sum_{i=1}^N t_{iT}(\rho_i) \quad (3.22)$$

\bar{t} is the standardized form t and \bar{t} -statistic converges to the standard normal distribution as N and $T \rightarrow \infty$. \bar{t} -statistic is better in terms of performance with smaller time series dimension. Hence, the cross-section demeaned version of both tests are employed as the errors in different regressions contain a common time-specific component.

3.4.2 Panel Co-integration Test

After performing the panel unit root test, the panel co-integration test will be conducted. This is to determine the existence of the long-run relationship among all the variables. Pedroni (1999) as well as Maddala and Wu (1999) were the first to use this panel co-integration. Pedroni considered the panel co-integration with heterogeneous intercepts and coefficient while Maddala and Wu emphasized the combination of the tests to elicit the test statistic for the full panel. Roudet, Saxeggard

and Tsangarides (2007) stated that the panel co-integration analysis can increase the efficiency of estimator.

Engle and Granger (1987) explained that the Engle-additional Granger test has low power and thus makes the panel data the best alternative to increase the power of the test. The panel co-integration technique is to allow researchers to selectively collect information which is associated with the long-term relationships across the panel and at the same time it allows the dynamic short-term relationship and specific variation to the panel unit or remains a heterogeneous effect among the panel units. The deterministic and dynamic effects in the data generating process may vary across each panel unit.

The panel data in this study involves dissimilar economic sectors; therefore, a heterogeneous panel model should be formed. This method was proposed by Pedroni (1999). The Pedroni method allows researchers to examine heterogeneous panel, which takes into account panel coefficient heterogeneity, fixed effects and deterministic trends specific to each individual. Actually, Pedroni provides the co-integration test for heterogeneous panel based on the two-step approach of Engle and Granger (1987) and the test is still based on the ADF and PP.

Pedroni (1999) proposed two types of statistical tests, namely, panel statistic and group statistic to determine the significance of the co-integration panel test. There are several test statistics of within-dimension approach such as panel ν -statistic, panel ρ -statistic, panel $\rho\rho$ -statistic and panel ADF-statistic. All of these statistics group around the unit autoregressive coefficients across different panel unit root tests on the estimated

residuals. The group statistical analysis of between-dimensional approach consists of group ρ -statistic, group $\rho\rho$ -statistic and group ADF-statistic. All of these statistics are derived from the estimator which is the average value for every estimated individual coefficient.

Panel v-statistic:

$$Z_v = \left(\sum_{i=1}^N \sum_{t=1}^T \hat{L}_{1li}^2 \hat{e}_{i,t-1}^2 \right)^{-1} \quad (3.23)$$

Panel ρ -statistic:

$$Z_p = \left(\sum_{i=1}^N \sum_{t=1}^T \hat{L}_{1li}^2 \hat{e}_{i,t-1}^2 \right)^{-1} \left(\sum_{i=1}^N \sum_{t=1}^T \hat{L}_{1li}^2 (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i) \right) \quad (3.24)$$

Panel $\rho\rho$ -statistic:

$$Z_p = \hat{\sigma}^2 \left(\sum_{i=1}^N \sum_{t=1}^T \hat{L}_{1li}^2 \hat{e}_{i,t-1}^2 \right)^{-1/2} \left(\sum_{i=1}^N \sum_{t=1}^T \hat{L}_{1li}^2 (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i) \right) \quad (3.25)$$

Panel ADF-statistic:

$$Z_p^* = \hat{\sigma}^2 \left(\sum_{i=1}^N \sum_{t=1}^T \hat{L}_{1li}^2 \hat{e}_{i,t-1}^2 \right)^{-1/2} \left(\sum_{i=1}^N \sum_{t=1}^T \hat{L}_{1li}^2 (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t}) \right) \quad (3.26)$$

Group v-statistic:

$$\tilde{Z}_t = \sum_{i=1}^N \left(\sum_{t=1}^T \hat{e}_{i,t-1}^2 \right)^{-1/2} \left(\sum_{t=1}^T (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i) \right) \quad (3.27)$$

Group $\rho\rho$ -statistic:

$$\tilde{Z}_t = \sum_{i=1}^N \left(\sum_{t=1}^T \hat{e}_{i,t}^2 \right)^{-1/2} \left(\sum_{t=1}^T (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i) \right) \quad (3.28)$$

Group ADF-statistic:

$$\tilde{Z}_t^* = \sum_{i=1}^N \left(\sum_{t=1}^T \hat{s}_i \hat{e}_{i,t}^2 \right)^{-1/2} \left(\sum_{t=1}^T (\hat{e}_{i,t-1} \Delta \hat{e}_{i,t}) \right) \quad (3.29)$$

where $\hat{e}_{i,t}$ is the estimated residual and \hat{L}_{1i}^2 represents the estimated long-run covariance matrix for $\Delta \hat{e}_{i,t}$. Similarly, \hat{s}_i and $\hat{s}_i(\hat{s}_i^2)$ are respectively, the long-run covariance matrix for individual i . These statistics compute the group mean of the individual conventional time series statistic. The asymptotic distribution of each of those five statistics can be expressed in the following form:

$$\frac{X_{N,T}}{\sqrt{v}} \xrightarrow{\mu\sqrt{N}} N(0,1) \quad (3.30)$$

where $X_{N,T}$ is the corresponding form of the test statistic, μ is the mean, and v is the variance of each test [they are given in Table 2 in Pedroni (1999)]. The hypotheses for the panel co-integration test can be represented by equations (3.31) and (3.32).

$$H_0: \rho_i = 0 \quad (3.31)$$

$$H_1: \rho_i < 0 \quad (3.32)$$

Equation (3.31) is the equation of the null hypothesis for no co-integration of both panel statistical test and group average statistical test. Equation (3.32) is the equation

of each alternative hypothesis for panel statistical test and group average statistical test.

3.4.3 Panel Estimation

The panel estimation can be performed to see the long-run relationship among energy consumption, economic sectors and carbon dioxide emission in Malaysia on the condition that there is an existence of a panel co-integration. In this case, FMOLS by Phillips and Hansen (1990) and extended by Pedroni (1996, 2000), and DOLS by Mc Coskey and Kao (1998) and extended by Kao and Chiang (2000) can be employed in the panel estimation. DOLS is better than FMOLS in terms of bias in a small sample. Kao and Chiang explained that FMOLS and DOLS generate estimators in a co-integrated regression which are asymptotically normal with zero mean, while the OLS estimator using panel data suffers from inconsistency and biasedness which cannot be ignored in infinite samples.

According to Pedroni, FMOLS estimation methods were developed to estimate and test hypotheses of co-integration vectors in panel heterogeneity leading to unbiased parameters asymptotically when there are idiosyncratic dynamics and fixed effects. Furthermore, according to Christopoulos and Tsionas (2004), this method can solve the problem of endogeneity, simultaneity and non-stationarity in this study.

Phillips and Hansen (1990) addressed the problem of asymptotic bias and nuisance parameter related to the estimated co-integration vector in a single equation. Then, Phillips (1995) showed the advantage of FMOLS methods when VAR is not stationary with the unknown co-integrated rank. FMOLS estimators can produce good inference

in a dynamic heterogeneous panel model when cross-sectional dimension increases but the dimension of time-series is short. The group-mean FMOLS will be used in this study since its estimation method can have more flexible alternative hypothesis based on the presence of heterogeneity of vector co-integration and it is less problematic with the small sample size compared with the pooled panel FMOLS.

In the context of FMOLS estimation, the co-integrated system for the panel sector, $i = 1, 2, \dots, N$ as shown by equation (3.33) and equation (3.34) is used to derive FMOLS estimator

$$y_{it} = \alpha_i + \beta x_{it} + \mu_{it} \quad (3.33)$$

$$x_{it} = x_{it-1} + \varepsilon_{it} \quad (3.34)$$

where y_{it} and x_{it} are non-stationary, the error vector $\xi_{it} = (\mu_{it}, \varepsilon_{it}) \sim I(0)$ has a long-term covariance matrix or asymptotic covariance matrix, $\Omega_i = L_i L_i'$, (L_i is under triangular decomposition of Ω_i). y_{it} and x_{it} variables are co-integrated for each member of the panel with co-integration vector β . The intercept term represents a specific fixed effect, allowing for co-integrated relationship. Asymptotic covariance matrix Ω_i is different across each panel member and it is divided into $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i'$, where Ω_i^0 is the contemporaneous covariance and Γ_i is the number of auto-covariance. Equation 3.35 showed the estimator of the average group of FMOLS.

$$\check{\beta}_{GFM}^* = \frac{1}{N} \sum_i \left[\frac{\sum_{t=1}^T (x_{i,t} - \bar{x}_i) y_{i,t}^* - T \check{y}_i}{\sum_{t=1}^T (x_{i,t} - \bar{x}_i)^2} \right], \quad (3.35)$$

with $y_{i,t}^* = (y_{it} - \bar{y}_i) - \frac{\hat{L}_{21,i}}{\hat{L}_{22,i}} \Delta x_{it}$ and $\hat{y}_i = \hat{T}_{21,i} + \hat{\Omega}_{21,i}^0 - \frac{\hat{L}_{21,i}}{\hat{L}_{22,i}} (\hat{T}_{22,i} + \hat{\Omega}_{22,i}^0)$ and $\hat{\Omega}_{22,i}^0$ are the long-term covariance between error stationary and auto-regressive error unit. The estimator is shown by equation (3.28).

$$\hat{\beta}_{FM}^* = [\sum_{i=1}^n \sum_{t=1}^T (x_{it} - \bar{x}_i)(x_{it} - \bar{x}_i)']^{-1} [\sum_{i=1}^n (\sum_{t=1}^T (x_{it} - \bar{x}_i) \hat{y}_{it} - T \Delta_{\varepsilon\mu}^+)] \quad (3.36)$$

with $\Delta_{\varepsilon\mu}^+$ is a serial correlation correction terms and y_{it}^+ is a co-integration correction.

The hypothesis test group average FMOLS allows the null hypothesis, $H_0 : \beta_i = \beta_0$ and the alternative hypothesis, $H_1 : \beta_i \neq \beta_0$ for all i . This means that homogeneity does not apply across panel units under the alternative hypothesis. T-statistic towards $\hat{\beta}_{FM}^*$ is represented by equation (3.37):

$$t_{\hat{\beta}_{FM}^*} = (\hat{\beta}_{FM}^* - \beta) (\sum_{i=1}^N L^{-2}{}_{22,i} \sum_{i=1}^T (x_{it} - \bar{x}_i)^2)^{-\frac{1}{2}} \quad (3.37)$$

3.4.4 Pooled Mean Group (PMG) and Mean Group (MG)

Next, the Mean Group (MG) test and Pooled Mean Group (PMG) test are conducted to achieve objective 2 and objective 3 (to explore the effects of energy on CO₂ emission in the short and long runs, and to examine the impacts of output on CO₂ emission in the short and long runs). PMG and MG are used in this study to capture the short run effects for the overall economy and each sector. Pesaran and Smith introduced the MG method in 1995, while the PMG method was introduced in 1999 (Pesaran, Shin & Smith, 1999). The MG and PMG tests are also conducted in this study to examine the

short- and long-run effects of energy consumption and national output on CO₂ emission.

The selection of lag length for both MG and PMG models must be appropriate. In these two methods, the Hausman test is conducted to determine which one is favorable, either MG or PMG (Pesaran, Shin & Smith, 1997). If the results of the Hausman test suggest that it is significant, it means that PMG is better than MG, and vice versa.

If the results show no correlation between regressors and their effects, then PMG is consistent and MG is not consistent. If the results show the existence of correlation, then MG is consistent and PMG is not consistent. There is no difference between the estimators under the null hypothesis of no correlation. Therefore, to conduct the Hausman test. We calculate $\hat{\beta}_{PMG} - \hat{\beta}_{MG}$ and its covariance. The covariance of an efficient estimator with its difference from an inefficient estimator should be zero. Under the null hypothesis, we should estimate:

$$W = (\beta_{PMG} - \beta_{MG})' \hat{\Sigma}^{-1} \beta_{PMG} - \beta_{MG} \sim x^2(k) \quad (3.38)$$

If W is significant, then MG is favourable and if W is insignificant, then PMG is favourable.

The MG model is derived from the ARDL model. The regression should be analyzed separately for the panel data. The MG model is as follows:

$$a_i(Q)y_{it} = b_i(Q)x_{it} + d_iz_{it} + e_{it} \quad (3.39)$$

where Q refers to output, i refers to the long-run parameter for the number of sector 1,2,..., N and t refers to time 1,2,...,T. Meanwhile $\theta_i = \frac{b_i(1)}{d_i(1)}$, and MG estimator for the whole panel data for error correction coefficient is $\theta = \frac{1}{N} \sum_{i=1}^N \hat{\theta}_i$ and the variance is $\hat{\Delta}_{\theta} = \frac{1}{N(N-1)} \sum_{i=1}^N (\hat{\theta}_i - \hat{\theta})^2$.

However, Pesaran, Shin and Smith (1999) combined several data sets and introduced PMG estimation. The estimation can estimate the short- and long-runs coefficients. According to Pesaran, Shin and Smith (1999), the maximum likelihood (ML) estimation refers to PMG estimator and is used to estimate a long-run coefficient, θ . Unrestricted specification ARDL model for time period, $t = 1, 2, \dots, T$ and the number of sector, $i = 1, 2, \dots, N$ and the following equation is derived:

$$y_{it} = \sum_{j=1}^m \lambda_{ij} y_{i,t-j} + \sum_{j=0}^n \delta'_{ij} x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (3.40)$$

where x_{ij} refers to the explanatory variables vector, $(k \times 1)$ for group i and μ_i refers to fixed effects. The parameter for VECM is as follows:

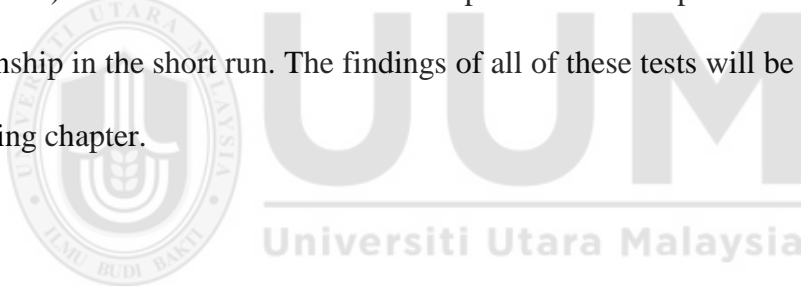
$$\Delta y_{it} = \theta_i (y_{i,t-1} - \beta'_i x_{i,t-1}) + \sum_{j=1}^{m-1} \gamma_{ij} \Delta y_{i,t-j} + \sum_{j=1}^{n-1} \sigma'_{ij} x_{i,t-j} + \sum_{j=1}^{p-1} \tau'_{ij} z_{i,t-j} + \mu_i + \varepsilon_{it} \quad (3.41)$$

where β'_i refers to long-run parameter, γ_{ij} and γ'_{ij} refer to short run coefficient vectors, y_{it} refers to dependent variables (lnQ and lnCO₂), $x_{i,t-j}$ refers to the vector of non-stationary variables, $z_{i,t-j}$ refers to stationary variables, μ refers to fixed effect, ε refers

to error term and θ_i refers to error correction parameter. The PMG model is developed based on the VECM model.

3.5 Summary

In summary, the Cobb-Douglas production function and EKC underline this study. The panel data analysis is used to answer all the objectives. The panel unit root test is employed to check the stationarity of the data while the panel co-integration test is applied to see the long-run relationship. The panel estimation based on FMOLS is employed to see the effects of energy consumption (coal, electricity, gas and oil) on carbon dioxide emission and economic sectors (industrial, transportation, and agriculture). The PMG and MG tests are performed to explore the direction of the relationship in the short run. The findings of all of these tests will be explained in the following chapter.



CHAPTER FOUR

FINDINGS

4.1 Introduction

This chapter discusses the results of the panel data analysis (panel unit root, panel co-integration, FMOLS and PMG). Besides, descriptive statistics analysis is also reported in this chapter. The panel unit root tests are employed to see the stationarity of the data, while the panel co-integration tests are employed to see the co-integrating relationship among the variables. FMOLS and PMG are employed to examine the short- and long-run effects of energy consumption on sectorial output and CO₂ emission.

4.2 Descriptive Statistics

The descriptive statistics exhibit the maximum, minimum, mean and standard deviation values for all variables used (oil consumption, coal consumption, gas consumption, electricity consumption, industrial output, agricultural output, transportation output, CO₂ emission, capital and labour). The results are reported in Table 4.1.

Table 4.1

Descriptive Statistics

Variables	Mean	Maximum	Minimum
Q (RM millions)	63622.4675	155250.6373	13332.24
Q/L (RM millions/labour)	19.5135	59.6888	0.2784
O (millions ktoe)	7.9958	20.998	1.424
L (millions)	109.0919	437.077	0.4007
K (RM millions)	10088.8618	56684.2452	41.45
CO ₂ (millions tons)	33.8898	59	15.3
G (TJ)	91292	394198	183
E (GWh)	19941.6818	63205	12

Based on the table, the variation of each variable (Q, Q/L, CO₂, E, G, K, L, and O) is of large difference across sectors. The variable of Q shows the largest mean of 63622.4675 million while E exhibits the lowest mean of 19941.6818. The largest difference between maximum and minimum values are exhibited by Q with the different value of 141918.4 million. The smallest difference between maximum and minimum values are shown by E. The difference value is 63193.

4.3 Panel Data Analysis

The panel data analysis is conducted to investigate the effects of energy consumption on sectorial output and CO₂ emission as well as the effects of sectorial output on CO₂ emission. The panel co-integration and the panel estimation using the FMOLS approach are performed to achieve these objectives. Besides, this study also employs Pooled Mean Group (PMG) and Mean Group (MG) to discover the short-run effects across sectors.

4.4 Panel Unit Root Results

The unit root tests based on LLC, PP and ADF are performed to see the existence of the stationarity of the data for all variables. The results are split into two categories: level and first difference. Table 4.2 reports the findings of the unit root tests. When the tests are performed using individual intercept with and without trends, the results show that we fail to reject the null hypothesis of unit root at level for the test of ADF. Therefore, we can conclude that the data are not stationary. However, the data for the all variables become stationary at first difference for the test of ADF. Hence, these results suggest that the panel co-integration test can be proceeded.

Table 4.2
Unit Root Results

Variables	Level			First Difference		
	LLC	ADF	PP	LLC	ADF	PP
Individual intercept without trends						
lnQ	-1.7062 [0]** (0.0440)	5.1006 [0] (0.5310)	16.8357 [0]*** (0.0099)	-7.7245 [0]*** (0.0000)	45.9172 [0]*** (0.0000)	52.0781 [0]*** (0.0000)
lnQ/L	-1.9563 [1]** (0.0252)	4.0122 [1] (0.6750)	3.6565 [1] (0.7230)	-6.6881 [1]*** (0.0000)	48.9127 [1]*** (0.0000)	82.8891 [1]*** (0.0000)
lnCO ₂	-1.1037 [1] (0.1349)	4.4961 [1] (0.6099)	7.1648 [1] (0.3059)	-8.0098 [1]*** (0.0000)	50.9798 [1]*** (0.0000)	50.9316 [1]*** (0.0000)
lnE	-0.7196 [1] (0.2359)	0.5294 [1] (0.7674)	0.7462 [1] (0.6886)	-7.9975 [1]*** (0.0000)	28.2539 [1]*** (0.0000)	43.8305 [1]*** (0.0000)
lnG	-1.1389 [1] (0.1274)	2.2835 [1] (0.6838)	2.1008 [0] (0.7172)	-3.0756 [1]*** (0.0011)	18.6918 [1]*** (0.0009)	25.1414 [0]*** (0.0000)
lnK	-2.0910 [0]** (0.0183)	4.9502 [0] (0.5502)	21.4789 [0]*** (0.0015)	-3.4474 [0]*** (0.0003)	21.7433 [0]*** (0.0013)	23.3722 [0]*** (0.0007)
lnL	-1.0188 [0] (0.1541)	6.5769 [0] (0.3617)	6.3206 [0] (0.3883)	-7.5109 [0]*** (0.0000)	44.2361 [0]*** (0.0000)	44.2372 [0]*** (0.0000)
lnO	0.0822 [0] (0.5328)	3.1095 [0] (0.7950)	2.8814 [0] (0.8236)	-8.1297 [0]*** (0.0000)	48.0100 [0]*** (0.0000)	46.2902 [0]*** (0.0000)

Note: [] refers to lag, () refers to probability while ***, **, and * denote the significance level at 1%, 5% and 10%, respectively.

Table 4.2 (Continue)

Variables	Level			First Difference		
	LLC	ADF	PP	LLC	ADF	PP
Individual intercept with trends						
LnQ	-2.1095 [0]** (0.0175)	7.7071 [0] (0.2154)	10.9673 [0]* (0.0894)	-6.8606 [0]*** (0.0000)	36.5295 [0]*** (0.0000)	46.9195 [0]*** (0.0000)
lnQ/L	-0.5148 [1] (0.3033)	7.8839 [1] (0.5507)	12.6506 [1]** (0.0489)	-5.7162 [1]*** (0.0000)	40.010 [1]*** (0.0000)	113.695 [1]*** (0.0000)
lnCO ₂	0.6247 [1] (0.7339)	2.0310 [1] (0.9161)	3.4654 [1] (0.7486)	-7.0283 [1]*** (0.0000)	41.3626 [1]*** (0.0000)	41.6789 [1]*** (0.0000)
lnE	-3.3700 [0]*** (0.0004)	1.0379 [0] (0.1526)	8.1446 [0]** (0.0170)	-6.9548 [0]*** (0.0000)	24.0002 [0]*** (0.0000)	112.149 [0]*** (0.0000)
lnG	0.5759 [1] (0.7177)	5.2793 [1] (0.2598)	0.6339 [1] (0.9592)	-2.5518 [1]*** (0.0054)	15.7183 [1]*** (0.0034)	21.0132 [1]*** (0.0003)
lnK	-2.9354 [0]*** (0.0017)	9.6657 [0] (0.1395)	21.6771 [0]*** (0.0014)	-4.5153 [0]*** (0.0000)	24.8429 [0]*** (0.0004)	24.8612 [0]*** (0.0000)
lnL	-0.1935 [0] (0.4233)	5.2444 [0] (0.5129)	3.2377 [0] (0.7785)	-6.9554 [0]*** (0.0000)	37.8368 [0]*** (0.0000)	38.9865 [0]*** (0.0000)
lnO	0.2771 [1] (0.6091)	2.7245 [1] (0.8425)	2.6218 [1] (0.8546)	-7.8329 [1]*** (0.0000)	44.8179 [1]*** (0.0000)	43.7267 [1]*** (0.0000)

Note: [] refers to lag, () refers to probability while ***, **, and * denote the significance level at 1%, 5% and 10%, respectively.

4.5 Panel Co-integration Results

The panel co-integration test is performed with two models: the relationship between energy consumption and output, and the relationship among energy consumption, output and CO₂ emissions. This panel co-integration is conducted using Pedroni Residual Co-integration and the results are reported in Table 4.3.

Table 4.3
Pedroni Residual Co-integration Results

Q= f (K, L, EC)		
Alternative hypothesis: common AR coefs. (within-dimension)		
Statistics tests	Statistics values	Prob.
Panel v-Statistic	-1.0654	0.8567
Panel rho-Statistic	0.8001	0.7882
Panel PP-Statistic	-2.3328***	0.0098
Panel ADF-Statistic	-1.7651**	0.0338
Alternative hypothesis: individual AR coefs. (between-dimension)		
Group rho-Statistic	1.4573	0.9275
Group PP-Statistic	-2.1961**	0.0140
Group ADF-Statistic	-1.7787**	0.0376
CO₂= f (Q, EC)		
Alternative hypothesis: common AR coefs. (within-dimension)		
Statistics tests	Statistics values	Prob.
Panel v-Statistic	2.4076***	0.0080
Panel rho-Statistic	-2.9548***	0.0016
Panel PP-Statistic	-2.7161***	0.0033
Panel ADF-Statistic	-0.0804	0.4680
Alternative hypothesis: individual AR coefs. (between-dimension)		
Group rho-Statistic	-2.4298***	0.0076
Group PP-Statistic	-3.2221***	0.0006
Group ADF-Statistic	-0.1135	0.4548

Note: *** and ** denote the significance level at 1% and 5%, respectively.

For the first model (the relationship between energy consumption and output), the results of the panel ADF-statistic within dimension and the group ADF-statistic are significant. Other than that, the panel PP statistic and the group PP statistic are also significant. Therefore, the results confirm that there is a co-integrated relationship between energy consumption and output. However, the other statistics (panel v-

statistic and panel rho-statistic) do not show any significant and co-integrated relationship. Out of seven test statistics, four confirm the existence of co-integration among the variables (labour, capital, energy consumption, and output).

For the second model (the relationship running from energy consumption, and output to CO₂ emissions), the results show that several statistics, namely, panel v-statistic, panel PP-statistic and group PP-statistic are higher than the critical values. Out of seven test statistics, five confirm the existence of co-integration among the variables (energy consumption, output, and CO₂ emissions). As the results for both of the models suggest that there is a co-integrated relationship among the variables, the panel estimation can be subsequently conducted.

4.6 Panel Estimation Results

In this study, the panel estimation tests are performed using the FMOLS approach. Since the FMOLS results do not capture the short run effects of energy consumption, this study employs the PMG and MG approaches as well. The Hausman test is conducted in order to choose either PMG or MG. If the results show that it is significant, MG is appropriate and if it is not, PMG is appropriate. The results are classified into three categories: 1) the effects of energy consumption on outputs, 2) the effects of energy consumption on CO₂ emission, and 3) the effects of output on CO₂ emission.

4.6.1 Results of the Effects of Energy Consumption on Outputs

This part discusses the results of the effects of energy (oil, gas and electricity) consumption on aggregate output in two dimensions: short run and long run. The

aggregate output was calculated by totaling the output for all sectors (industrial, agricultural and transportation). Other than that, this part also discusses the results of the effects of energy consumption on output for each sector (disaggregate). The panel estimation is important to see the seriousness of the effects of each energy type on output.

Table 4.4 shows the results of the long-run panel estimations for dependent variable $\ln Q$. From the results, we can achieve the first objective which is to examine the effects of energy consumption on output in the long run. The results show that capital is one of the significant determinants of aggregate output. These results are consistent across the two methods (FMOLS and PMG) albeit with different magnitudes. The results of FMOLS show that the estimated coefficient of capital is positive (as expected) and significant at the 5% level of significance; its magnitude of 0.1510 suggests that an increase of 1% in capital can cause output to increase by 0.1510% in the long run.

Table 4.4
Long-Run Panel Estimation Results for Aggregate Output (Dependent Variable: $\ln Q$)

Long run FMOLS			
Independent Variables	Coefficient	t-statistic	Prob.
$\ln K$	0.1510**	2.2086	0.0330
$\ln L$	0.8291***	4.2619	0.0001
$\ln O$	0.0583*	1.7720	0.0840
$\ln G$	0.3557**	2.4094	0.0207
$\ln E$	0.1096*	1.8076	0.0782
Long run PMG			
Independent Variables	Coefficient	z-value	Prob.
$\ln K$	0.2942***	3.30	0.001
$\ln L$	0.3492*	1.65	0.099
$\ln O$	0.1614***	3.57	0.000
$\ln G$	0.0490***	3.32	0.001
$\ln E$	-0.0203	-0.88	0.379
Long run MG			
Independent Variables	Coefficient	z-value	Prob.
$\ln K$	2.5104	1.24	0.216

Table 4.4 (Continue)

lnL	0.0642	0.08	0.937
lnO	0.0213	0.13	0.899
lnG	-0.3026	-0.92	0.356
lnE	-0.0540	-1.21	0.226

Hausman Test: 0.9091

Note: The Hausman probability is subjected to its variance which is not positive definite. ***, **, and * denote the significance level at 1%, 5% and 10%, respectively.

Due to the insignificant value in the Hausman test, PMG is favourable. The results of PMG show that the estimated coefficient of capital is positive (as expected) and significant at the 1% level of significance; its magnitude of 0.2942 suggests that an increase of 1% in capital can cause output to increase by 0.2942% in the long run.

Apart from that, the results from Table 4.4 show that labour can influence aggregate output in the long run. The significant relationship between these two variables are consistently obtained from the FMOLS and PMG tests although they produce quite distinct results in terms of magnitude. This means that labour is an important factor in determining aggregate output. The results of FMOLS show that it is significant at 1%. The coefficient value of 0.8291 indicates that a 1% increase in labour can cause aggregate output to increase by 0.8291%. The results of PMG also show a positive relationship with a coefficient value of 0.3492. The results show that it is significant at 1%. Therefore, a 1% increase in labour can increase in aggregate output by 0.3492%.

Oil consumption can boost aggregate output in the long run. These findings are consistent using FMOLS and PMG although the magnitude of the estimated coefficients differ a bit. The results imply that oil consumption is undeniably related to aggregate output. The results from FMOLS show that there is a positive and

significant relationship between oil consumption and aggregate output. The coefficient value of 0.0583 suggests that a 1% rise in oil consumption can push aggregate output up by 0.0583%. This significant result are supported by the results of PMG which both of the tests show significant values of 1%. The results for PMG show that the estimated coefficient of oil consumption is positive (as expected); its magnitude of 0.1614 suggests that an increase of 1% in oil consumption can cause output to increase by 0.1614% in the long run.

Gas consumption can also influence output in the long run. This significant result are supported using both FMOLS and PMG approach. The results of FMOLS show that it is significant at 5% and the coefficient value is 0.3557. Therefore, an increase of 1% in gas consumption can cause output to increase by 0.3557%. The results of PMG show that it is significant at 1% with its magnitude of 0.0490. Therefore a 1% increase in gas consumption can increase output by about 0.0490% in the long run.

Electricity consumption can also influence output in the long run. It is supported by the results of FMOLS. The results of FMOLS show that it is significant at 10% and the coefficient value is 0.1096. Therefore, an increase of 1% in gas consumption can cause output to increase by 0.1096%. The PMG analysis does not show any significant value of the relationship between gas consumption and aggregate output. However, FMOLS is advantageous in the group-means version for the long-run relationship (Madaleno, Moutinho & Mota, 2015).

From the long-run estimation, we now move to the short-run estimation. In this case, only PMG and MG are employed since FMOLS cannot estimate the short-run

relationship. Table 4.5 shows the short-run effects of energy consumption on aggregate output using the PMG and MG approaches. Since the results of the Hausman test show that the Hausman statistic is not significant, PMG is favourable compared to MG. The findings show that the ECT value is negative and significant at 1%. The coefficient value is 0.7401, it means that the deviations from the long-run growth rate in aggregate output are corrected by 0.7401%. The results also show that labour can affect aggregate output in the short run. The results of PMG show that it is significant at 1% and the coefficient value is 0.4340, thus a 1% increase in labour can help boost aggregate output by 0.4340%

Table 4.5

Short-Run Panel Estimation Results for Aggregate Output (Dependent Variable: $\ln Q$)

Short run PMG			
Independent Variables	Coefficient	z-value	Prob.
$\ln K$	0.7698	1.25	0.210
$\ln L$	0.4340***	3.61	0.000
$\ln O$	0.0403	0.74	0.462
$\ln G$	0.1466	1.20	0.231
$\ln E$	0.0581	0.83	0.408
Constant	-3.0216	-1.41	0.160
ECT	-0.7401***	-3.70	0.000
Short run MG			
Independent Variables	Coefficient	z-value	Prob.
$\ln K$	0.2024**	2.00	0.045
$\ln L$	0.4968***	4.30	0.000
$\ln O$	0.0685	1.19	0.234
$\ln G$	-0.0697	-1.49	0.135
$\ln E$	0.0947	0.88	0.377
Constant	-22.9846	-1.40	0.161
ECT	-0.4905	-1.48	0.139

Hausman Test : 0.9091

Note: The Hausman probability is subjected to its variance which is not positive definite. *** and ** denote the significance level at 1%, 5% and 10%, respectively.

The results of PMG do not show any significant relationship between capital and aggregate output in the short run. Other than that, the results of PMG also show that

all energy types (oil, gas and electricity) do not have any significant effect on aggregate output in the short run.

Besides examining the effects of energy consumption on aggregate output, we may also examine the effects of energy consumption on sectorial output. The idea is to see the relative dependence of sectorial output on energy. The economy is divided into three sectors consisting of agriculture, industrial and transportation, and the short-run effects of energy consumption on the output for each sector are analysed by conducting the PMG and MG tests. In view of the Hausman test result, however, this study rejects the use of MG in favour of PMG.

Table 4.6 shows the results of short-run panel estimation for each sector. Based on the results, we can see which energy consumption can influence agricultural, industrial, and transportation sectors. It can be learnt that there is no factor influencing the agricultural output in the short run. In the industrial sector, labour and gas do affect industrial output. The coefficient value for the relationship between labour and industrial output is 0.6148 and it is significant at 5%. Therefore, a 1% increase in labour can help boost industrial output by 0.6148% in the short run. Apart from that, gas consumption also plays an important role in determining output in the industrial sector as it is significant at 1% with the coefficient value of 0.3897. Therefore a 1% increase in gas consumption can increase industrial output by 0.3897%. However, other variables such as oil and electricity consumptions do not influence the industrial output.

In the transportation sector, the results show that there is a significant relationship between labour and output (with its significant level of 5%). The coefficient value is 0.4814 and therefore, a 1% increase in labour can increase output by 0.4814%. Besides, the results also show that there is a significant relationship between gas consumption and output (with significant level of 10%). The coefficient value is 0.0501 and thus suggesting that a 1% increase in gas consumption can boost output in the transportation sector by 0.0501%. However other energy types such as oil and electricity consumptions do not influence the output.

Table 4.6
Short-Run Panel Estimation for Sectorial Output (Dependent Variable: $\ln Q$)

Agriculture			
Independent variables	Coefficient	z-value	Prob.
lnK	1.9844	0.45	0.650
lnL	0.2060	0.75	0.453
lnO	0.0208	0.64	0.521
lnG	-	-	-
lnE	-	-	-
Constant	-1.2578	-1.36	0.175
Industrial			
Independent variables	Coefficient	z-value	Prob.
lnK	0.3209	1.54	0.123
lnL	0.6148**	2.35	0.019
lnO	-0.0434	-0.82	0.415
lnG	0.3897**	2.07	0.039
lnE	0.1976	0.70	0.484
Constant	-0.5108	-1.02	0.310
Transportation			
Independent variables	Coefficient	z-value	Prob.
lnK	0.0042	0.05	0.961
lnL	0.4814**	2.50	0.013
lnO	0.1435	1.42	0.156
lnG	0.0501*	1.89	0.059
lnE	-0.0234	-1.15	0.250
Constant	-7.2962***	-2.65	0.008

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

4.6.1.1 Discussion on the Effects of Energy Consumption on Output

The findings of this current study is split into two time dimensions: short run and long run. In the long run, energy consumption can influence economic growth in Malaysia. The results suggest that an increase in energy consumption can help boost economic growth in the long run in Malaysia. Parallel with that, any energy policy to reduce energy consumption might impede economic growth in Malaysia.

This finding was supported by Shahiduzzaman and Alam (2012) who investigated the factor of energy consumption influencing output and the results indicated that energy consumption is as important as capital and labour in determining national output. However, the study used data on aggregate energy consumption without dividing into several energy types. Not all energy types can influence economic growth since energy policies nowadays have reduced some energy types. Hence, it is important to disaggregate energy and therefore, this current study extends the previous study by including oil, gas and electricity.

Specifically, all energy types (oil, gas, and electricity) can affect aggregate output in the long run. The finding of this significant and positive relationship between oil consumption and national output is consistent with the finding by Aktas and Yilmaz (2008). The finding of the significant effects of gas consumption on output was supported by Shahbaz, Farhani and Rahman (2013). The finding of the existence of a long-run relationship between electricity consumption and output corresponds to the findings of Masduzzaman (2012). Therefore, we concluded that a decrease in any energy type can disrupt economic growth in Malaysia.

In the short run, this study found that oil consumption plays an important role in determining aggregate output. This finding is consistent with the finding of Naser (2011) who investigated the relationship between oil consumption and economic growth and found that economic growth is dependent on oil consumption in the short run. However, this study found that other energy types do not have a significant effect on aggregate output in the short run. Therefore, a reduction in all energy types (except oil), do not have any effect on sectorial output.

However, gas consumption can influence output in the industrial sector and transportation sector in the short run. This is because the Malaysian government has increased the consumption of natural gas to conserve the environment. This energy can produce the smallest amount of CO₂ emission, and thus slowing down the environmental degradation. The effects of gas consumption in the industrial sector is greater than that of gas consumption in the transportation sector. This is because the industrial sector consumes a larger amount of gas compared to the transportation sector. In 2014, the industrial sector consumed 226,506 TJ compared to 12,480 TJ which were consumed in the transportation sector (International Energy Agency, 2014).

Electricity consumption does not play an important role in determining output in all sectors in the short run. This finding is supported by the finding of Squalli and Wilson (2006) which stated that there is no relationship between energy consumption and output in UAE. An increase in electricity consumption does not matter to output in all sectors. This is because electricity is still consumed regardless of how many output are produced. Electricity is largely consumed in buildings for all sectors and it does

not affect output. We consume the same amount of electricity to produce more or less output as the size or the number of buildings remain the same, or the working hours remain the same.

4.6.2 Results of the Effects of Energy Consumption and Output on CO₂ Emission

This study does not only estimate the effects of energy consumption on output but also the effects of energy consumption and output on CO₂ emission. Hence, this study is composed of two models to achieve all of the objectives. In order to estimate the effects of energy consumption and output on CO₂ emission, this study employs the same method: FMOLS, PMG and MG. Since the results of FMOLS are not able to capture the short-run effects, PMG and MG are employed. The Hausman test is important to favour either PMG or MG method. The results of the Hausman test shows that the value of the probability (0.8088) is larger than 5%. Therefore, the PMG approach is preferred.

Table 4.7 shows the results of long-run panel estimations for dependent variable $\ln\text{CO}_2$. From the table, we can see the effects of energy consumption and output on the environment in the long run. The results in the table do not include a constant value in the long-run estimation. This is because the long-run panel estimation usually removes the individual effects by rejecting the individual mean.

Table 4.7

Long-Run Panel Estimation Results for Aggregate Output (Dependent Variable: $\ln CO_2$)

Long run FMOLS			
Independent Variables	Coefficient	t-statistic	Prob.
$\ln Q/L$	0.3946**	2.5812	0.0135
$\ln O$	0.5896***	16.3412	0.0000
$\ln G$	0.3571***	3.5010	0.0011
$\ln E$	-0.0795	-1.0242	0.3117
Long run PMG			
Independent Variables	Coefficient	z-value	Prob.
$\ln Q/L$	1.0624***	[2.60]	(0.009)
$\ln O$	0.9651***	[2.72]	(0.007)
$\ln G$	0.1807***	[3.27]	(0.001)
$\ln E$	-0.3989*	[-1.72]	(0.085)
Long run MG			
Independent Variables	Coefficient	z-value	Prob.
$\ln Q/L$	0.3493	[0.86]	(0.390)
$\ln O$	0.7690***	[2.64]	(0.008)
$\ln G$	0.3425	[0.99]	(0.322)
$\ln E$	-0.1532	[-1.03]	(0.301)

Hausman Test: 0.8088

Note: The Hausman probability is subjected to its variance which is not positive definite. ***, **, and * denote the significance level at 1%, 5% and 10%, respectively.

The results can achieve the second objective which show that aggregate output is an important factor that can influence CO_2 emission in the long run. The coefficient value is 0.3946 for FMOLS and it is significant at 5%. Therefore, an increase of 1% in output can cause CO_2 emission to increase by about 0.3946% in the long run. The result of PMG also shows a positive relationship between output and CO_2 emission with a coefficient value of 1.0624 in the long run. Therefore, an increase in output by 1% can increase CO_2 emission by 1.0624%.

Apart from that, the results from Table 4.7 also show the effects of energy (oil, gas and electricity) consumption on CO_2 emission. The results show that oil consumption can influence CO_2 emission in the long run. All the tests (FMOLS, PMG and MG) show consistent results despite different magnitudes. The significant relationship

between these two variables are obtained from the FMOLS, PMG and MG tests. The results of FMOLS show that it is significant at 1%. The coefficient value is 0.5896 which indicates that a 1% increase in output can cause CO₂ emission to increase by about 0.5896%. The results of PMG show there is a positive relationship with a different coefficient value of 0.9651 and it is significant at 1%. Therefore, a 1% increase in oil consumption can increase CO₂ emission by about 0.9651%.

The results of FMOLS and PMG also show that gas consumption can have a significant effect on CO₂ emission whereby the coefficient values are 0.3571 and 0.1807, respectively. Both of the tests produce consistent results albeit with different magnitudes. Therefore, the results of FMOLS suggest that a 1% increase in gas consumption can prompt about 0.3571% increase in CO₂ emission. The results of PMG show that a 1% increase in gas consumption can cause about 0.1807% increase in CO₂ emission.

Based on the results of FMOLS, electricity consumption does not have any relationship with CO₂ emission. However, the results are not consistent with that of PMG. The results of PMG show that electricity consumption can influence the environment in the long run. The results of PMG show that there is a negative and significant relationship between electricity consumption and CO₂ emission. The coefficient value is -0.3989. The results suggest that a 1% rise in electricity consumption can reduce CO₂ emission by 0.3989%, respectively.

As before, PMG and MG are employed to see the short-run effects of energy consumption and output on CO₂ emission. Table 4.8 shows the short-run effects of

energy (oil, gas and electricity) consumption and aggregate output on CO₂ emission. Since the results of the Hausman test show that the Hausman statistic is not significant, then PMG is favourable compared to MG. The findings show that the ECT value is negative and significant at 1%. The coefficient value is -0.7555, suggesting that the deviations from the long-run growth rate in CO₂ emission are corrected by 0.7555%. The results for the effects of output on CO₂ emission show that it is not significant. Therefore, an increase in output does not contribute to increasing CO₂ emission in the short run. The results of PMG show that oil consumption can produce more CO₂ emission in the short run. The coefficient value is 0.5294, therefore, it suggests that a 1% increase in oil consumption can cause CO₂ emission to increase by 0.5294%. However, the other energy types including gas and electricity do not have any effect on CO₂ emission.

Table 4.8
Short-Run Panel Estimation Results for Aggregate Output (Dependent Variable: $\ln CO_2$)

Short run PMG			
Independent Variables	Coefficient	z-value	Prob.
$\ln Q/L$	-0.1572	-1.20	0.232
$\ln O$	0.5294*	1.71	0.087
$\ln G$	-0.1246	-1.32	0.186
$\ln E$	0.0878	0.75	0.450
Constant	-1.9033	-0.93	0.353
ECT	-0.7555 ***	-3.72	0.000
Short run MG			
Independent Variables	Coefficient	z-value	Prob.
$\ln Q/L$	-0.1561	-1.08	0.281
$\ln O$	-0.6562	-1.42	0.156
$\ln G$	-0.1325	-1.31	0.190
$\ln E$	0.1139	0.105	0.294
Constant	-1.1391	-0.36	0.719
ECT	-0.2860	-0.95	0.344

Hausman Test: 0.8088

Note: The Hausman probability is subjected to its variance which is not positive definite. *** and * denote the significance level at 1% and 10%, respectively.

In this study, it is important to see the effects of energy consumption and output on CO₂ emission for each sector. This is because we can see which energy consumption and which sectorial output can influence CO₂ emission in the short run. Table 4.9 shows the results of short-run panel estimation for all sectors separately.

Table 4.9
Short-Run Panel Estimation Results for Sectorial Output (Dependent Variable: lnCO₂)

Agriculture			
Independent Variables	Coefficient	z-value	Prob.
lnQ/L	0.0187	0.13	0.900
lnO	1.0084 ***	33.10	0.000
lnG	-	-	-
lnE	-	-	-
Constant	0.2033	0.68	0.496
Industrial			
Independent Variables	Coefficient	z-value	Prob.
lnQ/L	-0.4143	-1.31	0.192
lnO	-0.0498	-0.49	0.621
lnG	0.3094	1.37	0.169
lnE	0.3184	0.87	0.385
Constant	-6.0001	-0.95	0.344
Transportation			
Independent Variables	Coefficient	z-value	Prob.
lnQ/L	-0.0759	-0.54	0.587
lnO	0.6295***	4.38	0.000
lnG	0.0645*	1.83	0.067
lnE	-0.0549**	-2.24	0.025
Constant	0.0868	1.04	0.297

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

In the industrial sector, it is learnt that all energy types and output do not have any significant effect on CO₂ emission. It means that an increase in energy consumption (oil, gas and electricity) in that sector does not contribute to increasing environmental degradation in Malaysia. Other than that, a rise in output in the industrial sector also does not cause any environmental problem.

In the agricultural sector, it is learnt that only oil consumption can affect CO₂ emission. The coefficient value is 1.0084 and it is significant at 1%. Thus, it suggests that a 1% increase in oil consumption in the agricultural sector can increase CO₂ emission by 1.0084%. The results also show that the other energy types do not have any significant effect on CO₂ emission. Therefore, an increase in gas and electricity consumptions do not result in higher CO₂ emission. Apart from that, agricultural output also does not significantly affect CO₂ emission.

In the transportation sector, the coefficient value for the relationship between oil consumption and CO₂ emission is 0.6295 and it is significant at 1%. Therefore, a 1% increase in oil consumption the transportation sector can contribute to increasing CO₂ emission by 0.6295% in. Gas consumption in the transportation sector can also influence CO₂ emission. The coefficient value is 0.0645 and significant at 10%. Therefore, a 1% increase in gas consumption can increase CO₂ emission by 0.0645%. Electricity consumption can have a good effect on CO₂ emission. The coefficient value is -0.0549 and it is significant at 5%. Therefore, a 1% increase in electricity consumption in the transportation sector can reduce CO₂ emission by about 0.0549% in Malaysia. Besides, transportation output does not have any significant effect on CO₂ emission.

4.6.2.1 Discussion on the Effects of Energy Consumption on CO₂ emission

In the long run, all energy types can be harmful to the environment in Malaysia except electricity. Therefore, a reduction in energy consumption is very important to conserve the environment. Energy consumption such as oil can produce CO₂ emission. The effects of oil consumption on the environment is greater than the effects of gas

consumption on CO₂ emission. According to the U.S Energy Information Administration (2016), natural gas produces a relatively lower CO₂ emission. Alkathlan et al. (2012) stated that an increase in energy consumption can worsen the environment.

However, the difference between this study and Alkathlan, Alam and Javid (2012) is that this current study includes several energy types to examine the effects of energy consumption on CO₂ emission. The importance of including several energy types is to determine which energy types actually harm the environment. This current study found out that the use of electricity can reduce CO₂ emission in Malaysia while the other energy types can increase CO₂ emission.

As mentioned in section 4.6, electricity consumption does not have deleterious effects on the environment in the long run. The findings suggest that an increase in electricity consumption can contribute to lower environmental degradation in Malaysia. This is because the country has been increasing the use of renewable energy such as hydro in generating electricity. According to the Malaysia Energy Statistic Handbook (2015), Malaysia generated electricity of 11799 GWh in 2013, which was 4909 GWh higher than it generated in the previous year. The use of such energy can conserve the environment as it does not produce CO₂ emission.

In the short run, only oil consumption can affect the environment while gas and electricity do not. Natural gas consumption has an effect on the environment only in the long run. However, in the short run, it does not. This is because natural gas is primarily methane which has a higher energy content relative to other energy types,

hence it produces a relatively lower CO₂ emission (U.S Energy Information Administration, 2016).

In the agricultural sector, oil consumption can affect CO₂ emission. Therefore, an increase in oil consumption in the sector can exacerbate the environmental degradation in Malaysia. The agricultural sector does not consume various types of energy compared to the industrial sector. However, in the industrial sector, all energy types (oil, gas and electricity) are not harmful to the environment. This is because Malaysia implemented several environmental policies such as the restriction on pollution of the atmosphere [Section 22 of the Environment Quality Act, EQA, 1974 (Act 127) and the Environmental Quality (clean air) Regulation 2014]¹ to control air pollution (Regional Forum on Environmental Compliance in Industrial Sector, 2015). These policies affected firms in the industrial sector.

In the transportation sector, various energy consumption can affect the environment. Oil and gas can be harmful to the environment. Therefore, an increase in those energy types in the sector can worsen the environmental degradation in Malaysia. The use of oil and gas emit CO₂ emission which directly jeopardize the environment. In contrast, an increase in electricity consumption can reduce CO₂ emission.

4.6.2.2 Discussion on the Effects of Output on CO₂ Emission

In the long run, output can influence CO₂ emission. This finding is supported by the finding of Asici (2011). Asici also used the panel data analysis to examine the effects

¹ Restrictions on pollution of the atmosphere [refer to Appendix 6] - No person shall, unless licenced, emit or discharge any wastes into the atmosphere in contravention of the acceptable conditions specified under section 21 (EQA, 1974).

of output on CO₂ emission. However, the study did not consider sectorial output in the study and therefore the study was unable to see which sector is dependent on energy consumption and which sector is not. Some energy policies are implemented and enforced in certain sectors such as industry in Malaysia. Therefore, it is important to examine and see the effects of industrial output on CO₂ emission in Malaysia.

In the short run, aggregate output does not influence CO₂ emission in Malaysia. In each sector (industry, transportation and agriculture) output does not have any effect on CO₂ emission. This is because, output in the short run is not as much as output in the long run. Hence, it can have an effect on CO₂ emission only in the long run.

4.7 Summary

This chapter is intended to achieve the objectives of this study: to investigate the effects of energy consumption on output in the short and long runs, to explore the effects of energy on CO₂ emission in the short and long runs, and to examine the impacts of output on CO₂ emission in the short and long runs. This study employed panel unit root tests, panel co-integration (Pedroni) and panel estimation (FMOLS, PMG and MG).

The first objective is to investigate the effects of energy consumption on output in the short and long runs. Based on the results, it is learnt that all the energy types, namely, oil, gas electricity consumptions can positively influence aggregate and sectorial output in the long run. However, in the short run, all the energy types do not affect aggregate and sectorial output in Malaysia. In the industrial and transportation sectors,

gas consumption can enhance output. In the agricultural sector, no energy types can significantly affect output.

The second objective is to explore the effects of energy on CO₂ emission in the short and long runs. It was found that oil and gas consumptions can have negative effects on aggregate CO₂ emission in the long run. Meanwhile, the electricity consumption can have a positive effect on aggregate CO₂ emission in the long run. However, in the short run, there is only one energy type (oil) that can affect the environment of Malaysia. Meanwhile, the other energy types cannot affect the environment. Oil consumption can cause negative effects on the environment in the industrial and transportation sectors, while gas consumption can give negative effects on the environment in the transportation. However, the electricity consumption can reduce the effects on the environment in Malaysia.

The third objective is to examine the impacts of output on CO₂ emission in the short and long runs. The results indicated that it does in the long run only. However, in the short run it does not give any impact to CO₂ emission. In all the sectors (agriculture, industry, and transportation), there is no relationship between every different sectorial output and CO₂ emission.

CHAPTER FIVE

CONCLUSION

5.1 Introduction

This chapter aims at giving a coherent overview of the thesis. The findings of the present study serve no purpose unless the discussion is moved towards the future development while considering some implications for the future policies pertaining to the issue of energy consumption and the national output. To do this, a summary of the research aim, questions, rationale, followed by the summary of findings are revisited. The summary of the findings is organised according to the research objectives as to provide a coherent overview of the thesis that allows for a conversation on the study's implications. Suggestions, strengths, and limitations of the study are given pursuant to the implications discussed. It concludes with some reflections as to further avenues of research.

5.2 Recapitalisation of Findings

The issue of energy consumption has been extensively debated in much literature as it has considerable potentials to influence the national output of a country. Noteworthy, energy consumption has the similar influence as that of labour and capital, with regards to economic growth. The understanding that energy is consumed to generate economic activities and thus its absence can stunt economic growth prevails in every individual country. Hence, energy is perceived to be vital in all sectors encompassing industrial, transportation and agriculture sectors.

In comparison, the industrial sector consumes the largest amount of energy compared to the other sectors. In terms of the energy source, it is not limited to one kind of energy being consumed to fuel economic growth. However, each type of energy source perhaps does not play an equal role to boost the economy judging by the nature of its sectorial consumption. For example, in 2014, the industrial sector consumed 63205 GWh of electricity, 1,477,000 tonnes of oil, and 226506 TJ of gas (International Energy Agency, 2014). These figures indicate the country's dependence on numerous types of energy source.

Despite its importance, energy consumption has fuelled debate among scholars and academics in terms of the alarming environmental problem inflicted on the country. It is argued that a larger consumption of energy can produce more CO₂ emission, thus affecting the air quality. Thus far, reports have been extensively documented on the inextricable association between CO₂ emission and the industrial, transportation as well as the agricultural sector. For instance, the agricultural sector is reported to emit 1.52% of CO₂ in 2013 in Malaysia (World Bank, 2015). Due to the alarming environmental problems that are being lamented in our society, the government has implemented several policies to conserve the environment.

However, these policies seem to remain ineffective as the environmental degradation is still on the rise. Therefore, these issues merit serious and meticulous attention thus triggering the researcher to embark on the study aiming at achieving the following objectives:

- i) To investigate the effects of energy consumption on output in the short and long runs.

- ii) To explore the effects of energy on CO₂ emission in the short and long runs.
- iii) To examine the impacts of output on CO₂ emission in the short and long runs.

To achieve the objectives, this study employed the panel data analysis which is composed of unit root, Co-integration, FMOLS, and PMG. In so doing, the data for the period 1990-2014 were analysed. The results of unit root test using ADF approach, suggest that all the variables used in this study are not stationary at level but stationary at first difference. Therefore, panel Co-integration was employed to determine the existence of co-integration among the variables for both models (the effects of energy consumption on sectorial output, and the effects of energy consumption and sectorial output on CO₂ emission).

The findings disclose that there is an existence of co-integration for both models. FMOLS and PMG tests were conducted to answer the questions of this current study. To shed some lights on the findings, this current study discusses two-time horizons: short and long runs. In addition, this study also emphasizes three types of energy source (oil, gas, and electricity) in three sectors (industry, agriculture and transportation). The discussion of these findings is organised according to the research objectives.

5.2.1 To Investigate the Effects of Energy Consumption on Output.

This section will discuss several perspectives. First is the effects of energy consumption in the long run, second is on the short run and third is on the sectorial effects. This study found that in the long run, aggregate output is dependent on energy consumptions. However, in the short run, energy consumption does not play an

important role in determining the output. In comparison with the work of Saidi, Rahman and Amamri (2017) who used panel data analysis on 53 countries and did not classify the energy sources, the long-run analysis reported a similar result with the present study. What differs is that their study also found a significant effect of energy consumption on output, in the short run. This is because this present study focuses on disaggregate output rather than aggregate output.

While in the study by Carmona, Feria, Golpe and Iglesias (2017), using two classifications of energy, i.e. renewable and non-renewable energy, it was found that only petroleum consumption was found to be a determinant of economic growth in the United States. The different economic status and pattern of energy used between Malaysia and the United States might account for the different findings between these two studies. While, Sarwar, Chen, and Waheed (2017) who explored several energy types, namely oil, coal and electricity in 200 countries, found a relationship between electricity consumption and economic growth. However, their study did not explore the influence of the energy consumption on sectorial output.

With regards to sectorial outputs, the present study found that gas consumption is the most influencing factor to the industrial and transportation sectors compared to other types of energy (oil and electricity). The classification of sectorial output used in the present study distinguishes it from the work of Carmona et al. (2017). The latter only studied the overall consumption of energy (renewable and non-renewable) on economy output without considering the effects of consumption in different sectorial output.

5.2.2 To Examine the Impacts of Energy Consumption on CO₂ Emission.

This current study found that in the long run, all energy types can cause environmental degradation in Malaysia except for electricity. In the short run, only oil consumption can affect the environment. Mirza and Kanwal (2017) also examined the effects of energy consumption on CO₂ emission in the long and short run in Pakistan. The results showed that energy consumption can cause CO₂ emission to escalate in the long and short run in Pakistan. However, Mirza and Kanwal (2017) did not classify energy into several types such as oil, gas and electricity. The study considered overall energy consumption without identifying which energy type can have a deleterious effect on the environment.

Amri (2017) investigated the non-renewable and renewable energy consumption on CO₂ emission in Algeria. However, the study still did not specify which non-renewable energy can be detrimental to the environment. Salahuddin, Alam, Ozturk and Sohag (2017) on the other hand only considered electricity consumption in exploring the effects of energy on CO₂ emission. The results indicated that electricity consumption can affect CO₂ emission.

In regards to sectorial energy, Talbi (2017) confirmed that oil used in the transportation sector can increase CO₂ emission in Tunisia. However, the study only focused on one type of energy (oil) and one sector (transportation) only. This current study also found that oil consumption in the transportation sector can increase CO₂ emissions. This current study also explores the effects of several energy types which include gas and electricity usage in the transportation sector on CO₂ emissions. The results showed significant effects of those energy types on CO₂ emissions.

Apart from that, there is no effect of all energy types consumed in the industrial sector on CO₂ emission in Malaysia. This is because of the strict environmental regulations in the industrial sector. Oil consumed in the agriculture sector can affect the environment. Other types of energy consumed in the sector do not cause any environmental degradation. Energy consumed in the transportation sector can have a detrimental effect on the environment.

5.2.3 To Examine the Impacts of Output on CO₂ Emission.

Output can influence CO₂ emissions in the long run. On the other hand, output was found to not influence CO₂ emission in Malaysia in the short run. Narayan, Saboori and Soleymani (2015) have also investigated the relationship between energy consumption and output in 181 countries. However, their results are mixed; some studies such as Apergis and Payne (2010), Asici (2011) and Li et al. (2011) found that there is a positive relationship between output and CO₂ emission, confirming the existence of EKC and this result is consistent with that of this current study. Some countries exhibit a negative relationship between output and CO₂ emission, suggesting that an increase in output can reduce CO₂ emission. Nevertheless, Narayan, Saboori and Soleymani (2015) did not state the output of which sector can influence CO₂ emission while this current study included which sector's output can cause CO₂ emission to intensify.

This current study included some sectors such as industry, transportation and agriculture. However, the findings did not show any significance across the sectors. Chen, Wu, Geng and Yu (2016) also investigated across several sectors including the industrial sector and others in China. Their findings showed that construction produces

the most emission followed by the industrial sector. However, this study did not discover the contribution of output in the specific agricultural sectors. The agricultural sector should be addressed in this study as this sector also consumes oil energy in generating its activity.

5.3 Key Contribution to the Literature

Studies on the effects of energy types (oil, gas and electricity) from various sectors on sectorial output (agricultural, industrial and transportation sectors) and CO₂ emission are still sparse. Based on the previous literature, it can be learnt that most previous studies only focussed on total energy consumption on aggregate output rather than energy types and disaggregate output. Therefore, this present study is important to contribute in terms of its novelty to the literature. The findings obviously show that oil consumption can have deleterious effects on transportation and agricultural output. Besides, gas consumption in the transportation sector was found to boost industrial output but increase CO₂ emission in the transportation sector. Electricity consumption does not have any unfavourable effect on the environment as it can reduce CO₂ emission not only in the long run but also in the short run in the transportation sector. Therefore, these findings can cater for the need to understand which energy type can be detrimental to the environment.

5.4 Policy Implication

These findings are important to help government agencies especially the Department of Environment of Malaysia improve the existing policies or formulate new policies. Other than that, the findings can also furnish firms from various sectors with information on the deleterious effects of non-renewable energy consumption on the

environment. As a result, firms can be imbued with environmental awareness. Generally, this study found that electricity can increase output in tandem with a reduction in CO₂ emission. The reason that electricity can reduce CO₂ emission is that this type of energy is generated by higher renewable energy such as hydro. Therefore, it is tenable that using more electricity is favourable. Electricity is mostly consumed in the industrial sector, compared to the other sectors (agriculture and transportation). While oil and gas are more widely used in the agriculture and transportation sectors, the unfavourable fact is that oil and gas have a long-term impact on CO₂ emissions. It exacerbates the perplexity when the results also show that oil and gas can spur output to growth. The government may apply carbon dioxide removal (CDR) to reduce CO₂ emission in the air. This move can benefit firms which produce a large amount of CO₂ emission as their output will not be affected.

It is profoundly understood that plants absorb CO₂ in the air to form organic carbon (Department of Agriculture Australia, 2013). However, too much CO₂ emissions will adversely affect agricultural land, community, and water (for agricultural areas near the river). This is a particularly worrying circumstance in Malaysia since to date, there is absence of control measure on CO₂ emissions imposed on all sectors. Hence, monitoring the activities done on these sectors is a good move. As an alternative for the oil and gas consumption, the Government should intensively initiate energy options such as the renewable ones. This is because non-renewable oil consumption such as diesel and petrol (fossil) will eventually be exhausted due to uncontrolled use (Darmanto & Sigit, 2006). Moreover, the mismanagement of oil will lead to air pollution through the release of CO₂ emissions.

Since agriculture and transportation consume more energy in the form of oil and gas compared to electricity, the Pollution Act, which was only imposed on the industrial sector should also be applied to the agriculture and transportation sectors. Therefore, the government should introduce new policies or at least improve existing policies to be applied to both agriculture and transportation sectors. The improvement of the existing act by the authorities is essential to help reduce pollution and CO₂ emissions in Malaysia.

Therefore, authorities need to reduce these non-renewable oil consumption and Malaysia may consider implementing eco-driving training in agriculture as an integrated production as conducted by some European countries. This eco-driving is a way of driving which can reduce fuel consumption, and thus conserve the environment (Domingo, Miguel & Hurtado, 2014). This eco-driving can also be applied to farming farms. In the European countries, this move has successfully reduced CO₂ emission. Besides, the provision of animal placement areas should be given attention. Various strategies can be developed to optimize the use of machinery. For example, using animals on farms can reduce fuel consumption.

In addition to oil reduction, electricity reduction should also be given special attention by policymakers in Malaysia. Electricity generation which also uses non-renewable such as oil needs to be controlled and replaced with renewable energy. Although electricity has less impact on the release of CO₂ emissions than oil and gas, from a point of view, the use of electricity generated by oil and gas should be reduced as oil and gas are harmful to the environment.

5.4.1 Renewable Energy

Renewable energy refers to energy generated from natural sources and can be renewed from time to time. It is an alternative source for non-renewable oil. According to Ciolkosz (2017), renewable energy is not harmful to the environment, but it is a low impact, particularly on CO₂ emissions. The energy produced from the sun, plants, water and other natural elements are fundamental to renewable energy. There are several numbers of renewable energy that can be considered by policy makers in Malaysia, either to improve existing policies or implement new policies that have been adopted by other countries such as biomass, biodiesel, biofuels, biogas, solar, hydroelectric and geothermal.

5.4.1.1 Biomass

The findings show that the use of oil in the transportation and agricultural sectors do not boost output but can result in higher CO₂ emissions in Malaysia. Therefore, these findings can shed some light to policy makers so that policies on a reduction in oil consumption can be formulated. This hazardous energy can be replaced by biomass. Biomass is a renewable resource originated from living organisms such as wood, waste and alcohol oil (Ciolkosz, 2017) which can replace the use of fossil oil (Domingo et al., 2014). According to reports of International Energy Agency (2014), both agricultural and transportation sectors in Malaysia consumed 975,000 tonnes and 20,998,000 tonnes of oil, respectively in 2014 and no biomass consumption was reported. The use of biomass can reduce CO₂ emissions and the cost of buying non-renewable fossil oil (Domingo, Miguel & Hurtado, 2014). Therefore, the government can introduce the use of biomass so that firms from the agricultural and transportation sectors can benefit from it and thus the environment can be conserved.

5.4.1.2 Biodiesel

We learn from the current findings that the use of oil in the transportation and agricultural sectors can contribute to air pollution without increasing output. Therefore, the use of renewable energy, particularly biodiesel can improve the quality of our environment. According to reports of the Malaysia Energy Statistics Handbook (2015), the transportation sector consumed biodiesel as much as 188,000 tonnes of oil equivalent in 2013. The use of this renewable energy should be increased in the transportation sector to reduce CO₂ emissions as much as we can. An alternative to diesel, which is non-renewable oil, biodiesel is produced through vegetable oil (Ciolkosz, 2017). Malaysia as one of the oil palm producing countries has conducted experiments on biodiesel produced from palm oil (Haryanto, 2002). The government should use this opportunity to produce biodiesel more efficiently through improvements in existing policy. This is because biodiesel can potentially help develop not only the transportation sector but also the agriculture sector in Malaysia while reducing air pollution.

5.4.1.3 Biofuels

The findings show that it is important for the policy makers to address the issue of oil and gas consumption in the transportation sector as it can have undesirable effects on CO₂ emission. To ensure that this problem can be alleviated, biofuels can be replaced. According to Darmanto and Sigit (2006), the value of CO₂ emissions is low for biofuels compared to oil and gas. This suggests the biofuels potential in reducing CO₂ emissions in Malaysia. Therefore, efforts to use biofuels as an alternative to oil and gas should be initiated by shuffling relevant policies. Policymakers can implement or improve existing policies related to these biofuels from time to time. The National

Biofuels Policy which has been introduced since 2005 (Bernama, 2010) should be improved so that the replacement of non-renewable energy with biofuel energy can be intensified. It is also timely that policy with regards to innovation in biofuels as a substitute for oil and gas in the transportation sector is given a serious attention by policy makers in Malaysia in line with Indonesia, which has also used these biofuels in their transportation industry (Mulyana & Istiqomah, 2013; Darmanto & Sigit, 2006).

5.4.1.4 Biogas

The results show that gas can boost industrial output but can contribute to CO₂ emission in the transportation sector. Therefore, it is important for the policy makers to formulate policies to ensure a reduction in CO₂ emission in the transportation sector. The use of biogas can play a role as important as gas consumption. Since Malaysia has not been using biogas in the transportation sector (Malaysia Energy Statistics Handbook, 2015), the country should introduce the use of biogas to decrease gas consumption. This effort can reduce the dependence on non-renewable energy, which can be detrimental to the environment, and thus CO₂ emission can be decreased simultaneously. Other than that, from the findings, firms in the transportation sector can have the awareness of the negative effects of gas consumption on the environment. Thus, they should move towards using biogas instead of gas.

5.4.1.5 Solar

As oil consumption can be detrimental to the agricultural and transportation sector. The policymakers can formulate policies on the replacement of non-renewable oil with solar. Solar energy can be used in the industrial, agricultural and transportation sectors.

Solar generates electricity from sunlight through the solar radiation grid (Domingo, Miguel & Hurtado, 2014). This solar energy generation indirectly reduces costs and minimizes CO₂ emissions. Hence, policymakers should consider the appropriate way to move Malaysia to increase the use of solar energy, especially in the transportation and agricultural sectors as the use of oil in these sectors can cause CO₂ emissions to escalate. In addition, policymakers may also implement or improve existing policies related to the use of this solar energy more widely in all sectors covering the agriculture sector, industrial sector, and transportation sector.

5.4.1.6 Hydroelectric

The findings show that electricity can reduce CO₂ emission not only in the long run but also in the short run in the transportation sector. In 2013, Malaysia generated 53,663 GWh of electricity from coal and 11,799 GWh from hydro. The government should increase the electricity generation from hydro to reduce more CO₂ emissions. Besides, this move can also reduce its dependence on non-renewable energy. Hydroelectricity is also one of the alternative ways to reduce non-renewable fuel consumption. According to Alberta Utilities Commission (2011), hydroelectric power generation is one of the cleanest energy production forms which in turn can reduce CO₂ emissions. Therefore, developing and strengthening the hydroelectric system in Malaysia as well as improving and revising the relevant policies is a potential alternative to saving the environment.

In Malaysia, several hydroelectric dams have been developed such as the Bakun hydroelectric dam in Sarawak and another one in Temenggor, Perak. This hydroelectric pump operates by converting the flow of water that runs through the

turbine into mechanical energy, which in turns converts this mechanical energy into electricity. The higher the turbine position and the larger flow of water, the more energy it can generate (Truckee Meadows Water Authority, 2015).

5.4.2 Kyoto Protocol

Despite the fact that Malaysia has been adopting the Kyoto Protocol policy, CO₂ emission is still on the rise. The energy types (oil, gas and electricity) are found to boost output but contribute to CO₂ emission in the long run. The Kyoto Protocol which was introduced in 1997 in Kyoto, Japan is an international agreement aimed at reducing CO₂ emissions caused by the greenhouse effect. Among the emphasis in the Kyoto Protocol is a commitment to fight global warming and reducing the CO₂ emission impacts caused by human actions (Khan, 2002). The implementation of the Kyoto Protocol in Japan has been successful as more than 100 countries have adopted the Kyoto Protocol policy. Somehow this policy appears to be ineffective and merits improvements in Malaysia.

To ensure the efficiency of its implementation, systematic and regular monitoring system should be executed consistently that demands the commitment from the policymakers. In order to accomplish the mission, policy makers need to establish partnerships with external agencies from foreign countries, particularly from Japan. This is particularly important to ensure the correct procedural implementation of the Kyoto Protocol in Malaysia, hence ensuring the successful target of reducing the CO₂ emissions to the environment. Apart from that, this policy can be improved by reducing CO₂ emissions in each sector rather than overall. Since a rise in oil

consumption in the agricultural and transportation sectors can result in higher CO₂ emissions, thus it is vital to implement a reduction in CO₂ emissions in those sectors.

5.4.3 Carbon Pollution Reduction Scheme

From the findings, it can be learnt that all energy types that can contribute to CO₂ emission in the long run and Malaysia is not the only country that is facing the aftermath of uncontrolled CO₂ emission. Therefore, these findings will serve as an informative guideline to the policy makers to formulate policies or improve the policies. The similar problem is also lamented by other countries such as Australia and China. To date, a scheme to address such problem is called Carbon Pollution Reduction Scheme. It has two sections, namely carbon footprint, and carbon tax. Malaysia should take seriously the conduct of this scheme as to retard the pollution caused by carbon deposition into the atmosphere.

5.4.3.1 Carbon Footprint

The carbon footprint refers to the process of greenhouse gas emissions resulting from fuels such as vehicle emissions, electricity, heating, and air leakage in the environment (Holtry et al., 2009) hence, posing a serious hazard to the environment (International Union of Railways, 2016). In other words, it is the measure of carbon dioxide and other carbon compounds amount emitted by a person, individual, organisation, etc. due to the consumption of fossil fuels. Even though Malaysia has initiated the authorisation of carbon footprint implementation, its reinforcement should be closely monitored and constantly revised. This is to ensure that the CO₂ emissions can be reduced not only in the agriculture sector but also for the transportation sector.

5.4.3.2 Carbon Tax

The imposition of carbon tax can actually help in reducing CO₂ emissions. For premises with higher chances of emitting high CO₂ through their activities, appropriate measures should be executed to ensure that any offense with regards to excessive emission of CO₂ is subjected to the carbon tax law. And at the same time, the level of Malaysian technology can be improved through the production of efficient renewable energy and so on. As a measure to curb the uncontrolled emission of CO₂, any international network between Malaysia and foreign countries should include carbon/credit trading.

In addition, if policy makers manage to reduce this CO₂ emission problem in Malaysia, Malaysia can indirectly create an international network with countries that have not implemented it through carbon/credit trading. According to Zhang et al. (2013), international intervention such as carbon/credit trading can accelerate the technological progress of a country. Policymakers can implement or improve the existing carbon-related tax policies more widely across sectors including the agriculture sector, industrial sector, and transportation sector.

5.5 Limitation of the Study

The study managed to access data from only three sectorial output (industrial, agricultural and transportation). This circumstance has minimised the researcher's effort in carrying out a more detailed study that includes sub-sectors. Besides, data on energy consumption from various sectors was also not accessible except for the three mentioned above. The findings will be more intriguing if this study can include sub-sectors rather than only the main sectors. For example, in the transportation sector

there are various modes of transportation such as flight, water and lands. If we divert our focus from general sectors to subsectors, we can discover which mode of transportations can increase the environmental degradation and thus policies are easier to be formulated.

The energy types included in this study is limited to non-renewable energy such as oil, gas, and electricity. The effects of renewable energy sources such as hydro, biomass, and solar on the sectorial output were not considered. It will be more interesting and intriguing if this study can extend the investigation on the renewable energy. We can compare the effects of non-renewable and renewable energy consumptions on the environment. Despite the fact that we move towards using renewable energy, it is still not be effective if there is inadequate enforcement.

Furthermore, the period of data used for the analysis ranging from 1990 to 2014 may seem short. However, the employment of panel data analysis in this study is good enough to achieve the objectives. This study will be more interesting, if the data period is longer and that we can analyse the effects in two periods: before and after the Four-fuel diversification. Apart from that, this limitation denies the study to use a higher number of lags for all variables in the model using the PMG analysis. The use of the higher number of lags especially in the dynamic analysis is important as it can capture the real effects of energy consumption on sectorial output, and the real effects of energy consumption and sectorial output on CO₂ emission in Malaysia,

Therefore, better emphasis on the collection of data and data reporting by using monthly or quarterly data which have a higher number of frequency can be made to

improve the findings. Hence, more reliable sources to formulating policies. The data should be easily accessed as they are vitally important so that the revision of the policies can be meticulously made.

5.6 Future Study

This study has provided an empirical evidence on the effects of energy consumption on sectorial output, and the effects of energy consumption and sectorial output on CO₂ emissions in Malaysia. This study also considers different sources of energy such as oil, electricity, and gas in influencing sectorial output and the environment. However, considering the popularity of renewable energy recently and that Malaysia has also started to use this kind of energy several years ago, it is critical to investigate the renewable energy influence on the environment and the national output. This new perspective will shed more light on the extent to which Malaysia can potentially reduce the deleterious effects of CO₂ emission on the environment and increase output in tandem.

In future, this study can be expanded by addressing the sectors of mining and quarrying, services and etc. These sectors also play important roles in determining national output. Therefore, it will elicit better results of the effects of energy consumption on sectorial output if we highlight the sectors.

In future, this study can include the effects of energy consumption before Four-fuel diversification policy is implemented. This will build up a better picture of how the policy works in the country as we can see whether the policy can improve the environmental degradation.

5.7 Summary

This study has successfully achieved the objectives by using the panel data analysis. This study used two models to investigate the effects of energy consumption on output, and the effects of energy consumption and output on CO₂ emissions. This study suggested energy consumptions as an important factor on national output, especially in the long run. In particular, gas consumption was found to be important in the industrial and transportation sectors while oil consumption in the agricultural sector can be detrimental to the environment. In a similar vein, the CO₂ emissions from the transportation sector are contributed by oil, electricity and gas consumptions.

Most of these findings have been supported by previous studies except for the agricultural sector as it has been sparsely explored by previous studies. The findings of the relationship between energy consumption and output, energy consumption and CO₂ emissions, and output and CO₂ emissions should merit attention from policymakers to formulate the right policies. This is to ensure that Malaysia supports sustainable development, which means that economic growth can be enhanced without affecting the environment. As a result, the vision to upgrade Malaysia as a developed country with sustainable environment in 2020 can be accomplished.

REFERENCE

- Abdul, R. M. & Lee, K. T. (2004). Energy Policy for Sustainable Development in Malaysia. *The Joint International Conference on Sustainable Energy and Environment (SEE)*, Hua Hin, Thailand, 1-3 December.
- Adhikari, D. & Chen, Y. (2012). Energy Consumption and Economic Growth: A Panel Cointegration Analysis for Developing Countries. *Review of Economics and Finance*, vol. 34, 68-80.
- Adom, P. K. (2011). Electricity Consumption - Economic Growth Nexus: The Ghanaian Case. *International Journal of Energy Economics and Policy*, vol. 1 (1), 18-31.
- Ahmed, S. S. & Ahmed, M. F., (2016). Renewable Energy Source: An Overview. *Journal of Applied Science*, vol. 2 (3), 1-7
- Akin, C. S. (2014). The Impact of Foreign Trade, Energy Consumption and Income on CO2 Emissions. *International Journal of Energy Economics and Policy*, vol. 4 (3), 465-475.
- Akinwale, Y., Jesuleye, O., & Siyanbola, W. (2013). Empirical Analysis of Causal Relationship between Electricity Consumption and Economic Growth in Nigeria. *British Journal of Economics, Management and Trade*, vol. 3 (3): 277 – 295.
- Aktas, C. & Yilmaz, V. (2008). Causal Relationship between Oil Consumption and Economic Growth in Turkey. *Kocaeli Universitesi Sosyal Bilimler Enstitusu Dergisi*, vol. 15, 44-55.
- Alam, M., & Huylenbroeck, G.V., (2011). Energy Consumption, CO2 Emissions and The Economic Growth Nexus in Bangladesh: Cointegration and Dynamic Causality Analysis. *Presented at the AAS-ICAS Joint Conference*, Honolulu, Hawaii, USA, Mar, 31-Apr, 3.

- Alberta Utilities Commission. (2011). Hydroelectric Power Generation Development Inquiry. *Proceeding*, no 561.
- Alkathlan, K., Alam, M., & Javid, M. (2012). Carbon dioxide Emissions, Energy Consumption and Economic Growth in Saudi Arabia: A Multivariate Cointegration Analysis. *BrJ Econ Manag Trade*, vol. 2 (4): 327–39.
- Amin, S. B., S. S. Ferdous & A.K. Porna (2012). Causal Relationship among Energy Use, CO2 Emissions and Economic Growth in Bangladesh: An Empirical Study. *World Journal of Social Sciences*, vol. 2 (4), 273-290.
- Amri, F. (2017). Carbon Dioxide Emissions, Output and Energy Consumption Categories in Algeria. *Environmental Science and Pollution Research*. Vol. 24 (17), 14567-14578.
- Apergis, N., & Danuletiu, D. (2012). Energy Consumption and Growth in Romania: Evidence from a Panel Error Correction Model. *International Journal of Energy Economics and Policy*, vol. 2 (4), 348-356.
- Apergis, N. & Payne, J. E. (2010). The Emissions, Energy Consumption, and Growth Nexus: Evidence from the Commonwealth of Independent States. *Energy Policy*, vol. 38 (1), 650-655.
- Apergis, N. & Ozturk, I. (2015). Testing Environmental Kuznets Curve Hypothesis in Asian Countries. *Ecological Indicators*, vol. 52, 16-22
- Asici, A. A. (2011). Economic Growth and its Impact on Environment: A Panel Data Analysis, *MPRA Paper 30238*, University Library of Munich, Germany.
- Atakhanova, Z. & Howie, P. (2007). Electricity Demand in Kazakhstan. *Energy Policy* vol. 35 (7), 3729-3743.
- Atif, S. M. & Siddiqi, M. W. (2010). The Electricity Consumption and Economic Growth Nexus in Pakistan: A New Evidence. *Econstore*, 1-13.

- Aytac, D. & Guran, M. C. (2011). The Relationship between Electricity Consumption, Electricity Price and Economic Growth in Turkey. *Argumenta Oeconomica*, vol. 27 (2), 101-123.
- Azlina, A. A., Law, S. H., & Mustapha, N. H. N. (2014). Dynamic Linkages among Transport Energy Consumption, Income and CO₂ Emission in Malaysia. *Energy Policy*, vol. 73, 598-606.
- Azomahou, T., Laisney, F. & Van, P., P. N., (2006). Economic Development and CO₂ Emissions: A Nonparametric Panel Approach. *Journal of Public Economics*, vol. 90, 1347-1363.
- Bayar, Y. & Ozel, H. A. (2014). Electricity Consumption and Economic Growth in Emerging Economies. *Journal of Knowledge Management, Economics and Information Technology*, vol. 4 (2), 1-18.
- Bedi-uz-Zaman, Farooq, M. & Ullah, A. (2011). Sectorial Oil Consumption and Economic Growth in Pakistan: An ECM approach. *American Journal of Scientific and Industrial Research*, vol. 2 (2), 14-156.
- Begum, R. A., Sohag, K., Abdullah, S. M. S. & Jaafar, M., (2015). CO₂ Emissions, Energy Consumption, Economic and Population Growth in Malaysia. *Renewable and Sustainable Energy Reviews*, vol. 41, 594-601.
- Belke, A, Dobnik, F. & Dreger, C (2011). Energy Consumption and Economic Growth: New Insights into the Co-Integration Relationship. *Energy Economics*, vol. 33 (5), 782-789.
- Bernamea. (2010). Malaysia Komited Jadi 'Negara Hijau'. *Utusan Malaysia*. Retrieved from [http://ww1.utusan.com.my/utusan/info.asp?y=2010&dt=0119&pub=Utusan Malaysia&sec=Muka_Hadapan&pg=mh_03.htm](http://ww1.utusan.com.my/utusan/info.asp?y=2010&dt=0119&pub=Utusan_Malaysia&sec=Muka_Hadapan&pg=mh_03.htm)
- Bildirici, M. E., Bakirtas, T., & Kayikci, F. (2012). Economic Growth and Electricity

- Consumption: Auto Regressive Distributed Lag Analysis. *Journal of Energy in Southern Africa*, vol. 23 (4), 29-45.
- Bildirici M., & Ozaksoy, F. (2013). The Relationship between Economic Growth and Biomass Energy Consumption in Some European Countries, *J. Renewable Sustainable Energy*, vol. 5, 023141.
- Bloch, H., Rafiq, S. & Salim, R. (2011). Coal Consumption, CO₂ Emission and Economic Growth in China. Empirical Evidence and Policy Responses. *Energy Economics*, 518-528.
- Bozkurt, C., & Akan, Y. (2014). Economic Growth, CO₂ Emissions and Energy Consumption: The Turkish Case. *International Journal of Energy Economics and Policy*, vol. 4 (3), 484-494
- Breitung, J. (2000). The Local Power of Some Unit Root Tests for Panel Data, in: B. Baltagi (ed.), *Nonstationary Panels, Panel Co-integration, and Dynamic Panels, Advances in Econometrics*, vol. 15, 161-178
- Campbell, J. Y. & Perron, P. (1991). Pitfall and opportunities: What Macroeconomists Should Know about Unit Roots. *Technical Working Paper 100, NBER Working Paper Series*, Massachusetts, USA: National Bureau Economic Research.
- Carmona, M., Feria, J., Golpe, A.A., & Iglesias, J. (2017). Energy consumption in the US Reconsidered. Evidence across Sources and Economic Sectors. *Renewable and Sustainable Energy Reviews*, vol. 77, 1055–1068
- Cassim, R., Akinboade, O.A., Niedermeier, E. W., Sibanda, F. & Jackson, W. (2004). Sustainable Development: The Case of Energy in South Africa. *TKN Paper*. International Institute for Sustainable Development.
- Chebbi, H. E., & Boujelbene, Y. (2008). CO₂ Emissions, Energy Consumption and Economic Growth in Tunisia. *12th Congress of the European Association of*

- Agricultural Economists*. Retrieved from <http://ageconsearch.umn.edu/bitstream/44016/2/367.pdf>
- Chen, J., & Huang, Y. (2013). The Study of the Relationship between Carbon Dioxide (CO₂) Emission and Economic Growth. *Journal of International and Global Economic Studies*, 45–61.
- Chen, W., Wu, F., Geng, W., & Yu, G. (2016). Carbon Emissions in China's Industrial Sectors. *Resources, Conservation and Recycling* (2016), <http://dx.doi.org/10.1016/j.resconrec.2016.10.008>
- Cheng, B. S. (1999). Causality between Energy Consumption and Economic Growth in India: An Application of Cointegration and Error-correction Modeling. *Indian Economic Review* vol. 34, 39-49.
- Cherniwchan, J. (2012). Economic Growth, Industrialization, and the Environment. *Resource and Energy Economics* vol. 34, 442-467.
- Chouaibi, N., & Abdessalem, T. (2011.). Causality between Electricity Consumption and Economic Growth in Tunisia: Policy Implications. *World Review of Science Technology and Sustainable Development*. Vol. 11 (1), 43 - 60
- Christopoulos, D. K. & Tsionas, E. G. (2004). Financial development and Economic Growth: Evidence from Panel Unit Root and Cointegration Tests. *Journal of Development Economics*, vol. 73, 55-74.
- Ciarreta, A. & Zarraga, A. (2010). Electricity Consumption and Economic Growth in Spain. *Appl. Econ. Lett.* Vol. 17, 1–5
- Ciolkosz, D. P. E. (2017). Why is Renewable Energy? *Pennstate Extension* from extension.psu.edu
- Cobb, C. W. & Douglas, P. H. (1928). *A Theory of Production*. *American Economic Review*, vol. 18 (Supplement), 139–165.

- Coskey, S. K. M. & Kao, C. (1998). A Residual-base Test of the Null of Cointegration in Panel Data. *Econometric Reviews*, vol. 17, 57 – 84.
- Cover, M. (2010). *Government Report Says Global Warming May Cause Cancer, Mental Illness*. Retrieved from <http://www.cnsnews.com/news/article/government-report-says-global-warming-may-cause-cancer-mental-illness>.
- Darmanto, S. & Sigit, I, A. (2006). Analisa Biodiesel Minyak Kelapa Sebagai Bahan Bakar Alternatif Minyak Diesel. *Traksi*, vol. 4 (2), 64-71
- DeMates, L.(2013). *What are the Differences between Biofuels, Bioethanol, Biodiesel, and Biogas? The Sustainability Co-op*. Retrieved on 23 January 2018 at <https://thesustainabilitycooperative.net/2013/12/26/the-difference-between-biofuel-bioethanol-biodiesel-and-biogas/>
- Department of Agriculture Australia. (2013). *Australian Agriculture: Reducing Emissions and Adapting to a Changing Climate Key Findings of the Climate Change Research Program*. Department of Agriculture; Australia.
- Department of Statistics, Malaysia (2014). Retrieved on 24 September 2016 from https://www.statistics.gov.my/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09
- Domingo, J., Miguel, E. D., & Hurtado, B. (2014). *Measures at Farm Level to Reduce Greenhouse Gas Emissions from EU Agriculture*. Directorate-General for Internal Policies, Agriculture and Rural Development; Europe Parliament.
- Dritsaki C., & Dritsaki M. (2014). Causal Relationship between Energy Consumption, Economic Growth and CO2 Emissions: A Dynamic Panel Data Approach. *International Journal of Energy Economics and Policy*, vol. 4 (2), 125-136.
- Engle, R. & Granger, C. W. J. (1987). Cointegration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, 55, 251-276.

- Environmental Quality Act. (1974). *Act 127*. Malaysia Law; Malaysia.
- Farhani, S. & Rejeb, J.B. (2012). Energy Consumption, Economic Growth and CO2 Emissions: Evidence from Panel Data for MENA Region. *International Journal of Energy Economics and Policy*, 2, 71-81.
- Ghadimzadeha, A., Makmomb, A. A., Mustapha, S., Ho, S., Askaric, A.A., Chngd, J., Naranie, T. S., & Shamsipour, R., (2015). Highlighting of the Factors, Interventions and Policies Affecting CO2 Emissions Level in Malaysian Transportation Sector. *International Journal of Advanced Scientific and Technical Research*, vol. 7 (5), 198-313.
- Ghali, K. H. & El-Sakka, M. I. T. (2004). Energy and Output Growth in Canada: A Multivariate Co-integration Analysis. *Energy Economics*. vol.26 (2), 225–238.
- Grossman, G. M. & Krueger, A. B. (1995). Economic Growth and the Environment. *Quarterly Journal of Economics*. Vol.110 (2). 353-377.
- Hamilton, T. (2009). Biofuels vs Biomass Electricity. *MIT Technology Review*. Retrieved on 23 January 2018 at <https://www.technologyreview.com/s/413406/bio-fuels-vs-biomass-electricity/>
- Harres. (2017). *Tanaman Solar*. Dalam Myagri Consulting di <http://myagri.com.my/2017/01/tanaman-solar/>
- Haryanto, B. (2002). *Bahan Bakar Alternatif Biodiesel*. USU Digital Library; Indonesia.
- Hassaballa, H. (2014). Testing for Granger Causality between Energy Use and Foreign Direct Investment Inflows in Developing Countries. *Renewable and Sustainable Energy Reviews*, vol. 31, 417–426.
- Hitam, M. B., & Borhan, H. B. (2012). FDI, Growth and the Environment: Impact on Quality Life in Malaysia. *Procedia Social and Behavioural Sciences*, vol. 50,333-

42.

- Hodges, A. W., Stevens, T. J. & Rahmani, M. (2010). *Economic Impacts of Expended Woody Biomass Utilization on the Bioenergy and Forest Products Industries in Florida*. Retrieved from <http://www.fred.ifas.ufl.edu/pdf/economicimpact-analysis/Woody-Biomass-Utilization.pdf>
- Holtry, M., Anderson, C., Conry, B., Freer, J., Helfst, A., & Sheetz, R. (2009). Carbon Footprint 101: A Guide For Food Retailers. *Carbon Footprint 101*
- Hou, Q. (2009). The Relationship between Energy Consumption Growth and Economic Growth in China. *Journal of Economics and Finance*, vol. 1(2), 232-237
- Ighodaro, C.A.U. & Owendseri-Ogbomo, F. (2008). Causality Relationship between Energy Demand and Economic Growth in Nigeria. *The Indian Journal of Economics*, vol. 89 (353).
- Ighodaro, C. A. (2010). Co-Integration and Causality Relationship between Energy Consumption and Economic Growth: Further Empirical Evidence for Nigeria. *Journal of Business Economics and Management*, vol. 11 (1), 97-111.
- Im, K. S., Pesaran, M. & Shin, Y. (1997). Testing for Unit Roots in Heterogeneous Panels. *Journal of Econometrics*, vol. 115 (1), 53-74.
- Imran, K. & Siddiqui, M. M. (2010). Energy Consumption and Economic Growth: A Case Study of Three SAARC Countries. *European Journal of Social Sciences*, vol. 16 (2), pp. 206-213.
- International Energy Agency (2014). Retrieved on 22 September 2016 from <https://www.iea.org/countries/non-membercountries/malaysia/>
- International Union of Railways. (2016). *Carbon Footprint of Railway Infrastructure*. International Union of Railways (UIC); Paris.
- Istikoma, Qurat-ul-Ain & Dahlan, A. A. A. (2015). The Transformation of Agriculture

- Based Economy to an Industrial Sector Through Crowd Sourcing in Malaysia
International Journal of Computer Science and Information Technology Research.
Vol. 3 (1). 34-41.
- Jalil, A. & Mahmud, S. F. (2009). Environment Kuznets Curve for CO2 Emissions:
A Co-Integration Analysis. *Energy and Policy*, vol. 37 (12), 5162-5172.
- Javid, A. Y., Javid, M., & Azwan, Z. A. (2013). Electricity Consumption and
Economic Growth: Evidence from Pakistan. *Economics and Business Letters*, vol.
2 (1), 21-32.
- Jebli, M. B., Yousef, S. B., & Ozturk, I. (2016). Testing Environmental Kuznets Curve
Hypothesis: The role of Renewable and Non-renewable Energy Consumption and
Trade in OECD countries. *Ecological Indicators*. Vol. 60, 824-831
- Jennejohn, D. (2011). Annual U.S. Geothermal Power Production and Development
Report. *Geothermal Energy Association*, April 2011.
- Kao, C. & Chiang, M. H. (2000). On the Estimation and Inference of a Cointegrated
Regression in Panel Data, *Advances in Econometrics*, vol. 15, 179-222.
- Kasgeri, M. T., Etesami, H. & Chemazketi, M. A. (2014). Relationship between
Petroleum Taking and Economic Development ARDL Testing-Iran Case Study.
International Journal of Management and Human Sciences, vol. 3 (2), 1378-1383.
- Khan, S. R. (2002). The Kyoto Protocol and Sustainable Development. *Working Paper
Series*, no 81.
- Kumar, S., & Shahbaz, M., (2010). Coal Consumption and Economic Growth
Revisited: Structural Breaks, Cointegration and Causality Tests for Pakistan.
MPRA Paper 26151, University Library of Munich, Germany
- Kuznets, S. (1955). Economic Growth and Income Inequality. *The American
Economic Review*. Vol. XLV. (1).

- Kim, H., Oh, K-Y. & Jeong, C.-W. (2005). Panel Cointegration Results on International Capital Mobility in Asian Economies. *Journal of International Money and Finance*, vol. 24, 71-82.
- Kraft, J. & Kraft, A. (1978). On the Relationship between Energy and GNP, *Journal of Energy and Development* vol. 3, 401-403.
- Lee, J. W. (2013). The Contribution of Foreign Direct Investment to Clean Energy Use, Carbon Emissions and Economic Growth. *Energy Policy* vol. 55: 483–489.
- Leung, G. C. K. (2009). Sectoral consumption of oil in china, 1990 – 2006. *Oil, Gas and Energy Law*, No. 3. at www.ogel.org/article.asp?key=2928
- Levin, A., Lin, C-F. & Chu, C.-S. J. (2002). Unit Root Test in Panel Data: Asymptotic and Finite-sample Properties. *Journal of Econometrics*, vol. 108 (1), 1-24.
- Li, F., Dong, S., Li, X., Liang, Q. & Yang, W. (2011). Energy Consumption Economic Growth Relationship and Carbon Dioxide Emissions in China. *Energy Policy*, vol. 39, 568–574
- Li, J. K. & Li, Z. X. (2011). A Causality Analysis of Coal Consumption and Economic Growth for China and India. *Natural Resources*, vol. 2, 54-60.
- Lin, B. & Xie, C. (2013). Estimation on Oil Demand and Oil Saving Potential of China's Road Transport Sector. *Energy Policy*, vol. 61, 472-482.
- Lin, X. & Lin, H. (2011). An ADRL Boundes Test Approach to CO2 Emissions, Energy Consumption and Economic Growth in China, *Proceedings of the ICEE*, Shanghai, May 6–8, 1–4.
- Lise, W. & Montfort, K. V. (2007). Energy consumption and GDP in Turkey: Is There a Co-integration Relationship?. Retrived on 21 September 2016 from <http://www.ecn.nl/docs/library/report/2005/rx05191.pdf>
- Madaleno, M., Moutinho, V. & Mota, J. (2015). Time Relationships among Electricity

- and Fossil Fuel Prices: Industry and households in Europe. *International Journal of Energy Economic and Policy*. Vol. 5 (2). 525-533
- Maddison, D. & Rehdanz, K. (2008). Carbon Emissions and Economic Growth: Homogeneous Causality in Heterogeneous Panels, *Working Paper* No. 1437, Kiel Institute for the World Economy.
- Maddala, G. S. & Wu, S. A. (1999). Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. *Oxford Bulletin of Economics and Statistics* vol. 61, 631-652.
- Malaysia Energy Statistic Handbook (2015). Retrieved on 20 September 2016 from meih.st.gov.my/documents/.../f3b9119e-e139-4527-9da6-d77e2eab1c34
- Malaysian Department of Environment. (2010). *Annual Report*. Retrieved on 21 September 2016 from <https://www.doe.gov.my>
- Malaysian Energy Information Hub. (2014). Retrieved on 21 September 2016 from <http://meih.st.gov.my/statistics>
- Manan, A. F. N. A., Baharuddin, A. & Chang, L. W. (2015). Ex-Post Critical Evaluations of Energy Policies in Malaysia from 1970 to 2010: A Historical Institutionalism Perspective. *Energies* 2015, vol. 8, 1936-1957.
- Masduzzaman, M. (2012). Electricity Consumption and Economic Growth in Bangladesh Co-integration and Causality Analysis. *Global Journal of Management and Business Research*, vol. 12 (11), 46-56.
- Menyah, K., & Wolde-Rufael, Y., (2010). CO2 Emissions, Nuclear Energy, Renewable Energy and Economic Growth in the US. *Energy Policy*, vol. 38, 2911-2915.
- Mirza, F. M., & Kanwal, A. (2017). Energy Consumption, Carbon Emissions and Economic Growth in Pakistan: Dynamic Causality Analysis. *Renewable and*

Sustainable Energy Reviews vol. 72, 1233–1240.

- Mohamed, A. R. & Teong, L. K. (2004). Energy Policy for Sustainable Development in Malaysia. *The Joint International Conference on Sustainable Energy and Environment (SEE)*. 1-3 December 2004, Hua Hin, Thailand. 940-944.
- Muhammad, J.. & Abdul, Q. (2013). Electricity Consumption GDP Nexus: A Structural Time Series Analysis. MPRA Paper No. 47448
- Mulyana, E., & Istiqomah, A. (2013). Energi Alternatif Untuk Indonesia di Masa Depan. *Penelitian Masalah Lingkungan di Indonesia*, 269-277.
- Mushtaq, K., Abbas, F., Abedullah, and Ghafoor, A. (2007). Energy Use for Economic Growth: Cointegration and Causality Analysis from the Agriculture Sector of Pakistan. *The Pakistan Development Review*, 1065-1073.
- Narayan, P. K., Saboori, B., & Soleymani, A. (2015). *Economic Growth and Carbon Emissions, Economic Model*. Retrieved on 25 February 2016 from, <http://dx.doi.org/10.1016/j.econmod.2015.10.027>
- Naser, H. (2011). Causal Dynamic between Oil Consumption, Nuclear Energy Consumption, Oil Price and Economic Growth. *MPRA Paper*. no. 65252.
- Nasiru, I. (2012). Coal consumption and Economic Growth in Nigeria: A Two-step Residual Test Approach to Co-integration. *European Scientific Journal*, vol. 8 (9), 140- 155.
- Nasreen S. & Anwer S. (2014). Causal Relationship between Trade Openness, Economic Growth and Energy Consumption: A Panel Data Analysis in Asian Countries. *Energy Policy*; vol. 69, 82-91.
- Ngah, N., Parzi, M. N. & Karim, L. A. A. (2017). Kerajaan Bincang Turunkan Harga Panel Solar. *Berita Harian*. Retrieved from <https://www.bharian.com.my/berita/nasional/2017/11/353012/kerajaan-bincang-turunkan-harga-panel-solar>

- Norlaila, A. C. & Khalid, A.R. (2013). Impact of Malaysian Industrial Energy Use on Carbon Dioxide Emissions. *Pertanika Journal of Social Sciences & Humanities*, vol. 21 (8): 13 - 28 (2013)
- Nyamdash, B. & Denny, E. (2010). The Causal Relationship between GDP and Electricity Demand at a Disaggregate Level: A Case Study of Ireland. *Energy Economics*. Retrieved from <http://www.eprg.group.cam.ac.uk/wp/content/uploads/2010/03/Batsaikham-Ntamdash.pdf>
- Ocal, O., Ozturk, I., & Aslan, A. (2013). Coal Consumption and Economic Growth in Turkey. *International Journal of Energy Economy and Policy*, vol. 3 (2), 193-198.
- Odularu, G. O., & Okonkwo, C. (2009). Does Energy Consumption Contribute to Economic Performance? Empirical Evidence from Nigeria. *East West Journal of Economics and Business*, vol. 12 (2), 43-79.
- Olusegan, G. (2007). Crude Oil and the Nigerian Economic Performance. *Oil and Gas Business*, 1-29.
- Omri, A. & Kahouli, B. (2014). Causal Relationships between Energy Consumption, Foreign Direct Investment and Economic Growth: Fresh Evidence from Dynamic Simultaneous-equations Models. *Energy Policy*. Vol. 67, 913-922.
- Operinde, A. (2010). Investigating the Relationship between Income, Health and Biomass Consumption: A panel Data Analysis. *Munich Personal RePEc Archive*, 1-49.
- Ozturk, I., Aslan, A. & Kalyoncu, K. (2010). Energy Consumption and Economic Growth Relationship: Evidence from Panel Data for Low and Middle Income Countries. *Energy Policy*, vol. 38 (8), 4422-4428.
- Panwar N. L., Kaushik, S. C. & Kothari, S. (2011). A Role of Renewable Energy Sources in Environmental Protection: A Review. *Renewable and Sustainable*

Energy Reviews Journal, vol.15, 1513–1524

- Pao, H. T. & Tsai, C. M. (2010). Multivariate Granger Causality between CO₂ Emissions, Energy Consumption, FDI (Foreign Direct Investment) and GDP (Gross Domestic Product): Evidence from a Panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy Policy*, vol. 38, 7850–60.
- Paul, S. & Bhattacharya, R. N. (2004). Causality between Energy Consumption and Economic Growth in India: A note on Conflicting Results. *Energy Economics*. vol. 26, 977– 983.
- Pedroni, P. (1996). Fully modified OLS for Heterogenous Cointegrated Panels and the Case of Purchasing Power Parity. *Indiana University Working Papers in Economics*, No. 96–020.
- Pedroni, P. (1999). Critical Values for Cointegration Tests in Heterogenous Panel with Multiple Regressors. *Oxford Bulletin of Economics and Statistics*, vol. 61, 653-670.
- Pedroni, P. (2000). Fully Modified OLS for Heterogenous Cointegrated Panels. *Advances in Econometrics*, vol. 15, 93 – 130.
- Pemptsoglou, M. (2014). Electricity Consumption and Economic and Growth: A Linear and Nonlinear Causality Investigation for Turkey. *International Journal of Energy Economics and Policy*, vol. 4 (2), 263-273
- Peng, S. & Sun, Z. (2010). Energy Consumption, Structural Breaks and Economic Growth: Evidence from China. *Proceedings of the International Conference on E-Business and E-Government*. 754-757.
- Pesaran, M. H., Shin, Y. & Smith, R. (1999). Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. *Journal of the American Statistical Association*. vol. 94, 621-634.
- Phillips, P. (1995). Fully Modified Least Squares and Vector Autoregression.

- Econometrica*, vol. 63, 1023-1078.
- Phillips, P., & Hansen, B. (1990). Statistical Inference in Instrumental Variables Regression with I (1) Processes. *Review of Economic Studies*, vol. 57, 99–125.
- Qazi, A. Q., Ahmed, K., & Mudassar, M. (2012). Disaggregate Energy Consumption and Industrial Output in Pakistan: An Empirical Analysis. *The Open-Access, Open Assesment E-journal*, 1-14.
- Ramirez, M. D. (2007). A Panel Unit Root and Panel Cointegration Test of the Complementarity Hypothesis in the Mexican Case: 1960-2001. *Atlantic Economic Journal*, vol. 35, 343-356.
- Regional Forum on Environmental Compliance in Industrial Sector. (2015). Retrieved on 10 February 2017 from http://www.aecen.org/sites/default/files/agenda_of_regional_forum_final.pdf
- Ren, S., Yuan, B., Ma, X. & Chen, X. (2014). International Trade, FDI (Foreign Direct Investment) and Embodied CO2 Emissions: A Case Study of China's Industrial Sectors. *China Economic Review*, vol. 28: 123–134.
- Roudet S., Saxeggard, M. & Tsangarides C. G. (2007). *Estimation of Equilibrium Exchange Rates in the WAEMU: A Robustness Analysis*, IMF-WP-07/194. Washington-DC
- Saidi, K., Rahman, M., & Amamri, M. (2017). The Causal Nexus between Economic Growth and Energy Consumption: New Evidence from Global Panel of 53 Countries. *Sustainable Cities and Society*, 33(April). 45-56
- Salahuddin, M., Alam, K., Ozturk, I., & Sohag, K. (2017). The Effects of Electricity Consumption, Economic Growth, Financial Development and Foreign Direct Investment on CO2 Emissions in Kuwait. *Renewable and Sustainable Energy Reviews*, (2017), <http://dx.doi.org/10.1016/j.rser.2017.06.009>

- Sarwar, S., Chen, W. & Waheed, R. (2017). Electricity Consumption, Oil Price and Economic Growth: Global Perspective. *Renewable and Sustainable Energy Reviews*. Vol. 76. 9-18.
- Satti, S. L., Hassan, M. S., Mahmood, H. & Shahbaz, M. (2014). Coal Consumption: An Alternate Energy Resource to Fuel Economic Growth in Pakistan. *Economic Modelling*, vol. 36, 282-287.
- Schwert, G. W. (1989). Tests for Unit Roots: A Monte Carlo Investigation. *Journal of Business & Economic Statistics*. Vol. 7 (2). 147-159
- Shaari, M. S., Hussain, N. E., & Ismail, M. S. (2012). Relationship between Energy Consumption and Economic Growth: Empirical Evidence for Malaysia. *Business Systems Review*, vol. 2 (1), 17-28
- Shaari, M. S., Rahim, H. A. & Rashid, I. M. A., (2013). Relationship among Population, Energy Consumption and Economic Growth in Malaysia. *The International Journal of Social Sciences*, vol. 13 (1). 39-45.
- Shaari M. S., Razak, N. A. A., & Basri, B. H. (2017). Energy Consumption in Various Sectors, Output and Carbon Dioxide Emission in Malaysia. *International Journal of Business and Technopreneurship*, Vol. 7 (2), 181-188.
- Shahbaz, M., Chandran, V.G. R & Pervaiz, A. (2011). Natural Gas Consumption and Economic Growth: Co-integration Causality and Forecast Error Variance Decomposition test for Pakistan. *MPRA Paper* No. 35103.
- Shahbaz, M. & Dube, S. (2012). Revisiting the Relationship between Coal Consumption and Economic Growth: Cointegration and Causality Analysis in Pakistan. *Applied Econometrics and International Development*, vol. 12 (1).
- Shahbaz, M., Farhani, S. & Rahman, M. M. (2013). Natural Gas Consumption and Economic Growth Nexus: The Role of Exports, Capital and Labor in France.

- MPRA Paper* No. 50619,
- Shahbaz, M., Lean, H. H. & Farooq, A. (2012). Natural Gas Consumption and Economic Growth in Pakistan. *MPRA Paper* No. 40959.
- Shahiduzzaman, M. & Alam, K. (2012). Co-integration and Causal Relationships between Energy Consumption and Output: Assessing the Evidence from Australia. *Energy Economics*, vol. 34 (6), 2182–2188.
- Silva, S., Soares, I., & Pinho, C. (2012). The impact of Renewable Energy Sources on Economic Growth and CO2 Emissions - a SVAR Approach. *European Research Studies*, XV (Special Issue), 133-144
- Squalli, J. & Wilson, K. (2006). A Bound Analysis of Electricity Consumption and Economic Growth in the GCC. *Working Paper Series* No. 06-09
- Stern, D. I. (1993). Energy and Economic Growth in the USA: A Multivariate Approach. *Energy Economics*, vol. 15 (2), 137–150.
- Stern, D. I & Cleveland, C. J. (2004). Energy and Economic Growth, *Rensselaer Working Papers in Economics 0410*, Rensselaer Polytechnic Institute, Department of Economics.
- Stern, D. I. (2000). A Multivariate Co-integration Analysis of the Role of Energy in The US Macroeconomy. *Energy Economics*, vol. 22 (2), 267–283.
- Stolyarova, E. (2009). Carbon Dioxide Emissions, Economic Growth and Energy Mix: Empirical Evidence from 93 Countries. *Climate Economics Chair Paris-Dauphine University*.
- U. S. Energy-Related Carbon Dioxide Emissions. (2015). Retrieved on 1 February 2017 from <https://www.eia.gov/environment/emissions/carbon/>
- Talbi, B. (2017). CO2 Emissions Reduction in Road Transport Sector in Tunisia. *Renewable and Sustainable Energy Reviews*, (2016), from <http://dx.doi.org/10.>

1016/j.rser.2016.11.208

- Tang, C. F., & Shahbaz, M. (2013). Sectoral Analysis of the Causal Relationship between Electricity Consumption and Real Output in Pakistan. *Energy Policy*, vol. 60, 885-891
- Tian, P., & Cul, H. (2013). Economic Growth and Coal Consumption in China. *Telkomnika*, vol. 11 (3), 1449-1455.
- Tiwari, A. K. (2011). Energy Consumption, CO₂ Emissions and Economic Growth: Evidence from India. *Journal of International Business and Economy*, vol. 12: 85- 122.
- Truckee Meadows Water Authority. (2015). Water Topic in Our Community: Hydroelectric Power Plants. *Truckee Meadows Water Authority* at www.tmwa.com
- Wang, W. C., Mu, H. L., Kang, X. D., Song, R. C., & Ning, Y. D. (2010). Changes in Industrial Electricity Consumption in China from 1998 to 2007. *Energy Policy*, vol. 38, 2684-2690.
- Wei, P., Yaoguo, D., & Xia, Z. (2009). Analysis on Grey Relation of the Impact of China's Energy Consumption on Environment Quality. *Proceeding of 2009 IEEE International Conference on Grey Systems and Intelligent Services*, November 10-12, Nanjing, China, 290-294.
- World Bank (2015). Retrieved from worldbank.org
- Yatim, P., Mamat, M., Mohamad-Zailani, S. H., & Ramlee, S., (2016). Energy Policy Shifts towards Sustainable Energy Future for Malaysia. *Clean Technologies and Environmental Policy*, vol. 18 (88), 1-11.
- Yazdan, G. F., & Hossein, S. S. M. (2012). Causality between Oil Consumption and Economic and Iran: An ARDL Testing Approach. *Asian Economic and Financial Review*, vol. 2 (6), 678-686.

- Yildirim, E., Sarac, S., & Aslan, A. (2012). Energy Consumption and Economic Growth in the USA: Evidence from Renewable Energy. *Renewable and Sustainable Energy Review*, vol. 16, 6770-6774.
- Yusoff, S. & Kardooni, R. (2012). Barriers and Challenges for Developing RE Policy in Malaysia. *International Conference on Future Environment and Energy IPCBEE* vol. 28.
- Zaleski, P. (2001), Energy and Geopolitical Issues, In Rao, D. B., D. Harshyita (eds.), *Energy Security*, Discovery Publishing House, New Delhi.
- Zhang, X. P., & Cheng, X. M. (2009). Energy Consumption, Carbon Emissions, and Economic Growth in China. *Ecological Economics*, 68 , 2706–2712.
- Zhang, M., Li, H. N., Zhou, M., & Mu, H. L. (2011). Decomposition Analysis of Energy Consumption in Chinese Transportation Sector. *Applied Energy*, vol. 88, 2279-2285.
- Zhang, W., Dou, Z., He, P., Ju, X., Powlson, D., Chadwick, D., Norse, D., Lu, Y., Zhang, Y., Wu, L., Chen, X., Cassman, K. G., & Zhang, F. (2013). New Technologies Reduce Greenhouse Gas Emissions from Nitrogenous Fertilizer in China. *PNAS*, vol. 110 (21), 8375-8380
- Zhao, D. (2014). Analysis of Relationship between Rural Energy Consumption of Biomass Resources and Income Alteration of Farmers. *Interdisciplinary Journal of Contemporary Research in Business*, vol. 5 (10), 76-84.
- Zikovic, S., & Dizdarevic, N. V. (2011). Oil Consumption and Economic Growth Interdependence in Small European Countries. *Ekonomika Istrazivanja*, vol. 24 (3), 15- 32.

APPENDIX A

Descriptive Statistics

	K	Q/L	Q/P	L	O	CO2	G	E
Mean	10088861786.9402 6	19513457.8513932 3	63622467456.2022 5	109091943.181818 2	7995795.45454545 5	33889772.7272727 3	91292.7840909090 9	19941.6818181818 2
Median	381066000 3	1021171.84463421 3	47740146325.5957 3	43729000 3	5462000 3	33380000 3	29168 3	14188.5 3
Maximum	56684245170.7055 3	59688788.0552844 5	155250637309.920 3	437077000 3	20998000 3	59000000 3	394198 3	63205 3
Minimum	41450000 2	279384.880868697 2	13332240016.8137 9	400700 9	1424000 9	15300000 9	183 9	12 9
Std. Dev.	14752360199.7122 3	22511727.9260144 7	42844399188.8371 4	132619680.261721 4	4785426.29424519 2	9195784.04124370 4	112419.495235189 8	20941.8866465037 1
Skewness	1.64129351381242 9	0.43687707439982 07	0.57537692190446 71	0.93347581017198 65	0.78427181459486 9	0.40465591176840 73	1.14355843111606 4	0.51140117687433 42
Kurtosis	4.98976725720090 8	1.40251814799316 7	2.04464944715919 8	2.59045663587225 7	2.71744667776712 6	3.63096510144045 1	3.22324109758102 6	1.85960879108505 1
Jarque-Bera	27.0133441082263 5	6.07822339673224 1	4.10103666106614 8	6.69759588631110 3	4.65697007705700 4	1.93068807607911 3	9.68135690345213 9	4.30213073437457 9
Probability	1.36184242038872 6e-06	0.04787740018305 431	0.12866819364699 55	0.03512655284638 921	0.09744325810625 465	0.38085214957060 92	0.00790169131650 8198	0.11636012545567 83
Sum	443909918625.371 1	858592145.461300 9	2799388568072.90 1	4800045500 1	351815000 1	1491150000 1	4016882.5 1	877434 1
Sum Sq. Dev.	9.35818165286829 7e+21	2.17914494512407 e+16	7.89326292996544 1e+22	7.56283122487007 9e+17	984713107159091 9e+17	3636185097727273 9e+17	543440145084.199 9e+17	18858192501.5454 4
Observations	44	44	44	44	44	44	44	44

APPENDIX B
Unit Root Test

Panel unit root test: Summary

Series: LNCO2

Date: 02/21/17 Time: 10:20

Sample: 1990 2014

Exogenous variables: Individual effects

User-specified lags: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.10371	0.1349	3	69
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	0.17503	0.5695	3	69
ADF - Fisher Chi-square	4.49606	0.6099	3	69
PP - Fisher Chi-square	7.16476	0.3059	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: D(LNCO2)

Date: 02/21/17 Time: 10:23

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-8.00983	0.0000	3	69
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-7.51260	0.0000	3	69
ADF - Fisher Chi-square	50.9798	0.0000	3	69
PP - Fisher Chi-square	50.9316	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNCO2

Date: 02/21/17 Time: 10:23

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

User-specified lags: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	0.62467	0.7339	3	69
Breitung t-stat	0.36951	0.6441	3	66
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	1.00363	0.8422	3	69
ADF - Fisher Chi-square	2.03896	0.9161	3	69
PP - Fisher Chi-square	3.46535	0.7486	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNCO2)

Date: 02/21/17 Time: 10:24

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.02832	0.0000	3	69
Breitung t-stat	-3.55750	0.0002	3	66
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.71871	0.0000	3	69
ADF - Fisher Chi-square	41.3626	0.0000	3	69
PP - Fisher Chi-square	41.6789	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNE

Date: 02/21/17 Time: 10:25

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.71961	0.2359	1	23
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	0.64725	0.7413	1	23
ADF - Fisher Chi-square	0.52941	0.7674	1	23
PP - Fisher Chi-square	0.74617	0.6886	1	23

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNE)

Date: 02/21/17 Time: 10:25

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on AIC: 1

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.99752	0.0000	1	23
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-7.12182	0.0000	1	23
ADF - Fisher Chi-square	28.2539	0.0000	1	23
PP - Fisher Chi-square	43.8305	0.0000	1	23

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNE

Date: 02/21/17 Time: 10:26

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on AIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.37000	0.0004	1	23
Breitung t-stat	-2.42029	0.0078	1	22
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.32363	0.0101	1	23
ADF - Fisher Chi-square	-1.03794	0.1526	1	23
PP - Fisher Chi-square	8.14456	0.0170	1	23

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNE)

Date: 02/21/17 Time: 10:26

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on AIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-6.95478	0.0000	1	23
Breitung t-stat	-5.10802	0.0000	1	22
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.61594	0.0000	1	23
ADF - Fisher Chi-square	24.0002	0.0000	1	23
PP - Fisher Chi-square	112.149	0.0000	1	23

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNG

Date: 02/21/17 Time: 10:27

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.13888	0.1274	2	47
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	0.29976	0.6178	2	47
ADF - Fisher Chi-square	2.28352	0.6838	2	47
PP - Fisher Chi-square	2.10079	0.7172	2	48

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: D(LNG)

Date: 02/21/17 Time: 10:27

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.07559	0.0011	2	45
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.33939	0.0004	2	45
ADF - Fisher Chi-square	18.6918	0.0009	2	45
PP - Fisher Chi-square	25.1414	0.0000	2	46

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNG

Date: 02/21/17 Time: 10:27

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 4

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	0.57588	0.7177	2	47
Breitung t-stat	0.83899	0.7993	2	42
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.22730	0.4101	2	47
ADF - Fisher Chi-square	5.27929	0.2598	2	47
PP - Fisher Chi-square	0.63394	0.9592	2	48

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: D(LNG)

Date: 02/21/17 Time: 10:28

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.55165	0.0054	2	45
Breitung t-stat	-2.71857	0.0033	2	43
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.86426	0.0021	2	45
ADF - Fisher Chi-square	15.7183	0.0034	2	45
PP - Fisher Chi-square	21.0132	0.0003	2	46

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNK

Date: 02/21/17 Time: 10:29

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on AIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.09098	0.0183	3	72
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	0.42863	0.6659	3	72
ADF - Fisher Chi-square	4.95024	0.5502	3	72
PP - Fisher Chi-square	21.4789	0.0015	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: D(LNK)

Date: 02/21/17 Time: 10:30

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.44741	0.0003	3	68
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.24536	0.0006	3	68
ADF - Fisher Chi-square	21.7433	0.0013	3	68
PP - Fisher Chi-square	23.3722	0.0007	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNK

Date: 02/21/17 Time: 10:29

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.93544	0.0017	3	71
Breitung t-stat	2.05458	0.9800	3	68
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.68656	0.2462	3	71
ADF - Fisher Chi-square	9.66574	0.1395	3	71
PP - Fisher Chi-square	21.6771	0.0014	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNK)

Date: 02/21/17 Time: 10:30

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-4.51530	0.0000	3	69
Breitung t-stat	-3.80199	0.0001	3	66
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-4.06219	0.0000	3	69
ADF - Fisher Chi-square	24.8429	0.0004	3	69
PP - Fisher Chi-square	24.8612	0.0004	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNL

Date: 02/21/17 Time: 10:31

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.01880	0.1541	3	72
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.11018	0.4561	3	72
ADF - Fisher Chi-square	6.57694	0.3617	3	72
PP - Fisher Chi-square	6.32055	0.3883	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNL)

Date: 02/21/17 Time: 10:32

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.51086	0.0000	3	69
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.56123	0.0000	3	69
ADF - Fisher Chi-square	44.2361	0.0000	3	69
PP - Fisher Chi-square	44.2372	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNL

Date: 02/21/17 Time: 10:31

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.19350	0.4233	3	71
Breitung t-stat	0.55219	0.7096	3	68
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	0.34823	0.6362	3	71
ADF - Fisher Chi-square	5.24444	0.5129	3	71
PP - Fisher Chi-square	3.23773	0.7785	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNL)

Date: 02/21/17 Time: 10:32

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-6.95541	0.0000	3	69
Breitung t-stat	-5.31748	0.0000	3	66
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.14633	0.0000	3	69
ADF - Fisher Chi-square	37.8368	0.0000	3	69
PP - Fisher Chi-square	38.9865	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNO

Date: 02/21/17 Time: 10:33

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	0.08224	0.5328	3	72
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	1.19246	0.8835	3	72
ADF - Fisher Chi-square	3.10946	0.7950	3	72
PP - Fisher Chi-square	2.88143	0.8236	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNO)

Date: 02/21/17 Time: 10:34

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-8.12972	0.0000	3	68
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-7.01275	0.0000	3	68
ADF - Fisher Chi-square	48.0100	0.0000	3	68
PP - Fisher Chi-square	46.2902	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNO

Date: 02/21/17 Time: 10:34

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 2

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	0.27709	0.6091	3	70
Breitung t-stat	2.21541	0.9866	3	67
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	1.28037	0.8998	3	70
ADF - Fisher Chi-square	2.72449	0.8425	3	70
PP - Fisher Chi-square	2.62184	0.8546	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNO)

Date: 02/21/17 Time: 10:35

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.83288	0.0000	3	68
Breitung t-stat	-2.34685	0.0095	3	65
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-7.16144	0.0000	3	68
ADF - Fisher Chi-square	44.8179	0.0000	3	68
PP - Fisher Chi-square	43.7267	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNQ_L

Date: 02/21/17 Time: 10:35

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 2

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.95632	0.0252	3	70
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.00347	0.4986	3	70
ADF - Fisher Chi-square	4.01222	0.6750	3	70
PP - Fisher Chi-square	3.65647	0.7230	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNQ_L)

Date: 02/21/17 Time: 10:36

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-6.68812	0.0000	3	67
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-7.09166	0.0000	3	67
ADF - Fisher Chi-square	48.9127	0.0000	3	67
PP - Fisher Chi-square	82.8891	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNQ_L

Date: 02/21/17 Time: 10:35

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.51483	0.3033	3	71
Breitung t-stat	0.12739	0.5507	3	68
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.26890	0.3940	3	71
ADF - Fisher Chi-square	7.88390	0.2467	3	71
PP - Fisher Chi-square	12.6506	0.0489	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: D(LNQ_L)

Date: 02/21/17 Time: 10:36

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-5.71620	0.0000	3	67
Breitung t-stat	-5.82075	0.0000	3	64
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.34172	0.0000	3	67
ADF - Fisher Chi-square	40.0101	0.0000	3	67
PP - Fisher Chi-square	113.695	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNQ_P

Date: 02/21/17 Time: 10:37

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.70620	0.0440	3	72
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	0.25860	0.6020	3	72
ADF - Fisher Chi-square	5.10061	0.5310	3	72
PP - Fisher Chi-square	16.8357	0.0099	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNQ_P)

Date: 02/21/17 Time: 10:37

Sample: 1990 2014

Exogenous variables: Individual effects

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.72449	0.0000	3	69
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-6.78764	0.0000	3	69
ADF - Fisher Chi-square	45.9172	0.0000	3	69
PP - Fisher Chi-square	52.0781	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary

Series: LNQ_P

Date: 02/21/17 Time: 10:37

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0

Newey-West automatic bandwidth selection and Bartlett kernel

Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.10948	0.0175	3	72
Breitung t-stat	-0.87009	0.1921	3	69
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.78780	0.2154	3	72
ADF - Fisher Chi-square	7.70713	0.2604	3	72
PP - Fisher Chi-square	10.9673	0.0894	3	72

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.



Panel unit root test: Summary

Series: D(LNQ_P)

Date: 02/21/17 Time: 10:38

Sample: 1990 2014

Exogenous variables: Individual effects, individual linear trends

Automatic selection of maximum lags

Automatic lag length selection based on SIC: 0 to 1

Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-6.86061	0.0000	3	68
Breitung t-stat	-5.87103	0.0000	3	65
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-5.85706	0.0000	3	68
ADF - Fisher Chi-square	36.5295	0.0000	3	68
PP - Fisher Chi-square	46.9195	0.0000	3	69

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

APPENDIX C

Cointegration

Pedroni Residual Cointegration Test
 Series: LNQ_P LNK LNL LNO LNG LNE
 Date: 02/21/17 Time: 10:50
 Sample: 1990 2014
 Included observations: 75
 Cross-sections included: 2 (1 dropped)
 Null Hypothesis: No cointegration
 Trend assumption: No deterministic trend
 User-specified lag length: 1
 Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	<u>Statistic</u>	<u>Prob.</u>	<u>Weighted Statistic</u>	<u>Prob.</u>
Panel v-Statistic	-1.065404	0.8567	-1.068083	0.8573
Panel rho-Statistic	0.800096	0.7882	0.781489	0.7827
Panel PP-Statistic	-2.332752	0.0098	-2.368964	0.0089
Panel ADF-Statistic	-1.765071	0.0388	-1.753278	0.0398

Alternative hypothesis: individual AR coefs. (between-dimension)

	<u>Statistic</u>	<u>Prob.</u>
Group rho-Statistic	1.457271	0.9275
Group PP-Statistic	-2.196120	0.0140
Group ADF-Statistic	-1.778726	0.0376

Cross section specific results

Phillips-Peron results (non-parametric)

Cross ID	AR(1)	Variance	HAC	Bandwidth	Obs
industrial	0.246	0.001635	0.000430	7.00	24
transportation	0.008	0.001756	0.000954	4.00	24
agricultural	0.245	0.002607	0.002502	2.00	24

Augmented Dickey-Fuller results (parametric)

Cross ID	AR(1)	Variance	Lag	Max lag	Obs
industrial	-0.067	0.001353	1	--	23
transportation	-0.167	0.001758	1	--	23
agricultural	0.157	0.002651	1	--	23

Pedroni Residual Cointegration Test
 Series: LNCO2 LNQ_L LNO LNG LNE
 Date: 02/21/17 Time: 10:51
 Sample: 1990 2014
 Included observations: 75
 Cross-sections included: 2 (1 dropped)
 Null Hypothesis: No cointegration
 Trend assumption: No deterministic trend
 User-specified lag length: 1
 Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	<u>Statistic</u>	<u>Prob.</u>	<u>Weighted Statistic</u>	<u>Prob.</u>
Panel v-Statistic	2.407576	0.0080	2.080260	0.0188
Panel rho-Statistic	-2.954831	0.0016	-3.118845	0.0009
Panel PP-Statistic	-2.716105	0.0033	-3.034855	0.0012
Panel ADF-Statistic	-0.080404	0.4680	-0.557934	0.2884

Alternative hypothesis: individual AR coefs. (between-dimension)

	<u>Statistic</u>	<u>Prob.</u>
Group rho-Statistic	-2.429812	0.0076
Group PP-Statistic	-3.222113	0.0006
Group ADF-Statistic	-0.113513	0.4548

Cross section specific results

Phillips-Peron results (non-parametric)

Cross ID	AR(1)	Variance	HAC	Bandwidth	Obs
industrial	0.067	0.003605	0.004043	2.00	24
transportation	-0.114	0.001837	0.001674	2.00	24
agricultural	-0.137	0.003411	0.003101	2.00	24

Augmented Dickey-Fuller results (parametric)

Cross ID	AR(1)	Variance	Lag	Max lag	Obs
industrial	0.267	0.003591	1	--	23
transportation	-0.224	0.001899	1	--	23
agricultural	-0.137	0.003411	1	--	23

APPENDIX D
FMOLS

Dependent Variable: LNQ_P
 Method: Panel Fully Modified Least Squares (FMOLS)
 Date: 02/21/17 Time: 10:54
 Sample (adjusted): 1991 2014
 Periods included: 24
 Cross-sections included: 2
 Total panel (balanced) observations: 48
 Panel method: Grouped estimation
 Cointegrating equation deterministics: C
 Long-run covariance estimates (Bartlett kernel, Newey-West fixed bandwidth)
 Warning: one more more cross-sections have been dropped due to estimation errors

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNK	0.150993	0.068366	2.208583	0.0330
LNL	0.829056	0.194526	4.261933	0.0001
LNO	0.058276	0.032888	1.771958	0.0840
LNG	0.355730	0.147645	2.409365	0.0207
LNE	0.109626	0.060648	1.807573	0.0782
R-squared	-14.630503	Mean dependent var		7.449897
Adjusted R-squared	-17.365841	S.D. dependent var		0.813739
S.E. of regression	3.487310	Sum squared resid		486.4531
Long-run variance	0.001214			

Dependent Variable: LNCO2
 Method: Panel Fully Modified Least Squares (FMOLS)
 Date: 02/21/17 Time: 10:55
 Sample (adjusted): 1991 2014
 Periods included: 24
 Cross-sections included: 2
 Total panel (balanced) observations: 48
 Panel method: Grouped estimation
 Cointegrating equation deterministics: C
 Long-run covariance estimates (Bartlett kernel, Newey-West fixed bandwidth)
 Warning: one more more cross-sections have been dropped due to estimation errors

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNQ_L	0.394603	0.152878	2.581170	0.0135
LNO	0.589598	0.036080	16.34121	0.0000
LNG	0.357051	0.101985	3.501009	0.0011
LNE	-0.079451	0.077572	-1.024225	0.3117
R-squared	-47.550366	Mean dependent var		17.24946
Adjusted R-squared	-54.655298	S.D. dependent var		0.323089
S.E. of regression	2.410321	Sum squared resid		238.1955
Long-run variance	0.002073			

APPENDIX E

Pooled Mean Group (PMG) and Mean Group (MG)

MG (Q/P)

	D.lnyp	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
ECT	lnK	2.510359	2.03075	1.24	0.216	-1.469838	6.490555
	lnL	0.0641577	0.8155732	0.08	0.937	-1.534336	1.662652
	lnO	0.0213331	0.1677704	0.13	0.899	-0.3074907	0.350157
	lnG	-0.3026351	0.3280575	-0.92	0.356	-0.945616	0.3403458
	lnE	-0.0539932	0.0446071	-1.21	0.226	-0.1414214	0.033435
Sectors	ECT	-0.4904644	0.3312988	-1.48	0.139	-1.139798	0.1588692
	lnK D1.	0.2023731	0.101031	2.00	0.045	0.0043559	0.4003903
	lnL D1.	0.496837	0.1155154	4.30	0.000	0.270431	0.7232431
	lnO D1.	0.068484	0.0575221	1.19	0.234	-0.0442573	0.1812253
	lnG D1.	-0.0696792	0.0466262	-1.49	0.135	-0.1610648	0.0217064
	lnE D1.	0.0947177	0.1071755	0.88	0.377	-0.1153424	0.3047779
	_cons	-22.98464	16.40747	-1.40	0.161	-55.1427	9.173411

PMG (Q/P)

Panel Variable (i): sector1
 Time Variable (t): year

Number of obs = 72
 Number of groups = 3
 Obs per group: min = 24
 avg = 24.0
 max = 24

Log Likelihood = 111.3156

	D.lnyp	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
ECT	lnK	0.2942183	0.0891552	3.30	0.001	0.1194774	0.4689592
	lnL	0.3491967	0.2114159	1.65	0.099	-0.0651708	0.7635642
	lnO	0.1614306	0.0452385	3.57	0.000	0.0727648	0.2500965
	lnG	0.0489643	0.0147563	3.32	0.001	0.0200425	0.0778861
	lnE	-0.0202932	0.0230582	-0.88	0.379	-0.0654864	0.0249001
Sectors	ECT	-0.7400665	0.1998044	-3.70	0.000	-1.131676	-0.3484571
	lnK D1.	0.7698131	0.6141246	1.25	0.210	-0.4338489	1.973475
	lnL D1.	0.4340473	0.1203388	3.61	0.000	0.1981876	0.6699069
	lnO D1.	0.0403181	0.0548385	0.74	0.462	-0.0671633	0.1477996
	lnG D1.	0.1466069	0.1224	1.20	0.231	0.3865064	0.0932926
	lnE D1.	0.0580659	0.0701037	0.83	0.408	-0.0793348	0.1954666
	_cons	-3.021617	2.148147	-1.41	0.160	-7.231908	1.188675

PMG (Q/P)

Panel Variable (i): sector1
 Time Variable (t): year

Number of obs = 72
 Number of groups = 3
 Obs per group: min = 24
 avg = 24.0
 max = 24

Log Likelihood = 111.3156

D.lnyp		Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
ECT	lnK	0.2942183	0.0891552	3.30	0.001	0.1194774	0.4689592
	lnL	0.3491967	0.2114159	1.65	0.099	-0.0651708	0.7635642
	lnO	0.1614306	0.0452385	3.57	0.000	0.0727648	0.2500965
	lnG	0.0489643	0.0147563	3.32	0.001	0.0200425	0.0778861
	lnE	-0.0202932	0.0230582	-0.88	0.379	-0.0654864	0.0249001
Agriculture	ECT	-0.2613786	0.1655233	-1.58	0.114	-0.5857982	0.0630411
	lnK D1.	1.984378	4.367168	0.45	0.650	-6.575114	10.54387
	lnL D1.	0.2060257	0.2745659	0.75	0.453	-0.3321135	0.7441649
	lnO D1.	0.0208206	0.0324441	0.64	0.521	-0.0427686	0.0844099
	lnG D1.		0 (omitted)				
	lnE D1.		0 (omitted)				
	_cons	-1.257843	0.9275497	-1.36	0.175	-3.075807	0.560121
Industrial	ECT	-0.0665685	0.0692176	-0.96	0.336	-0.2022324	0.0690954
	lnK D1.	0.3208678	0.208142	1.54	0.123	-0.087083	0.7288186
	lnL D1.	0.6147579	0.2617032	2.35	0.019	0.1018292	1.127687
	lnO D1.	-0.0434032	0.0532188	-0.82	0.415	-0.1477102	0.0609038
	lnG D1.	0.3896898	0.1884288	2.07	0.039	0.7590035	0.0203761
	lnE D1.	0.1976196	0.2825937	0.70	0.484	-0.3562539	0.7514932

	_cons	-0.5108	0.5026419	-1.02	0.310	-1.49596	0.4743601
Transportation	ECT	-1.143446	0.2021744	-5.66	0.000	-1.539701	-0.7471916
	lnK D1.	0.0041933	0.0863831	0.05	0.961	-0.1651144	0.1735011
	lnL D1.	0.4813582	0.192782	2.50	0.013	0.1035125	0.8592039
	lnO D1.	0.143537	0.1011916	1.42	0.156	-0.054795	0.341869
	lnG D1.	0.050131	0.026509	1.89	0.059	0.1020876	0.0018257
	lnE D1.	-0.0234219	0.0203431	-1.15	0.250	-0.0632938	0.0164499
	_cons	-7.296207	2.749748	-2.65	0.008	-12.68561	-1.906801

Hausman Test (Q/P)

	----- Coefficients -----			Sqrt (diag(V_b – V_B) S.E
	MG (b)	PMG (B)	Difference (b-B)	
lnK	2.510359	0.2942183	2.21614	3.191809
lnL	0.0641577	0.3491967	-0.285039	1.264821
lnO	0.0213331	0.1614306	-0.1400975	0.2598861
lnG	-0.3026351	0.0489643	-0.3515994	0.5156108
lnE	-0.0539932	-0.0202932	-0.0337	0.0662394

b = consistent under Ho and Ha, B = inconsistent under Ha, efficient under Ho;

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(5) &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\ &= 1.53 \end{aligned}$$

$$\text{Prob}>\text{chi2} = 0.9091$$

(V_b-V_B is not positive definite)

MG (CO₂)

	D.lnyp	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
ECT	lnL	0.3492756	0.4066467	0.86	0.390	-0.4477373	1.146288
	lnO	0.7690431	0.2908159	2.64	0.008	0.1990546	1.339032
	lnG	0.3425328	0.3459793	0.99	0.322	-0.3355742	1.02064
	lnE	-0.153237	0.1482676	-1.03	0.301	-0.4438362	0.1373622
Sectors	ECT	-0.2860122	0.3023972	-0.95	0.344	-0.8786998	0.3066754
	lnL D1.	-0.1561356	0.1449777	-1.08	0.281	-0.4402866	0.1280155
	lnO D1.	-0.6562281	0.4622489	-1.42	0.156	-1.562219	0.2497632
	lnG D1.	-0.1324533	0.1011557	-1.31	0.190	-0.3307147	0.0658082
	lnE D1.	0.1139188	0.1085573	1.05	0.294	-0.0988495	0.3266871
	_cons	-1.139123	3.16799	-0.36	0.719	-7.348269	5.070023

PMG (CO₂)

Panel Variable (i): sector1
 Time Variable (t): year

Number of obs = 72
 Number of groups = 3
 Obs per group: min = 24
 avg = 24.0
 max = 24

Log Likelihood = 99.43596

	D.lnyp	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
ECT	lnL	1.062394	0.4081998	2.60	0.009	0.2623374	1.862451
	lnO	0.1807315	0.0664885	2.72	0.007	0.0504165	0.3110465
	lnG	0.9650822	0.2951339	3.27	0.001	0.3866303	1.543534
	lnE	-0.3988808	0.2319482	-1.72	0.085	-0.8534908	0.0557293
Sectors	ECT	-0.7555251	0.2115024	-3.72	0.000	-1.167953	-0.3504791
	lnL D1.	-0.1571588	0.131413	-1.20	0.232	-0.4147235	0.100406
	lnO D1.	0.5293769	0.3095496	1.71	0.087	-0.0773291	1.136083
	lnG D1.	-0.1246296	0.0942278	-1.32	0.186	-0.3093128	0.0600536
	lnE D1.	0.0878394	0.1163673	0.75	0.450	-0.1402364	0.3159151
	_cons	-1.90334	2.048673	-0.93	0.353	-5.918665	2.111986

PMG (CO₂)

Panel Variable (i): sector1
 Time Variable (t): year

Number of obs = 72
 Number of groups = 3
 Obs per group: min = 24
 avg = 24.0
 max = 24

Log Likelihood = 99.43596

	D.lnyp	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
ECT	lnL	1.062394	0.4081998	2.60	0.009	0.2623374	1.862451
	lnO	0.1807315	0.0664885	2.72	0.007	0.0504165	0.3110465
	lnG	0.9650822	0.2951339	3.27	0.001	0.3866303	1.543534
	lnE	-0.3988808	0.2319482	-1.72	0.085	-0.8534908	0.0557293
Agriculture	ECT	0.028213	0.0323958	0.87	0.384	-0.0352815	0.0917075
	lnL D1.	0.0186736	0.148371	0.13	0.900	-0.2721282	0.3094755
	lnO D1.	1.008415	0.0304652	33.10	0.000	0.948704	1.068125
	lnG D1.		0 (omitted)				
	lnE D1.		0 (omitted)				
	_cons	0.2033031	0.2985	0.68	0.496	-0.3817462	0.7883524
Industrial	ECT	0.0044006	0.0078863	0.56	0.577	-0.0110562	0.0198575
	lnL D1.	-0.4142505	0.3173397	-1.31	0.192	-1.036225	0.2077239
	lnO D1.	-0.0497813	0.100658	-0.49	0.621	-0.2470674	0.1475049
	lnG D1.	0.3093669	0.2251139	1.37	0.169	0.750582	0.1318482
	lnE D1.	0.3184064	0.3663892	0.87	0.385	-0.3997032	1.036516
	_cons	-6.000134	6.343254	-0.95	0.344	-18.43268	6.432416
Transportation	ECT	-0.8906503	0.2322733	-3.83	0.000	-1.345898	-0.4354031
	lnL D1.	-0.0758994	0.1399088	-0.54	0.587	-0.3501156	0.1983168
	lnO D1.	0.6294973	0.1437998	4.38	0.000	0.3476548	0.9113398

lnG D1.	0.064522	0.0352887	1.83	0.067	0.1336865	0.0046426
lnE D1.	-0.0548883	0.0244735	-2.24	0.025	-0.1028556	-0.0069211
_cons	0.0868121	0.0832085	1.04	0.297	-0.0762736	0.2498978

Hausman Test (CO₂)

	---- Coefficients ----			Sqrt (diag(V _b – V _B))
	MG (b)	PMG (B)	Difference (b-B)	S.E
lnL	0.3492756	1.062394	-0.7131186	0.4857157
lnO	0.7690431	0.1807315	0.5883116	0.4488442
lnG	0.3425328	0.9650822	-0.6225494	0.4519856
lnE	-0.153237	-0.3988808	0.2456438	.

b = consistent under Ho and Ha, B = inconsistent under Ha, efficient under Ho;

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(4) &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\ &= 1.60 \\ \text{Prob}>\text{chi2} &= 0.8088 \\ &(\text{V}_b\text{-V}_B \text{ is not positive definite}) \end{aligned}$$

APPENDIX F

Section 22 of the Environment Quality Act, EQA, 1974 (Act 127).

22. Restrictions on pollution of the atmosphere.

- (1) No person shall, unless licenced, emit or discharge any wastes into the atmosphere in contravention of the acceptable conditions specified under section 21.

- (2) Without limiting the generality of the subsection (1), a person shall be deemed to emit or discharge wastes into the atmosphere if -
 - (a) he places any matter in a place where it may be released into the atmosphere;
 - (b) he causes or permits the discharge of odours which by virtue of their nature, concentration, volume or extent are obnoxious or offensive;
 - (c) he burns any wastes of the trade, process or industry; or
 - (d) He uses any fuel burning equipment not equipped with any device or control equipment required to be fitted to such equipment.

- (3) Any person who contravenes subsection (1) shall be guilty of an offence and shall be liable to a fine not exceeding the thousand ringgit or to imprisonment for a period not exceeding two years or to both and to a further fine not exceeding one thousand ringgit a day for every day that the offence is continued after a notice by the Director General requiring him to cease the act specified therein has been served upon him.