THE ROLE OF TOURISM IN THE LINKAGE BETWEEN CO_2 EMISSION, ENERGY CONSUMPTION, AND ECONOMIC GROWTH: EVIDENCE FROM THE G-20 COUNTRIES

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By

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ABSTRACT

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Ng Cheong Fatt

This study examines the relationship between carbon dioxide (CO_2) emission, energy consumption, economic growth and tourism by using panel cointegration and causality approaches for the group of G-20 countries for the period of 1995-2010. By using Panel Dynamic Ordinary Least Square (DOLS) and Generalized Method of Moments (GMM), the study finds: First, more energy consumption leads to more CO_2 emission. Next, the Environmental Kuznets Curve (EKC) hypothesis is supported where there is an inverted-U relationship between economic growth and CO_2 emission. To examine the direction of causality, a panel Vector Error Correction Model (VECM) Granger causality test is performed. The finding indicates a bi-directional Granger causality exists between economic growth and energy consumption, tourism and energy consumption, and economic growth and tourism. Also, there is unidirectional short run Granger causality running from energy consumption to CO_2 emission, from economic growth to CO_2 emission, and lastly from tourism to CO_2 emission. The most important finding in this study is the role of tourism, namely: Increased tourism results in more CO_2 emission,

however, the emission could be reduced if energy is being used wisely especially in the tourism sector. This is shown when an interaction term between tourism and energy consumption is added into the analysis. This finding suggests an alternative, which is energy efficiency in tourism sector other than energy conservation policy to reduce CO_2 emission as energy conservation policy may have negative impact on economic growth.

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APPROVAL SHEET

This dissertation entitled "**THE ROLE OF TOURISM IN THE LINKAGE BETWEEN CO_2 EMISSION, ENERGY CONSUMPTION, AND ECONOMIC GROWTH: EVIDENCE FROM THE G-20 COUNTRIES**" was prepared by NG CHEONG FATT and submitted as partial fulfillment of the requirements for the degree of Master of Philosophy at Universiti Tunku Abdul Rahman.

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SUBMISSION OF DISSERTATION

It is hereby certified that ***Ng Cheong Fatt*** (ID No: ***13ABM06667***) has completed this dissertation entitled "*The Role of Tourism in the Linkage between CO_2 Emission, Energy Consumption, and Economic Growth: Evidence from the G-20 Countries.*" under the supervision of Prof. Dr. Choong Chee Keong from the Department of Economics, Faculty of Business and Finance, and Dr. Lau Lin Sea from the Department of Economics, Faculty of Business and Finance.

I understand that University will upload softcopy of my dissertation in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

____

(*Ng Cheong Fatt*)

DECLARATION

I hereby declare that the dissertation is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

Name ______________________________

Date _______________________________

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LIST OF ABBREVIATIONS

ARDL	Autoregressive Distributed Lag
BRICS	Brazil, Russia, India, China, and South Africa
CO_2	Carbon Dioxide Emissions
DOLS	Dynamic Ordinary Least Square
EC	Energy Consumption
ECT	Error Correction Term
EKC	Environmental Kuznets Curve
EU	European Union
EXT	Interaction between Energy Consumption and Tourism
FDI	Foreign Direct Investment
FMOLS	Fully Modified Ordinary Least Square
GDP	Real Gross Domestic Product Per Capita
GDP^2	Square Term of Real Gross Domestic Product Per Capita
GHG	Greenhouse Gases
GLS	Generalized Least Square
GMM	Generalized Method of Moments
GMSL	Global Mean Sea Level
IATA	International Air Transport Association
IEA	International Energy Agency
IMF	International Monetary Fund
OECD	Organization for Economic Cooperation and Development

OLS	Ordinary Least Square
OPEC	Organization of Petroleum Exporting Countries
SO_2	Sulfur Dioxide
T	Tourism
UNFCCC	United Nations Framework Convention on Climate Change
UNWTO	United Nations World Tourism Organization
UNEP	United Nations Environment Program
VECM	Vector Error Correction Model
VAR	Vector Autoregressive Model
WDI	World Development Indicators
WMO	World Meteorological Organization

CHAPTER 1

INTRODUCTION

1.1 Research Background

The concern on the issue of global warming has been growing rapidly especially in the recent decade. Global warming is often related to the change in the climate due to an increase in overall temperature. According to a recent summary on the current climate change by the World Meteorological Organization (WMO), the global average temperature is estimated to have risen by 0.6^{o} C over the course of 20th century. It is added that 2001-2010 was the warmest decade and 2010 was the warmest year on record since the beginning of modern monitoring of global temperature (WMO, 2013).

The direct effect from this global warming and climate change is the shifting of global mean temperature. This change will result in the born of a new climate (figure 1.1) with more occurrences of hot weather and less occurrences of cold weather. As a result, global sea level will increase due to the melting of glaciers and ice caps from the poles. Figure 1.2 shows the global mean sea level from 1880 to 2011. This phenomenon is worrisome because it may lead to the submergence of coastal countries if the trend continues. Other hidden consequences of this global warming and climate change are still an ongoing research by the scientists.

Besides, the United Nations Framework Convention on Climate Change (UNFCCC) projected that the average temperature of the Earth will go up by 1.8^{o} C to 4^{o} C by 2100 if no action is taken. At that time, about 20-30% of plants and animal suffer from the risk of extinction. This implies potential food crisis if no action is taken to counter this global warming and climate change.

From the facts above, the issue of global warming started to draw attention from the environmentalists and practitioners. It has been identified that greenhouse gases (hereafter GHG) are the main cause of global warming and climate change. Among the GHG, carbon dioxide (hereafter CO_2) is the major contributor. To reduce the emission of GHG, Kyoto Protocol was adopted in 1997 to commit the members by setting international target of emission reduction. However, some countries still recorded a positive change in CO_2 emission compared with previous years.

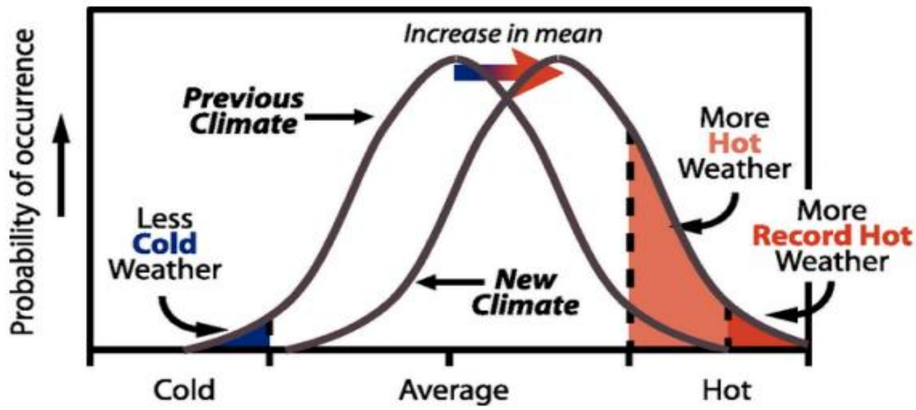

Figure 1.1 Birth of a new climate due to global warming

(Source: WMO, 2013)

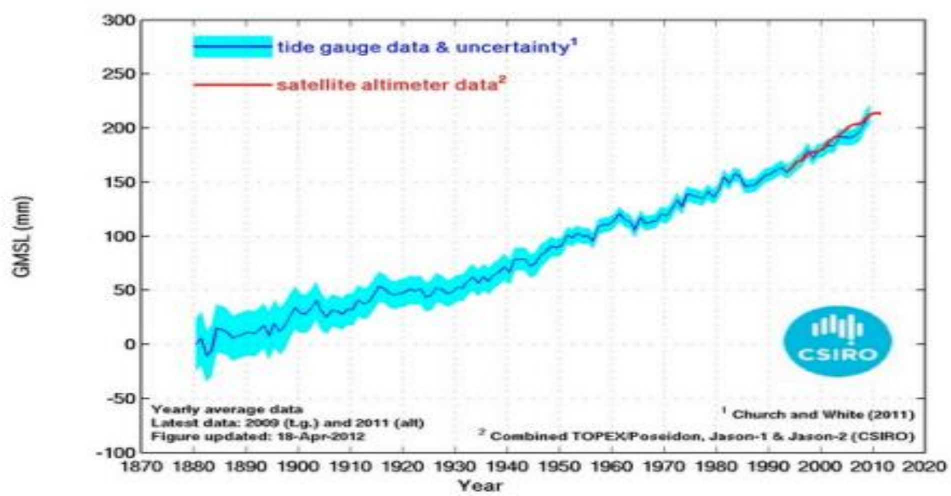

Figure 1.2 Global mean sea level (GMSL) from 1881-2011

(Source: WMO, 2013)

An ideal situation would be achieving sustainable economic growth while minimizing the emission of CO_2. This is exactly what academicians and policy makers wish to achieve. Thus, academicians and researchers in the past first attempted to examine the relationship between CO_2 emission and economic growth. This line of research sooner developed and included energy consumption into the analysis. Despite with the inclusion of additional variable, the results from various works were unable to draw a consistent conclusion. Details are discussed in Chapter 2, Literature Review.

The following subsection provides a brief introduction as well as the linkages between CO_2 emission, economic growth, and energy consumption.

1.2 The Linkage between Economic Growth, Energy Consumption, and Emissions

1.2.1 Economic Growth and Energy Consumption

Economic growth and energy consumption could be jointly determined. This is because the growth of an economy is closely related to energy use and efficiency. First, higher energy usage is required in order to achieve higher output growth. Likewise, higher energy efficiency use also requires higher level of economic growth (Pao, Yu, & Yang, 2011).

Starting from the pioneering work by Kraft and Kraft (1978), many studies attempted empirical analysis to analyze the two variables using

Granger causality and cointegration approach. A detailed explanation on the review of this line of research is provided in Chapter 2.

1.2.2 Economic Growth and CO_2 Emission

This strand of research concentrates on the effect of economic growth on environmental degradation. Most of the works devote to testing the validity of the Environmental Kuznets Curve (hereafter EKC) hypothesis. This term is originated from the work by Kuznets (1955) whereby an inverted-U shape relationship is found between income and income inequality. This inverted-U shape relationship is then being introduced into the environmental economics literature and becomes the EKC hypothesis.

Regarding the reasoning behind this inverted-U shape curve, Panayotou (2003) suggests 3 reasons. He said that the turning point of EKC is due to the communities placing greater emphasis on cleaner environment. Second, when the industrialization of a country became advanced, service industry would be dominant and pollution will be reduced. When the country begins her industrialization, it gave rise to scale effect and pollution increases. When the country developed further, the country would switch to less-polluting industries and composition effect occurs. Lastly, technique effect would be observed when the country emphasized on green investment and advance technology which will produce less pollution. The diagram is shown in figure 2.1, Chapter 2.

Since the first attempt to test the EKC hypothesis by Grossman and Krueger (1991), a large number of literature emerged to test the validity of EKC on different countries. Early work by Friedl and Getzner (2003) intended to verify the functional form of the EKC (linear, quadratic, or cubic). Stern (2004) and Dinda (2004) provided extensive review on the early EKC works and pointed out potential problem in the analysis (refer to subsection 2.3.2).

Recent works such as Coondoo and Dinda (2008), Lee and Lee (2009) and Akbostanci, Turut-Asik, and Tunc (2009) examine the relationship between economic growth and CO_2 emission by using time series dynamics and causality approach. However, the results appear to be inconclusive. Detail on the evolution of this line of research is left for discussion of literature review in Chapter 2.

1.2.3 Linking Energy Consumption, Economic Growth, and CO_2 Emissions Together

Higher emission of CO_2 is always related to rapid economic development. It explains the reason why developed countries are liable and being pressured to reduce their GHG emission. If reduced GHG emission has negative impact on the economic growth, policy makers and countries leaders would most likely be reluctant to commit to the reduction target. In other words, leaders would not sacrifice economic growth in exchange for a better environment quality. This is true unless alternative is found to boost the economic growth and at the same time, reduce environmental degradation.

The role of energy consumption is important in affecting both economic growth and emission. First, economic growth and energy consumption are highly correlated (refer to literature review for detailed explanation) regardless of the direction of causality (unidirectional or bidirectional). Second, the direct combustion of energy such as fossil fuel, coal and the like is the main source of increasing GHG emission, especially the emission of CO_2. The energy is needed for the development of sectors such as transportation, manufacturing, electricity generation and others despite its contribution to global GHG emission.

From the above, the energy needed for development will eventually contribute to overall economic growth. Also at the same time, more energy used would lead to an increase in overall CO_2 emission. Summarizing the relationship, it can be concluded that more energy consumption leads to higher economic growth and more CO_2 emission.

Despite the implementation of Kyoto Protocol starting from 1997 to reduce global GHG and CO_2 emission, the results are below satisfaction level. One of the policies in the Kyoto Protocol to reduce emission is to reduce the consumption of energy. However, reducing energy consumption may eventually handicap the growth of a country, especially high income countries with high energy consumption. This urges the inclusion of new alternative in the policy to effectively reduce GHG emission and if possible, maintain sustainable economic development.

Most of the recent works categorized in this line of research is a multivariate analysis that combines the three variables. The original motivation is initiated by Ang (2007). Following them, various studies including Halicioglu (2009), Zhang and Cheng (2009), Soytas and Sari (2009), Apergis and Payne (2009) analyze this combined line of research for different countries. Due to different countries, time period, and time series methodology in the above studies, the results are varied (Huang, Hwang & Yang, 2008).

As economic growth and energy consumption may not be enough to explain the emission of CO_2, this study includes a new variable into this line of research, namely tourism. This is because tourism sector is able to contribute to economic growth of a country. Moreover, the emission of CO_2 from the use of automobiles in tourism industry should not be underestimated. Hence, the energy utilized in tourism industry is expected to affect the environment adversely. The following subsections outline the role of tourism in this relationship.

1.3 The Role of Tourism

1.3.1 Impact of tourism on economic growth

Previous works have found that tourism has positive effects on the country's economic growth. Those studies include Albalate and Bel (2010) and Holzner (2011) for the European Union (hereafter EU), Hall (1998) for the Eastern Europe, Falk (2010) for Austria, and Bernini (2009) for Italy.

Arcording to Choi and Sirakaya (2006) and Dwyer and Forsyth (2008), the tourists' visit and spending on the goods and services can create income, taxes, foreign currency, as well as job opportunities. This is consistent with Archer (1995) and West (1993) where they found that tourism is a significant source of foreign exchange earnings and a way to generate more income than export.

The study by Mihalic (2002) pointed out the benefits of using tourism as a growth strategy in contrast with international trade. Following this, it is reported that many countries have started to focus on developing tourism industry for the growth of economy (Sahli & Nowak, 2007).

Similarly, Lee and Chang (2008) also found that more tourism activities contribute to the growth of a particular sector, and also trigger the growth of entire economy at the same time. In brief, the literature discussed above showed that tourism has positive effect on output growth of an economy.

Despite the benefits of tourism on economic growth, some studies argued that tourism could have a negative impact on a country. Those impacts include adverse economic, socio-cultural, and environmental issue (Liu & Var, 1986; Long, Perdue, & Allen, 1990; and Milne, 1990). Adverse economic refers to the expenditure by foreign tourists on tertiary and nondurable goods may alter domestic consumption pattern. Other than that, there is additional cost incurred from the specialized field related to tourism such as communication, transportation, catering and hospitality. All the fields mentioned required various types of skilled labour, and hence, the country will need to invest more on human capital to meet the above demand (Sinclair, 1998).

The other case of social cost is on flora, fauna and other sociological and ecological factors. Those include pollution, congestion, and despoliation of fragile environment (Gursoy & Rutherford, 2004). Other than that, Dunn and Dunn (2002) also stressed on the cost for crime controlling, as well as maintaining public security. Therefore, whether tourism has positive or negative impact on an economy, it depends on the cost and benefit analysis which is beyond the scope of this study.

In term of the direction of causality, the tourism-led growth hypothesis (tourism Granger cause economic growth) is supported by Holzar (2010), Seetanah (2011), Tiwari (2011) and etc. On the other hand, Oh (2005) and Katircioglu (2009) found that economic growth Granger cause tourism which supported the growth-led tourism hypothesis. The neutrality hypothesis is found by Kim, Chen, and Jang (2006), and Ozturk and Ali (2009).

1.3.2 Tourism Reduces CO_2 Emission with New Policies and Improved Energy Efficiency

There are some arguments that tourism may have negative impact on the environment especially the emission from transport and travel. The emission is mainly from the combustion of fossil fuel used in the vehicles on the road as well as air planes (see Table 1.1). However, a study by the United Nations World Tourism Organization (UNWTO), United Nations Environment Program (UNEP), and the World Meteorological Organization (WMO) revealed that absolute reduction in emission in tourism could be achieved based on two mitigation scenarios (UNWTO-UNEP-WMO, 2008).

The two scenarios consist of higher energy efficiency (biofuel) and the changes in tourist patterns and policies which include transport modal shift, the choice of closer destinations, spending on goods and services with favorable eco-efficiency, and increase in the length of stay. The second scenario is highly dependent on the initiative within the industry, as well as incentive and regulatory from outside the sector (Scott, Peeters, & Gossling, 2010).

A report by International Energy Agency pointed out the potential of biofuels in reducing emission (IEA, 2012). The report also added that more than 50 countries and the EU have mandated or promoted biofuel blending to displace oil in domestic transport supply. The shift in transport modal refers to the reduction on the dependence on air travel as it generates most tourism related emission. The reduction of air travel does not indicate the reduction in total tourist trips, but choosing other alternative such as car, rail, and coach travel (Scott, Peeters, & Gossling, 2010).

Other than the IEA, Yin et al. (2015) also stressed the importance of biofuel and electricity in reducing carbon in transport sector. They explained that the transport sector is more difficult to decarbonize than any other sector. Furthermore, they noticed that passenger transport turnover reduction and modal shift is less sensitive to carbon price in China.

As the dominant contributor in tourism-related CO_2 emission is from the air transport (UNWTO-UNEP-WMO, 2008) (see Table 1.1), the International Air Transport Association (IATA) presented a worldwide commitment in 2009 in three ways: improving fuel efficiency, stabilizing net emission, and a reduction of 50% of emission by 2050.

Addressing the commitment by the AITA above, a sustainability report by Virgin Atlantic (2013), states that the airline company is moving towards a low carbon economy. Specifically, new aircrafts are replaced with less efficient aircrafts and the development of sustainable fuel such as biofuel. The report claimed that the airline was the first to conduct test flight with biofuel in 2008. In addition, their partnership with Lanza Tech to develop a new sustainable low carbon fuel is expected to increase energy efficiency and reduce the emission of CO_2. Other highlights in the report include higher load factor, air traffic management and etc.

With this direction of promoting low carbon economy (tourist patterns and policies), lower emissions technology implementation (biofuel), replacing old and inefficient aircrafts, better flight and load management and etc, Lee and Brahmasrene (2013) hypothesized that tourism could help to keep down CO_2 emission and at the same time boosting the economy by increasing the number of tourists. Their findings support their hypothesis for a panel of EU countries.

For energy consumption, enhanced energy efficiency and low emission technology implementation mentioned above should be able to cut down the consumption of fossil fuel, hence reduce the emission from the direct combustion of fossil fuel without affecting the economy's sustainable growth.

Table 1.1 Distribution of emissions from tourism by sector, 2005

Sector	CO_2 (Mt)	% of total
Air transport	515	40%
Car transport	420	32%
Other transport	45	3%
Accommodation	274	21%
Activities	48	4%
Total	1307	100%

Source: Modified from UNWTO-UNEP-WMO (2008).

1.4 The G-20 Major Economies

The G-20 consists of members from the G-8 (Japan, Russia, Germany, France, United Kingdom, Italy, United States, and Canada), BRICS (Brazil, Russia, India, China, and South Africa), OECD or Organization for Economic Cooperation and Development (Japan, Germany, France, United Kingdom, Italy, United States, Canada, South Korea, Turkey, Mexico, and Australia), EU (28 Europe countries), Argentina, Indonesia, and Saudi Arabia.

The formation of group was proposed by the former Prime Minister of Canada, Paul Martin and inaugurated in 1999. The countries in the group come from different economic classification (developing and advanced) and region (Asia, Europe, Africa, South and North America and etc.). All the G-20 countries are listed among the top 29 economies as measured in GDP at nominal price by the International Monetary Fund (IMF).

In the Pittsburgh summit in 2009, the G-20 leaders announced that the group will replace the G-8 as the main economic council of wealthy nations. Besides, the BRIC (Brazil, Russia, China, and India) are emerging economies in the G-20 that should not be underestimated. Sachs (2003) proposed that the BRIC economies would surpass the G-6 (United States, Japan, Germany, France, Italy, and the United Kingdom) in less than 40 years and become a larger force in the world economy. By 2025, the BRIC could account for over half of the size of the G-6. Along with the rapid development in economy, emission also rose steeply over the past decade.

Other than the BRIC, the EU also exhibited steady increase in CO_2 emission with 6% average growth rate for the period from 1990 to 2008 (Boden, Marland, & Andres, 2011). As a whole, the G-20 countries accounted 90% of the global economy, 66% of total population in the world, and also 84% of the world's total fossil fuel emissions.

Table 1.2 summarizes the data of G-20 countries in GDP, tourism receipts, CO_2 emission and energy use in 2010. From the data, only 9 countries recorded lower CO_2 emission than the world average in 2010. The 9 countries are Argentina, Brazil, India, Indonesia, Mexico, Croatia, Latvia, Lithuania, and Romania. Luxembourg is the top CO_2 emitter in the panel with 21.36 metric ton per capita in 2010 while India is the lowest with 1.66 metric ton per capita. As a whole, the G-20 countries' CO_2 emissions are almost double compared with the world average in 2010.

Turn to the grouping of countries, the BRIC, EU, G-8 and OECD all recorded higher CO_2 emission in 2010 compared to the world average. Their emissions are 5.55, 7.83, 10.35, and 9.72 metric ton per capita respectively compared to the world average of 4.9 metric ton per capita. It is noticeable that the BRIC which consists of only 4 countries are emitting more CO_2 than the world average. Within the BRIC, Russia alone contributes 12.22 metric ton per capita of CO_2 in 2010.

In term of economic growth, the G-20 countries' GDP per capita are 3 times of the world in 2010. For EU, G-8, and OECD, their GDP per capita are higher than the world. Only BRIC contributes roughly half of the world average GDP per capita. Despite the contribution of only half of the world average GDP per capita, the BRIC's CO_2 emission is higher than the world average. Though other groups' (EU, G-8 and OECD) GDP per capita are higher than the world average, there are still concerns on their "emission for development" patterns especially the G-8 which is the highest among the group.

Almost all the countries in the G-20 have high level of energy use measured in kg of oil equivalent. It is believed that the combustion of fossil fuel has direct linkage with increased CO_2 emission. Thus, several measures such as improving energy efficiency and development of renewable energy (such as biofuel) have become major discussion in Kyoto Protocol, IEA and etc.

Based on the information and data from table 1.2, there are few reasons why G-20 is chosen in this study. First, this group represents the world's wealthiest nations with mean GDP per capita of $22394. This figure is almost triple compared to world average. Second, the group consists of 43 countries if EU is counted separately. The 43 countries can be further divided to 4 different groups (BRIC, EU, OECD, and G-8). As the commitment of reducing CO_2 emission not only lies on developed countries, developing countries especially BRIC should be given attention because the problem of global warming is a global issue. The data in table 1.2 shows that BRIC emitted more CO_2 in 2010 than the world average although they are developing countries.

For the tourism indicator, tourism receipts per capita, the EU's performance is outstanding compared with others. From the consolidated mean for the EU in table 1.2, tourism receipts per capita for EU in 2010 accounted $1327. This figure is almost triple compared to OECD and G8. Despite this outstanding performance in tourism sector, the CO_2 emission per capita for EU was lower (7.82 metric ton) than the OECD (9.72 metric ton) and G8 (10.35 metric ton).

As pointed out by Lee and Brahmasrene (2013), the EU's tourism sector plays an important role in its economy and has negative impact on CO_2 emission. If this found to be true in this study, other countries (BRIC, G-8, and OECD) can put in extra effort to take EU as reference in tourism-related policy to reduce CO_2

emission without affecting the growth of economy, or if possible, boost economy at the same time.

Thus, from the above point of view, it is worth to analyze the G-20 countries as the group represents the world wealthiest nations.

Table 1.2 Summary statistics of the G-20 countries, 2010

Country	GDP[1]	Tourism receipts[2]	CO_2 emission[3]	Energy consumption[4]
Argentina	9133.00	139.42	4.47	1935.94
Australia	36202.84	1465.46	16.90	5552.25
Brazil	5618.32	31.65	2.15	1362.05
Canada	35277.26	537.03	14.62	7354.74
China	2869.09	37.49	6.19	1881.37
France*	33898.38	865.46	5.55	4015.87
Germany*	36127.04	600.73	9.11	4032.54
India	1034.24	11.74	1.66	600.30
Indonesia	1570.15	31.65	1.80	877.92
Italy*	29163.14	662.29	6.71	2814.63
Japan	36472.84	120.48	9.18	3915.96
Mexico	8117.35	107.28	3.76	1517.76
Russia	6385.66	92.97	12.22	4932.20
Saudi Arabia	15994.78	276.46	17.03	7043.84
South Africa	5794.23	206.19	9.20	2846.30
South Korea	20625.09	279.39	11.48	5058.96
Turkey	7833.52	343.56	4.13	1457.39
United	37899.31	654.33	7.92	3241.12

Kingdom*				
United States	43952.44	533.89	17.56	7162.35
European Union				
Austria	38803.23	2494.82	7.97	4079.75
Belgium	36742.01	1066.85	9.99	5588.69
Bulgaria	4378.87	535.55	5.93	2375.44
Croatia	10475.64	1868.57	4.72	1938.45
Cyprus	23156.53	2148.25	6.98	2213.09
Czech Republic	14112.90	762.08	10.62	4186.64
Denmark	46379.66	1028.17	8.34	3480.25
Estonia	10369.83	1053.60	13.68	4154.52
Finland	38064.65	840.89	11.53	6792.27
Greece	21310.18	1112.44	7.66	2442.21
Hungary	10926.46	633.79	5.05	2566.70
Ireland	46214.95	1829.76	8.93	3177.94
Latvia	6923.88	430.10	3.40	2074.18
Lithuania	8320.17	333.75	4.12	2145.53
Luxembourg	80276.01	8087.53	21.36	8324.24
Malta	15992.43	3021.67	6.22	2038.59
Netherland	41110.24	1124.86	10.95	5020.99
Poland	10035.85	261.52	8.30	2659.21
Portugal	18535.13	1219.19	4.92	2213.02
Romania	5233.16	76.07	3.67	1634.05
Slovakia	14161.79	430.01	6.64	3283.10
Slovenia	19054.25	1328.23	7.48	3529.42
Spain	25595.99	1281.54	5.85	2772.86
Sweden	42825.66	1419.89	5.59	5471.79
Consolidated				
Mean (G-19+EU)	22394.60	962.47	8.17	3529.45

Mean (BRIC)	3976.82	43.46	5.55	2193.98
Mean (EU)	25931.69	1327.56	7.82	3509.53
Mean (OECD)	29597.20	560.90	9.72	4193.05
Mean (G-8)	32397.00	508.39	10.35	4683.67
World average	7519.10	161.82	4.90	1880.60

[1]GDP per capita (constant 2005 U.S.$) [2]Tourism receipts per capita (current U.S.$) [3]$CO_2$ emission per capita (metric ton) [4]Energy consumption per capita (kg of oil equivalent)
[*]France, Germany, Italy and United Kingdom are also members of the EU. Thus, G-20 consists of 43 countries if EU is counted separately. All data are retrieved from the World Development Indicator, World Bank. The means of the groups are own estimations.

1.5 Problem Statement

The problem of global warming is getting severe and needs to be solved or at least relieved because it will lead to a change in climate and an increase in overall temperature. If the current trend continues, the melting of ice in the North and South Pole will eventually lead to a great increase in global sea level. Other serious threats may occur as mentioned under research background.

Most of the literature on CO_2 emission and economic growth were based on the EKC hypothesis. The hypothesis proposed an inverted-U shape relationship between pollution and economic growth. Starting from the pioneering work by Grossman and Krueger (1991), many literatures tried to find evidence to support the hypothesis. As a result, different functional forms were identified. Particularly:

i. Linear relationship by Shafik and Bandyopadhyay (1992), Shafik (1994), and Azomahou, Laisney, and Phu (2006);
ii. Inverted-U relationship by Roberts and Grimes (1997), Cole, Rayner, and Bates (1997), Schmalensee, Stoker, and Judson (1998) and Galeotti and Lanza (1999);
iii. Cubic or N-shape relationship by Grossman and Krueger (1995) and Friedl and Getzner (2003).

As this line of literature develops with improved time series and econometric methods, the EKC hypothesis is supported even with energy consumption as additional variable (Ang, 2007; Jalil & Mahmud, 2009; Nasir & Rehman, 2011). In term of causality, different countries showed different direction of causality. For example, energy consumption Granger causes GDP in France (Ang, 2007); GDP Granger causes CO_2 emission in China (Jalil & Mahmud, 2009) and Pakistan (Nasir & Rehman, 2011); energy consumption Granger causes CO_2 emission (Zhang & Cheng, 2009).

Other than this, bidirectional causality is found between energy consumption and CO_2 emission (Apergis & Payne, 2009) and between energy consumption and GDP (Apergis & Payne, 2010). The findings above suggest that reducing CO_2 emission requires the reduction of energy consumption which may eventually reduce the growth of an economy as well. Thus, achieving sustainable economic growth and reducing CO_2 emission at the same time could be two opposing goals.

The above shortcoming of the existing EKC framework urges for further research on this line of studies. From table 1.2, the EU's tourism sector outperforms other countries in this panel while their CO_2 emission is still below than those in the OECD and G8 countries. It must have been due to the significant effort in EU's energy-tourism related policy such as the implementation of biofuel and better energy management in tourism sector. The way energy is used in the EU could possibly account for the relatively low CO_2 emission compared to other G-20 countries. Since the tourism receipt and CO_2 emission in the G-20 outperform the world average, if such tourism-related energy efficient policies were implemented in G-20 as well, CO_2 emission in this region could be reduced. In view of this, there is a need to examine if efficient use of energy in the tourism sector could have a bearing on emission abatement. This study tends to fill the gap by exploring this energy-tourism induced EKC framework for the entire G-20 countries instead of EU. Hence, it is plausible to introduce the role of tourism into the EKC framework to address the above shortcoming.

A recent work by Lee and Brahmasrene (2013) included tourism in determining the relationship between economic growth and CO_2 emission. However, their study did not consider the EKC hypothesis, particularly the inverted-U shape relationship between economic growth and CO_2 emission. Furthermore, they included foreign direct investment (FDI) as additional variable based on their hypothesis in which FDI varies with economic growth but negatively related with CO_2 emission. They found that tourism is positively affecting economic growth and negatively affecting CO_2 emission. This finding further supports the hypothesis that increased tourism may not necessarily lead to more CO_2 emission. This could help in reducing CO_2 emission without sacrificing economic growth.

Up to date, this study is the first attempt to include tourism in exploring the relationship between economic growth, energy consumption, and CO_2 emission within the EKC framework. Based on the above point of arguments, it is plausible to hypothesize that increased tourism does not necessary lead to increased CO_2 emissions. It can even help to reduce CO_2 emissions and boost the economy at the same time.

1.6 Research Objectives

The purpose of this study is to examine the relationship between the three variables, namely economic growth, CO_2 emission, energy consumption together with tourism as additional variable for a panel of G-20 countries. There are three objectives to address the purpose.

i. To examine the relationship between economic growth and CO_2 emission underlying the EKC hypothesis with energy consumption as additional variable.
ii. To determine the role of tourism by introducing it into the EKC framework above.
iii. To determine the direction of causality between the variables (long run and/or short run) and provide relevant policy recommendation.

1.7 Significance of the Study

1.7.1 Contribution to Existing EKC Framework

Up to date, this study is the first attempt to include tourism in exploring the relationship between economic growth, energy consumption, and CO_2 emission within the EKC framework. As discussed in 1.5 Problem Statement, early attempts in 1990s on the EKC mainly concentrated in the functional form relating economic growth and pollutants. As a result, different functional forms were identified.

The discussion in the Problem Statement also revealed that even with energy consumption as additional variable, those recent studies failed to provide conclusive results. This suggests that economic growth and energy consumption might not be adequate to explain the CO_2 emission pattern in the real world. This urges the modification on the existing EKC framework either with new variable or new econometrics technique.

Based on the explanation and argument in subsection 1.3, this study introduces tourism into the existing EKC framework. The inclusion of tourism indicator into the framework might be useful to better understanding the CO_2 emission pattern in the G-20 countries.

1.7.2 Contribution of Public Policies

The results from this study are ought to be useful for policy making for the G-20 countries especially on the matter of reducing CO_2 emission. From the Research Background, the ideal situation is when sustainable economic growth could be achieved and, preferably lowering the CO_2 emission at the same time.

If tourism is found to be consistent with the proposed hypothesis as discussed in subsection 1.3, it is recommended for the G-20 countries to further promote the tourism industry. Since the performance of the EU is outstanding in term of its tourism receipts among the group of panel (table 1.2), other countries in the panel especially the BRIC can refer to EU's tourism related policy.

1.8 Conclusion

The concern on global warming has reached a critical stage. The emissions of CO_2 have been identified as the main source that contributes to global warming. Most developed and developing countries are being pressured to reduce their emissions of CO_2.

Some recent work as mentioned above ruled out the possibility of the role of tourism in reducing emissions of CO_2. With the direction of promoting low carbon economy (tourist patterns and policies), lower emissions technology implementation (biofuel), replacing old and inefficient aircrafts, better flight and load management and etc, the hypothesis is supported empirically by the work of Lee and Brahmasrene (2013) for the panel of EU.

The purpose of this study is to examine the relationship for economic growth, energy consumption, CO_2 emission and tourism for a panel of G-20 countries. There has not been a time series analysis for the energy-pollution-growth nexus with tourism as additional variable. Furthermore, the examination of the role of tourism in the energy-pollution-growth nexus using cointegration and Granger causality test is also a new attempt in this line of research.

The result from this study is able to tell whether tourism is applicable to reduce CO_2 emission and promote economic growth at the same time. This is ought to be useful to make legislative responses and policy recommendation to current environmental issue in the G-20 countries.

1.9 Organization of Chapters

The remainder of the study is organized as follow: Chapter 2 is the review of previous literatures which includes the historical development of the energy-growth nexus, growth-pollution nexus, combination of both nexus, and the role of tourism in economic development and emissions. Chapter 3 has a discussion on the data and methodology used in this study. Chapter 4 presents and discusses the findings from the hypothesis testing. Chapter 5 is the conclusion which includes limitation and recommendation for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Early literatures on the relationship between economic growth, energy and emission were divided into two lines. The two lines consisted of pollution-growth nexus and energy-growth nexus. The pollution-growth nexus relied on the EKC hypothesis to find out the relationship between pollution and economic growth. The energy-growth nexus aimed to find out the relationship between energy consumption and economic growth. The energy-growth nexus believed that higher energy consumption results in higher economic growth.

The energy-growth nexus aimed to find out the relationship between energy consumption and economic growth. Starting from the early empirical work in the 1990s, many literatures were attempted to test for the validity of the EKC. As a result, different kind of functional forms were found. This inconsistency gained the attention from the researchers to review and critic on the previous works. Even though the EKC framework improved with recent econometric time series econometric approach, the results varied due to the different time period and region in the analysis.

For the energy-growth nexus, the earliest empirical work could be dated back to the late 1970s, but similar with the EKC framework, the findings were not consistent. This could be due to spurious regression of a bivariate model resulted from omitted variables bias. Another reason could be the difference in term of development, energy use, and emission pattern possessed by different countries. If this is true, then it explains the inconsistent results from different countries.

Lastly, the literatures on the relationship between tourism, economic growth, and CO_2 emissions are reviewed and discussed.

2.2 Energy-Growth Nexus

This nexus aimed to find out the relationship between energy consumption and economic growth. The initial motivation of conducting this line of research was the oil crisis in 1973. This crisis started by the reduction of crude oil production by the Organization of Petroleum Exporting Countries (OPEC). The consequence of this reduction was the severe negative impact on the economic activities all around the world, especially oil dependent countries. This had lead to the interest of conserving energy, development of alternative energy sources and the increase of efficiency in energy consumption (Soytas & Sari, 2006). Early empirical mostly based on this idea in determining the relationship between economic growth and energy consumption (energy conserving policy).

Another reason behind this line of research was the Kyoto Protocol which came into play in 1997, with the objective to solve global warming. One of the main policies in this protocol was to reduce energy consumption. However, if the economic growth is determined by the energy consumption, then achieving sustainable economic growth and reducing GHG emission may be two conflicting goals. Empirical work in the late 90s and 2000 onwards mostly consider the issue of global warming in the study.

Huang, Hwang, and Yang (2008) pointed that if the benefit in economic growth is more than the cost of environmental damage, then it is reasonable to increase energy use to promote economic growth. Otherwise, if energy consumption does not increase or even negatively impacts economic growth, then an energy conserving measures is necessary to avoid negative impacts on the economic growth.

This line of research can dated back to the late 1970s. Starting with the pioneering work by Kraft and Kraft (1978), the following subsections provide a detail review of previous literatures across time.

2.2.1 Overview of Early Energy-Growth Nexus Empirical Work (1970s and 1980s)

The pioneering work on this line of research was the work by Kraft and Kraft (1978). Using U.S. data from 1947-1974, they found that GNP leads to energy use. Following this, Akarca and Long (1979) used monthly data from 1973-1979 in the U.S. and employed a different proxy for economic growth, employment. They found that energy use leads to employment. There was inconsistency in the two studies.

In the 1980s, Akarca and Long (1980), Erol and Yu (1987a), Yu and Choi (1985), and Yu and Hwang (1984) failed to find any relationship between energy consumption and economic growth. Erol and Yu (1987b), and Yu, Choi, and Choi (1988) advanced to validate the neutrality hypothesis and no causal relationship was found between the two variables.

Huang, Hwang, and Yang (2008) commented on the above discrepancy in results. They explained the main reason came from the use of different econometric method. Specifically, the OLS estimation of the log-linear without the consideration of the time series properties may result in spurious regression. Therefore, previous results were biased and misleading.

2.2.2 Development of the Energy-Growth Nexus in 1990s

The relationship between energy consumption and economic growth was revisited with improved time series econometric method. Yu and Jin (1992) employed the Engle-Granger (EG) approach and found that energy consumption and economic growth are not cointegrated in the long run. This result supports the neutrality hypothesis as in Erol and Yu (1987b) and Yu, Choi, and Choi (1988).

Masih and Masih (1996, 1997) adopted the Johansen conintegration test for Pakistan, India, Malaysia, Indonesia, Singapore, Taiwan, Philippines, and South Korea from 1955-1990. The results showed no cointegration for Malaysia, Singapore and Philippines. The other countries showed that both energy use and real GDP are cointegrated. From the causality test derived from the Vector Error Correction Model (VECM) or Vector Autoregressive Model (VAR), the results varied across countries. First, they found that energy consumption leads to economic growth in India. This result was the exact opposition with the finding in Indonesia. Bidirectional causality was identified in Pakistan, Taiwan and South Korea.

Cheng and Lai (1997) used the Engle-Granger cointegration test by using data of Taiwan from 1955-1993. They discovered a unidirectional causality from GDP to energy consumption. This is inconsistent with Masih and Masih (1997) in the above paragraph.

Glasure and Lee (1997) continued to fill in the literature gap for South Korea and Philippines. Using cointegration approach and error correction model, they found bidirectional causality for both countries. Without consider the cointegration between variables, they discovered no causality in South Korea and a unidirectional causality from energy consumption to GDP in Philippines. This reflects the importance of the cointegration issue in contributing to the inconsistent results.

2.2.3 Literature of Energy-Growth Nexus in 21st Century

To reduce the problem of the omission variable of bias, some recent literatures started to add relevant variables in the model. Asafu-Adjaye (2000) included the price factor to represent the price of energy in the study involving four Asian countries. By using Johansen cointegration and the Granger causality test, the findings showed bidirectional causality in Thailand and Philippines. Also, India and Indonesia showed one-way causality running from energy use to GDP.

Hondroyiannis, Lolos, and Papapetrou (2002) used a multivariate model which consisted of energy consumption, real GDP and price to fill in the literature gap of this nexus. They used Johansen cointegration and ECM to test for causal relationship in Greece from 1960-1996. The results for the three variables are neutral. This finding of neutrality was supported by the work of Altinay and Karagol (2004) which studied the causality between energy consumption and GDP in Turkey from 1950-2000.

Soytas and Sari (2003) used the cointegration and VECM approach to test for the causality between GDP and energy consumption from 1950-1992 in the top ten emerging countries and the G-7 countries. They identified bidirectional causal relationship in Argentina, one-way causality from energy consumption to GDP in Turkey, France, West Germany and Japan, and the causality from GDP to energy consumption in Italy and Korea. The result in Korea showed a conflicting causality with Masih and Masih (1996, 1997).

Oh and Lee (2004a) included capital and labor in their analysis in South Korea from 1981-2004. They used the VECM to examine the short run and long run relationship and found no short run relationship, but GDP Granger caused energy consumption in the long run. Oh and Lee (2004b) used the same technique in the same country, but different time period from 1970-1999. From the results, they found short run causality from energy use to GDP and long run bidirectional causality. Similar study from Paul and Bhattacharya (2004), which also included capital and labor, resulted in the same findings where bidirectional causality was identified.

Lee (2006) investigated the energy-growth nexus for eleven industrialized countries from 1960-2001 by using the Toda-Yamamoto (TY) approach. The findings revealed different causality across countries. First, no causality was identified between energy consumption and GDP in U.K., Germany, and Sweden. Second, bidirectional causality was found in U.S. Third, a one-way causality was identified from energy consumption to GDP in Canada, Belgium, Netherland, and Switzerland. Lastly, France, Italy, Japan indicated a unidirectional causal relationship running from GDP to energy consumption. The causality in Italy matched with the findings of Soytas and Sari (2003), but not for Japan and France.

From the panel analysis by Lee and Chang (2007) which included 18 developing countries and 22 developed countries, they found a one-way causality from GDP to energy use in developing countries. For developed countries, they identified bidirectional causality between the two variables. The result in developing countries was contradicted with Lee (2005), in which a one-way causality was found running from energy consumption to GDP.

A recent study by Saidi and Hammani (2015) examined the effect of energy consumption on economic growth and CO_2 emission. By using simultaneous equation model with a panel of 58 countries over the period 2990 to 2012, they found that energy consumption resulted in more economic growth and also CO_2 emission. Thus, this study would like to seek for possible alternative to reduce emission without sacrificing economic growth.

2.2.4 Summary on the Energy-Growth Nexus

The past results from this line of research failed to draw convincing conclusion. The causality tests on the same country (Korea, France and Japan) were different. Huang, Hwang, and Yang (2008) reviewed that this problem might be arising from the different time period and different methodologies in the studies. They added that most of the studies used data from thirty to forty years span. So there might be inadequate number of observation in the data. As many past literatures depended on the unit root test and Johansen cointegration test, the dataset of thirty to forty year may lead to low statistical testing power. Therefore, they concluded that inconsistencies of results from the past are reasonable.

Due to the inconsistency above, researchers extended this line of research to include more variables in order to avoid the problem of omitted variables bias. The most common variable added was CO_2 emission. It was believed that more economic growth required more energy, and this led to more CO_2 emission. This gave rise to the born of the pollution-energy-growth nexus which will be discussed in subsection 2.4.

Table 2.1 Summary of energy-growth causality results

Author (year)	Findings
Kraft and Kraft (1978)	GNP $\longrightarrow$ energy consumption
Akarca and Long (1979)	Energy consumption $\longrightarrow$ employment
Akarca and Long (1980)	Neutral
Erol and Yu (1987a)	
Yu and Choi (1985)	
Yu and Hwang (1984)	
Erol and Yu (1987b)	
Yu, Choi, and Choi (1988)	
Yu and Jin (1992)	
Hondroyiannis, Lolos, and Papapetrou (2002)	
Altinay and Karagol (2004)	

Masih and Masih (1996, 1997)	Mixed
Cheng and Lai (1997)	GDP → energy consumption
Glasure and Lee (1997)	GDP ↔ energy consumption
Asafu-Adjaye (2000)	Mixed
Soytas and Sari (2003)	Varied across countries
Lee (2006)	Different causality across countries
Lee and Chang (2007)	GDP → energy consumption (developing countries) GDP ↔ energy consumption (developed countries)
Oh and Lee (2004a)	GDP → energy consumption
Oh and Lee (2004b)	Energy consumption → GDP
Paul and Bhattacharya (2004)	Energy consumption ↔ GDP
Saidi and Hammani (2015)	Energy consumption → GDP, CO_2

Note: → indicates unidirectional causality without feedback
↔ indicates bidirectional causality

2.3 Pollution-Growth Nexus

2.3.1 Environmental Kuznets Curve (EKC)

This line of research mainly concentrates on testing the validity of EKC. The EKC hypothesis, named after Simon Kuznets, was developed from the original work by Kuznets (1955) where he found an inverted-U shape curve for inequality in income distribution and income. The EKC hypothesis proposed that when the income of a country increases, the emission of GHGs also increases. However, once the country reaches a certain level of income, the country will emit fewer pollutants as the country develops further. In other words, this suggests that damage to the environment is unavoidable in the initial stage of development of a country. Also, it indicates economic growth is a solution to pollution.

For the inversion in pollution, Panayotou (2003) suggests 3 reasons. He said that the turning point of EKC is due to the communities placing greater emphasis on cleaner environment. Second, when the industrialization of a country became more advance, service industry would dominant and pollution will be reduced. Third point he said that when the country begins industrialization, it gave rise to scale effect and pollution increases. When the country developed further, the country would switch to less-polluting industries and composition effect occurs. Lastly, technique effect would be observed when the country emphasized on green investment and advance technology which will produce less pollution. The three effects are illustrated in figure 2.1 below.

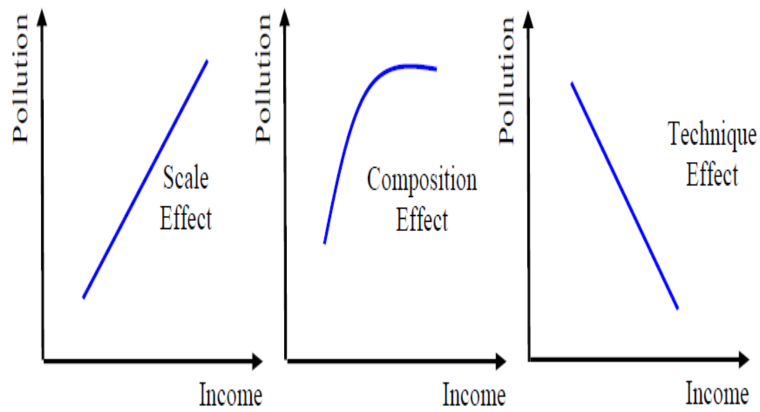

Figure 2.1 Scale effect, composition effect and technique effect
(Source: Panayotou, 2003)

The first empirical study on the EKC hypothesis was done by Grossman and Krueger (1991). Ever since then, many literatures followed their path on testing the economic growth and environmental pollution nexus. The earlier studies mainly using traditional pollutants for testing the validity of the EKC. Those include Panayotou (1993), Selden and Song (1994), Shafik (1994), Holtz-Eakin and Selden (1995), Stern, Common, and Barbier (1996), Roberts and Grimes (1997), Kaufmann, Davidsdottir, Garnham, and Pauly (1998) and etc. However, the estimated turning points for those pollutants were from as low as \$3137 (Panayotou, 1993) to \$101166 (Stern & Common, 2001).

As CO_2 is the major contributor behind global warming, many literatures started using CO_2 instead of traditional pollutants mentioned above as the pollution indicator. A linear relationship was found by Shafik and Bandyopadhyay (1992), Shafik (1994), and Azomahou, Laisney and Phu (2006). Roberts and Grimes (1997), Cole, Rayner, and Bates (1997), Schmalensee, Stoker, and Judson (1998), Galeotti and Lanza (1999) found an inverted-U shaped relationship in consistent with the EKC hypothesis. Other than linear and inverted-U shape relationship, some previous studies also found the cubic or N-shape relationship (Shafik, 1994; Grossman & Krueger, 1995; Friedl & Getzner, 2003). The summary is illustrated in Table 2.2.

The above contradictions have gained attention from some researchers to review the EKC framework. First, Stern, Common and Barbier (1996) pointed out that it is inappropriate to estimate a single equation model by assuming the existence of a unidirectional causality from economic growth to pollution. Also, Stern (2004) managed to categorize the econometric critiques of the EKC framework into four categories. Each category is elaborated in the following subsection.

Table 2.2 Functional form of EKC identified by early empirical works

Author (year)	Research Findings
Shafik and Bandyopadhyay (1992)	Linear EKC
Shafik (1994)	
Azomahou, Laisney, and Phu (2006)	
Roberts and Grimes (1997)	Inverted-U shape EKC
Cole, Rayner, and Bates (1997)	
Schmalensee, Stoker, and Judson (1998)	
Galeotti and Lanza (1999)	
Shafik (1994)	Cubic or N-shape EKC
Grossman and Krueger (1995)	
Friedl and Getzner (2003)	

2.3.2 Econometric critiques on the EKC

a) Heteroskedasticity

Stern, Common, and Barbier (1996) argued the problem of heteroskedasticity might arise in the previous EKC studies. They added that in the presence of heteroskedasticity, ordinary least square (OLS) estimation is inefficient, even it is unbiased. They suggested testing the residuals for potential heteroskedasticity problem and using Generalized Least Square (GLS) approach to get efficient estimation, if heteroskedasticity problem is detected. The literatures reviewed by them were all Ordinary Least Square (OLS) based without results from heteroskedasticity test reported.

b) Simultaneity

The EKC hypothesis assumes only a unidirectional causality from economic growth to pollution without feedback. In fact, economic growth and pollution could be jointly determined. It is inappropriate to estimate single equation relationship by OLS when simultaneity exists. This could lead to biased and inconsistent estimates.

c) Omitted variable bias

Stern and Common (2001) concluded that EKC is an inappropriate model which may suffer from omitted variable bias. By using Hausman test and serial correlation, they found that the regressors are likely to be correlated with omitted variables and the regression coefficients are biased. This also indicates misspecification either in term of omitted variables or missing dynamics. Magnani (2001) used the Ramsey test, which is an alternative to test for model misspecification, to test on cross sectional EKC and resulted in similar finding with Stern and Common (2001).

d) Cointegration issue

Perman and Stern (2003) stated that appropriate method of inference depend on whether the data are integrated or not, especially in panel and time series data. They added that if stochastic trend presents in the data, the t and F statistic as well as the R squared could be biased and lead to spurious regression. Overall, they concluded that empirical work on the EKC using time series and panel data should consider the time properties in the data. This could be done by using unit root test and cointegration test. Also, dynamic model should be preferred over previous static model to capture the time effect in the data.

2.3.3 Past Studies Modifications of EKC

With the improvement of time series econometric technique and the critiques from the past, recent studies on the EKC started using cointegration and causality approach to test for the validity of the EKC. Fodha and Zaghdoud (2010) investigated the relationship between economic growth and emission in Tunisia during the period 1961-2004. They found that CO_2 emission and SO_2 (Sulfur Dioxide) are cointegrated with economic growth in the long run. They managed to identify the inverted-U shape curve for SO_2 but not CO_2. They found a monotonically increasing relationship is more suitable for CO_2. From the causality test, they concluded that economic growth caused emission of CO_2 to increase without feedback, in both short run and long run.

Ghosh (2010) examined the CO_2 and economic growth nexus for India for the time span of 1971-2006. Based on the multivariate framework which included additional variables such as energy supply, investment, and employment, the results showed no long run equilibrium relationship between CO_2 emission and economic growth. In other word, both variables are not cointegrated and hence, no long term causality between the two variables. This study only identified short run bidirectional causality between economic growth and CO_2 emission. This indicated the reduction of emission of CO_2 may reduce economic growth in the short run.

Saboori, Sulaiman, and Mohd (2012) tested the EKC framework in Malaysia using cointegration and Granger Causality test from 1980-2009. Based on the Autoregressive Distributed Lag (ARDL) model, they found that CO_2 emission and economic growth are conintegrated in the long run. They also managed to identify the inverted-U shape relationship as in the

EKC hypothesis. From the Granger Causality tested using the Vector Error Correction Model (VECM), they found unidirectional causality from economic growth to CO_2 emission in the long run, and not in the short run.

Jaunky (2010) carried out a panel study on the EKC for 36 high income countries over the period of 1980-2005. The result revealed that both CO_2 emission and economic growth are cointegrated. From the VECM based Granger Causality test, a unidirectional causality (not vice versa) was detected, running from economic growth to CO_2 emission, both in the short run and long run. At individual level, the EKC hypothesis only holds for 7 out of 36 countries.

A recent study by Robalino-Lopez, Mena-Nieto, Garcia-Ramos, and Golpe (2015) used the existing data together with projection data ranging from the year 1980 to 2025 to study the EKC hypothesis in Venezuela. They found that Venezuela did not fulfill the EKC hypothesis. The summary is provided in table 2.3.

Table 2.3 Recent EKC framework

Author (year)	Time period	Country	Findings
Fodha and Zaghdoud (2010)	1961-2004	Tunisia	GDP → CO_2
Ghosh (2010)	1971-2006	India	CO_2 ↔ GDP
Jaunky (2010)	1980-2005	36 high income countries (panel)	GDP → CO_2
Saboori, Sulaiman, and Mohd (2012)	1980-2009	Malaysia	GDP → CO_2
Robalino-Lopez et al. (2015)	1980-2025	Venezuela	No EKC

Note: → indicates unidirectional causality without feedback
↔ indicates bidirectional causality

2.3.4 Summary on the pollution-growth nexus

From the three time series studies (Tunisia, India, and Malaysia) and two panel studies, the contradiction suggests that each country may have different pattern in the economic growth and CO_2 emission. This indicates the general EKC hypothesis may not be applicable in all countries. Thus, individual countries analysis tends to bring the studies closer to the dynamic (Lindmark, 2002). Dinda (2004) also mentioned that EKC is a long run phenomenon because it depicts the development trajectory for a single country that has different stages of development over time.

For the mixed and conflicting results of the recent EKC studies, Jaunky (2010) suggested the definition of the variables, countries studied, the time period, and also the methodologies used have large influence on the results.

2.4 Pollution-Energy-Growth Nexus

2.4.1 The Emergence of Pollution-Energy-Growth Nexus

This line of research is the evolution from the past two nexus namely, pollution-growth nexus and the energy-growth nexus. The results from the two nexus were similar in term of inconsistencies even on a same country. This indicates that the relationships among the variables are not simple. Furthermore, previous bivariate analysis in both nexus may suffer from omitted variables bias. This leads to the emergence of this line of research, which aims to combine the two nexus in a multivariate analysis.

Another reason behind this nexus is the implementation of the Kyoto Protocol. One of the policies in the Kyoto Protocol to reduce the emission of GHG is the conservation of energy. However, applying energy conservation policy may have negative impact on the economic growth. If this relationship holds, then policy makers are less likely to sacrifice economic growth for lesser emission.

Therefore, by identifying the relationship between energy consumption, economic growth, and CO_2 emission, effective policy on growth, energy, and pollution can be provided. This is the reasoning and objective for this nexus. Following subsection provide detail explanation on the past empirical works divided into individual country and panel analysis.

2.4.2 Individual Country Analysis

Ang (2007) analyzed this line of research using data from 1960-2000 in France. By using ARDL and VECM approach, the findings was consistent with the EKC hypothesis, where an inverted-U shape curve was identified between emission and economic growth. The results from the causality test showed energy consumption leads GDP. This indicated the difficulty in applying energy conservation policy to reduce emission as it may harm the economy.

Using Johansen cointegration and VECM approach, Ang (2008) examined the relationship between economic development, emission, and energy consumption in Malaysia for the period of 1971-1999. The results showed that the variables are cointegrated and GDP Granger cause energy consumption in the short run and long run.

Halicioglu (2009) included an additional variable, namely foreign trade into the study of Turkey from 1960-2005.This study employed the same method as in Ang (2007) and found two bidirectional causalities between CO_2 emission and energy consumption, and between CO_2 and income.

Jalil and Mahmud (2009) also included foreign trade in their analysis for China from 1975-2005. Similarly, using ARDL bound test and VECM as in Ang (2007), they found that the variables are cointegrated in the long run and observed an inverted-U shape relationship supported the EKC hypothesis. This evidence on the validity of EKC hypothesis is in line with a recent study by Yin, Zheng, and Chen (2015). In term of causality, they identified one-way causality from GDP to CO_2 emission.

The study in China by Zhang and Cheng (2009) showed contradiction with Jalil and Mahmud (2009). By using Toda-Yamamoto procedure on the data from 1960-2007, they found two unidirectional causalities. The first causality was running from GDP to energy consumption and the second, from energy consumption to CO_2 emission.

Soytas and Sari (2009) analyzed five OPEC countries with an additional variable of total employment for the period of 1971-2002. The 5 OPEC countries are Saudi Arabia, Algeria, Nigeria, Indonesia, and Venezuela. Using ARDL cointegration approach, they found that the variables are cointegrated in the long run, but for Saudi Arabia only. In other word, there is no cointegration between income and energy in Algeria, Indonesia, Nigeria and Venezuela. For the causality test, the results were mixed across countries. This indicated different country needs to adopt different policy to reduce emission.

Menyah and Wolde-Rufael (2010) included labor and capital into the model to test the relationship between energy use, emission and growth in South Africa for the period of 1965-2006. The result from ARDL bound test indicated the short run and long run cointegration among the variables. The Granger causality test showed 3 unidirectional causal relationships from CO_2 to GDP, energy use to GDP, and lastly energy use to CO_2 emission. The causalities revealed that energy conservation policy might help to reduce emission, but at the same time, might handicap the economy in South Africa. They suggested developing alternative energy to coal and oil as a solution to reduce emission.

Acaravci and Ozturk (2010) applied ARDL on nineteen Europe countries for the period of 1960-2005. They found that most countries did not exhibit the EKC shape of relationship between income and emission. In term of causality, the results varied across countries.

Another study which included foreign trade as additional variable was the work by Nasir and Rehman (2011). They aimed to test the EKC in Pakistan from 1972-2008. The finding from the Johansen cointegration confirmed the existence of the EKC in the long run. From the VECM based causality, the results showed two unidirectional causalities from GDP to energy use and from GDP to CO_2 emission.

Pao, Yu, and Yang (2011) used the data from 1990-2007 in Russia and applied Johansen cointegration followed by ECM approach to examine the relationship between CO_2 emission, energy use, and economic growth. They managed to find cointegration among the variables, but the EKC hypothesis was not supported with the identification of negative impact of output on emission. They also concluded that output, energy use, and emission are jointly determined in the long run from the finding of strong bidirectional causality between the variables.

Most recent study in this line of research is on Malaysia by Begum, Sohag, Abdullah, and Jaafar (2015). By adding a new variable namely population, they found that the EKC hypothesis is not valid in Malaysia by using data from 1980 to 2009. Their study also suggested the transformation of low carbon economy especially the concept of renewable energy and enhancing energy efficiency could help to reduce emission and achieve sustainable economic growth.

From the reviews above, it is obvious that different country may have different relationship among the economic growth, energy use and CO_2 emission. Even with the aid of recently developed econometric time series method, the results were still not conclusive. Next, there were some attempts using panel data with the motivation of including more observation in the data. Following subsection review a few panel analyses in this line of research.

2.4.3 Panel Data Analysis

Apergis and Payne (2009) used the panel data from six Central America countries for the period of 1971-2004. By using Pedroni cointegration and panel VECM, they found evidence of long run cointegration among the variables and supported the EKC hypothesis. From the short run dynamics, they identified bidirectional causal relationship between energy use and GDP. Also, they found two unidirectional causalities flowing from energy use to CO_2 emission and from GDP to CO_2 emission. In the long run, bidirectional causality existed between energy consumption and CO_2 emission. Apergis and Payne (2010) found similar findings by using eleven independent states from the Commonwealth from 1992-2004.

Lean and Smyth (2010) examined the relationship between CO_2 emission, energy consumption, and economic growth using panel data from five ASEAN countries from 1980-2006. Instead of Pedroni cointegration, this study used the Johansen Fisher panel cointegration test and VECM. The results showed long run cointegration among the variables and the relationship between economic growth and CO_2 emission followed the EKC hypothesis. From the panel Granger causality test, short run causality was confirmed running from CO_2 emission to energy consumption. In the long run, energy consumption and CO_2 emission lead to GDP.

Pao and Tsai (2010) used BRIC countries which included Brazil, Russia, India and China in their study for the period of 1971-2005. Using panel cointegration and panel VECM causality approach, they found consistent result with the EKC hypothesis. The short run dynamics showed that GDP are determined by energy use and CO_2 emission. In the long run, bidirectional causality was confirmed between energy use and CO_2 emission, and also between energy use and GDP.

Wang, Zhou, Zhou, and Wang (2011) carried out the analysis of this energy-growth-emission nexus in China using panel data consisted of 28 provinces from 1995-2007. They used the Pedroni cointegration test for panel data and panel Granger causality derived from the ECM. The results showed cointegration among the variables in the long run. The Granger causality test confirmed two bidirectional causalities between CO_2

emission and energy consumption, and another between energy consumption and GDP.

It is noticeable from the above, the results from a few panel studies reviewed varied across countries and period used. Different from individual country analysis, the methodologies in the panel studies above were mostly similar. Most of the studies adopted panel conintegration (Pedroni or Johansen and Fisher, or both), panel VECM and Granger causality test. But due to the different time period and countries used in the studies, the findings were not consistent.

2.4.4 Comparison of Panel Data Analysis and Individual Country Analysis

Lean and Smyth (2010) justified their reason for using panel data analysis. Panel cointegration and Granger causality test has the advantage of including more data, more variability, more degree of freedom and more efficient estimation. They added that in most individual country analysis, the unit root test and cointegration with thirty to forty years of observation might result in spurious findings.

On the other hand, the assumption of homogenous relationship across countries in the panel analysis might not be true in practice. This homogenous assumption might not be true due to several reasons, such as economic structure, income and demographic difference possessed by different countries (Athukorala and Sen, 2002). Chandran and Tang (2013) commented on this assumption and stated that the panel analysis ignored the complexity and dynamism of a country by focusing on only one perspective. They suggested an economic model should be dynamic to capture the effect of the development of a country over time. They supported their argument with Maddala, Trost, Li, and Joutz (1997), which justified that panel estimation with the existence of heterogeneous problem might not be accurate.

The use of individual country analysis using time series data was emphasized especially in the pollution-growth or EKC framework. The argument came from Stern, Common, and Barbier (1996), which stated that the best way to analyze the relationship between economic growth and environmental impact is was to examine the historical development of individual countries. The validity of this argument might be true as recent results from literatures showed different direction of causality among the variables, namely economic growth, energy use and emission of CO_2 in different countries.

In short, the selection of panel or individual country analysis is up to the researchers' preferences. Both types of analysis have its own advantages as well as limitations. In this study, panel data analysis is used because this approach can include more observations to provide better result according to Lean and Smyth (2010). Furthermore, due to the data availability especially for tourism indicator which starts from 1995, individual country analysis is not suitable and appropriate for this study.

Table 2.4 Recent pollution-energy-growth studies

Author (year)	Time period	Country	Findings
Individual Country Analysis			
Ang (2007)	1960-2000	France	Energy use → GDP
Ang (2008)	1971-1999	Malaysia	GDP → energy use
Halicioglu (2009)	1960-2005	Turkey	CO_2 ↔ energy use CO_2 ↔ income.
Jalil and Mahmud(2009)	1975-2005	China	GDP → CO_2
Zhang and Cheng (2009)	1960-2007	China	GDP → energy use Energy use → CO_2
Soytas and Sari (2009)	1971-2002	Five OPEC countries	Mixed
Nasir and Rehman (2011).	1972-2008	Pakistan	GDP → energy use GDP → CO_2

Begum et al. (2015)	1980-2009	Malaysia	No EKC
Yin, Zheng, and Chen (2015)	1999-2011	China	EKC supported
<u>Panel Analysis</u>			
Apergis and Payne (2009)	1971-2004	Six Central America	Energy use ⟷ CO_2
Apergis and Payne (2010)	1992-2004	Eleven independent states from the Commonwealth	Energy use ⟷ GDP
Lean and Smyth (2010)	1980-2006	Five ASEAN countries	CO_2 ⟶ energy use CO_2 ⟶ GDP
Pao and Tsai (2010)	1971-2005	BRIC countries	Bidirectional causality between the variables

Note: ⟶ indicates unidirectional causality
⟷ indicates bidirectional causality

2.5 Summary of Pollution-Energy-Growth Nexus

This line of research was divided into two categories, individual country and panel analysis. From the individual country studies, contradictions of findings were found across countries. This suggests that country varies in term of emission, development, and also energy use. This is supported by Acaravci and Ozturk (2010), which used nineteen Europe countries in their analysis and resulted in different direction of causalities across countries. Some countries reported no relationship at all.

From another side, the panel analysis aimed to increase the number observations in the data to provide convincing results. Even the methodologies used in most literatures were similar (Pedroni or Johansen cointegration, VECM, and Granger causality test), the results also varied due to different region and time period included in the data.

In this study, other than the VECM Granger causality test, 2 methods are chosen to enhance the robustness of result. This is to detect inconsistency of results due to the methodology used. The 2 methods are panel Dynamic Ordinary Least Square (DOLS) and Panel Generalized Methods of Moments (GMM). Comparing to previous literatures, GMM is rarely used in this line of research. Therefore, the result from GMM is complemented and compared with DOLS to yield a better result.

2.6 The Role of Tourism

2.6.1 The Linkage between Tourism and Economic Growth

According to Choi and Sirakaya (2006) and Dwyer and Forsyth (2008), tourism has become an important sector in economies worldwide because tourism can generate income, taxes, and employment. Bramwell and Lane (1993) stated the contribution of tourism to economic progress when it develops within its natural structure for the regeneration and sustain productivity of natural resources.

Many previous studies concluded that tourism has positive effect on economic growth. Particularly, Albalate and Bel (2010), Holzner (2011) for EU; Hall (1998) for Eastern Europe; Falk (2010) for Austria; Dritsakis (2004a, b) for Greece; Bernini (2009) for Italy; and Blackstock, White, McCrum, Scott, and Hunter (2008) for United Kingdom. They proposed a tourism-led economic growth policy which assumes tourism to be a significant sector in the growth of overall economy in the long run.

The work by Mihalic (2002) proposed a few benefits of promoting tourism as a policy to achieve sustainable growth compared with export. Following this, Sahli and Nowak (2007) also found that more and more countries started to focus on tourism development to achieve economic growth.

Other than the above contribution, tourism is also a major contribution of foreign exchange earnings and export revenue (Archer, 1995; West, 1993). Overall, it is reported that tourism not only stimulates the growth of the sector, but also leads to economic growth of a country (Lee & Chang, 2008).

Despite the benefits of tourism on economic growth, some literatures argued that tourism could have a negative impact on a country. Those impacts include adverse economic, socio-cultural, and environmental issue (Liu & Var, 1986; Long, Perdue, & Allen, 1990; and Milne, 1990). Adverse economic refers to the expenditure by foreign tourists on tertiary and nondurable goods may alter domestic consumption pattern. Other than that, there is additional cost incurred from the specialized field related to tourism such as communication, transportation, catering and hospitality. All the fields mentioned required various types of skilled labour, and hence, the country will need to invest more on human capital to meet the above demand (Sinclair, 1998).

The other case of social cost is on flora, fauna and other sociological and ecological factors. Those include pollution, congestion, and despoliation of fragile environment (Gursoy & Rutherford, 2004). Other than that, Dunn and Dunn (2002) also stressed on the cost for crime controlling, as well as maintaining public security. Therefore, whether tourism has positive or negative impact on an economy, it depends on the cost and benefit analysis which is beyond the scope of this study.

In term of the direction of causality, the findings from this line of research can be divided into four hypotheses: The tourism-led growth hypothesis, the growth-led tourism hypothesis, the bidirectional or the feedback hypothesis, and the neutrality hypothesis. The tourism-led growth hypothesis (tourism Granger causes economic growth) is supported by Holzar (2010), Seetanah (2011), and Tiwari (2011) among others. On the other hand, Oh (2005) and Katircioglu (2009) found that economic growth Granger causes tourism which supported the growth-led tourism hypothesis. Durbarry (2004) and Tang (2011) found that the bidirectional causality exists between tourism and economic growth. This suggests the existence of feedback effect between the two variables. The neutrality hypothesis is found by Kim, Chen, and Jang (2006), and Ozturk and Ali (2009).

2.6.2 The Relationship between Tourism and CO_2 Emission

Zaman, Khan and Ahmad (2011) found that tourism leads to an increase in CO_2 emissions in Pakistan by using data from 1991 to 2010.

The cointegration test revealed that CO_2 emission has long-run effect on tourism development. The study also identified unidirectional causality running from tourism to CO_2 emissions.

Another study by Nademi and Najibi (2011) included 11 developed countries (Austria, Belgium, Canada, Chile, Denmark, France, Ireland, Japan, Korea Rep., Sweden and United States) from 2000 to 2007 to find out the relationship between CO_2 emission and international tourism. Their results indicated that the effect of CO_2 emission on international tourism is significantly negative.

A recent study on Cyprus by Katircioglu, Feridun, and Kilinc (2013) applied ARDL and ECM approach on data from 1970 to 2009. Their findings showed that tourism indicator (tourist arrivals) is a catalyst for energy consumption and CO_2 emission in the long run. Their results are contradicted with Lee and Brahmasrene (2013) for a panel of EU countries in which tourism is found to be negatively affecting CO_2 emissions.

The study by Lee and Brahmasrene (2013) analyzed the relationship between economic growth, tourism, CO_2 emission and FDI for EU countries. Their study did not consider the inverted-U shape relationship as in the EKC hypothesis. Also, they analyzed FDI instead of energy consumption which is not a common variable in this line of research. Hence, this study introduces the role of tourism into the EKC framework. Besides, energy consumption is also included in this study which is believed to have significant impact on CO_2 emission, economic growth as well as tourism.

2.6.3 Relating Tourism and CO_2 Emission to Energy Consumption

As mentioned in subsection 1.3.2, tourism will most likely increase CO_2 emission due to the vehicles and transportation used to transfer tourists from one destination to another. The emission is mainly from the fuel and energy used in the land and air vehicles (table 1.1).

However, absolute reduction in tourism related emission could be achieved by higher energy efficiency in tourism sector and changes in tourists' pattern and policy (UNWTO-UNEP-WMO, 2008). The changes in tourists' pattern and policy include reduction on the dependence on air travel as it generates most tourism related emission. Other than that, it also includes the choice of closer destinations, increase in the length of stay and spending on goods and services with favorable eco-efficiency. This pattern and policy is highly dependable on the initiative, incentive and regulatory within and outside the industry (Scott, Peeters, & Gossling, 2010).

For energy efficiency especially in tourism industry, biofuel is a potential form of energy in the future which help to reduce CO_2 emission based on a report by International Energy Association (IEA, 2012). The report also added that more than 50 countries and the EU have mandated or promoted biofuel blending to displace oil in domestic transport supply.

As the dominant contributor in tourism-related CO_2 emission is from the air transport (UNWTO-UNEP-WMO, 2008) (see Table 1.1), the International Air Transport Association (IATA) presented a worldwide commitment in 2009 in three ways: improving fuel efficiency, stabilizing net emission, and a reduction of 50% of emission by 2050.

Addressing the commitment by the AITA above, a sustainability report by Virgin Atlantic (2013), states that the airline company is moving towards a low carbon economy. Specifically, new aircrafts are replaced with less efficient aircrafts and the development of sustainable fuel such as biofuel. The report claimed that the airline was the first to conduct test flight with biofuel in 2008. In addition, their partnership with Lanza Tech to develop a new sustainable low carbon fuel is expected to increase energy efficiency and reduce the emission of CO_2. Other highlights in the report include higher load factor, air traffic management and etc.

With this direction of promoting low carbon economy (tourist patterns and policies), lower emissions technology implementation (biofuel), replacing old and inefficient aircrafts, better flight and load management and the like, Lee and Brahmasrene (2013) hypothesized that tourism could help to keep down CO_2 emission and at the same time boost the economy by increasing the number of tourists. Their findings support their hypothesis for a panel of EU countries.

Therefore, the interaction between energy consumption and tourism might play a significant role in the relationship between CO_2 emission and economic growth. To examine this hypothesis, an interaction term is added into the model. The purpose of the interaction term is to find out the extent in which the way energy is used in tourism sector can affect the CO_2 emission. In other word, the multiplicative effect between energy consumption and tourism may have significant impact on CO_2 emission.

2.7 Conclusion

The above review of literature is divided into three main categories. First, it is the pollution-growth nexus, followed by energy-growth nexus. Then the combination of the two nexus results in pollution-energy-growth nexus. Finally, the role of tourism in the nexus from previous literatures is also presented.

The pollution-growth nexus is basically based on the EKC hypothesis. From the early empirical that tested on the functional form and the validity of the EKC hypothesis, different functional forms were found and the issue of econometric problem was raised. Even the EKC framework changed to a newer econometric time series techniques, which is the dynamic model or the cointegration and VECM based causality test, the results also inconclusive. This might due to the difference in country and time period used in the analysis as discussed above.

Similarly for the energy-growth nexus, the findings were inconsistent. Starting from the early empirical work in the 1970s, to the development of the nexus with additional variables such as foreign trade in a multivariate framework, various causalities were identified as well. Again, the time period and the country used in the analysis play an important role in the contradiction of findings. The similar problem with the pollution-growth nexus urged the combination of the two nexus.

The combination of the two nexus aimed to address the issue of omitted variables bias. From the individual country and panel analysis in this line of research, the results indicate the possibility of the argument from Stern, Common, and Barbier (1996) which said that individual country analysis is more suitable because different countries might have different pattern of development and emission. This argument is the best explanation to the contradiction of results from the above.

As the above lines of research provided inconclusive results, this study includes tourism as additional variable into the analysis. Even some study showed that tourism leads to increased CO_2 emissions, the findings by Lee and Brahmasrene (2013) revealed that this is not necessary for EU countries. Due to the reliability of result from large sample in Lee and

Brahmasrene (2013), this study takes an advance step ahead to include tourism as additional variable in the energy-pollution-growth nexus to examine the cointegration relationship, the EKC hypothesis, as well as the direction causality between the variables. This approach of using the variables mentioned for the G-20 countries is a new attempt in this line of research.

Besides, an interaction term is added in this study. The interaction term measures the multiplicative effect between energy consumption and tourism. As in subsection 2.6.3, energy efficiency may help to reduce CO_2 emission and at the same time, maintain sustainable economic growth. If this hypothesis is true, it is possible to achieve the ideal situation where economic growth is achieved with lower CO_2 emission.

The following chapter describes the data and methodology used in this study. The source of data, the reason of adopting the selected method, and the procedure in carrying out the econometric approach are explained in detail in the next chapter.

CHAPTER 3

DATA AND METHODOLOGY

3.1 Theoretical Framework

From the EKC hypothesis, it is plausible to formulate the following relationship:

$$CO_2 = f\,(GDP, GDP^2)$$
$$\qquad\qquad + \qquad -$$

According to the hypothesis, as a country develops in the early stage, CO_2 emission increases. However, when the country develops further, CO_2 emission will reach a peak point. After the peak point, CO_2 emission will decrease due to the advancement of the country from manufacturing industry to service industry (Panayotou, 2003). Thus, the function of CO_2 emission postulates an inverted-U shape represented by the positive sign of GDP and negative sign of GDP^2.

A few studies such as Friedl and Getzner (2003) extended the quadratic relationship into a cubic analysis by including the GDP^3 to test for the N-shape relationship (refer to table 2.2). This line of research sooner evolved into a multivariate study to avoid the problem of omitted variable bias (Lean & Symth, 2010). The most common variable added into this line of research is the energy consumption. Thus, the EKC hypothesis is extended into the following relationship:

$$CO_2 = f\,(GDP,\ GDP^2,\ EC)$$

$$+ \quad - \quad +$$

As discussed in chapter 2, under subsection 2.4, the analysis of the relationship between CO_2 emission and GDP is improved with energy consumption as additional variable. Other than using additional variable, the analysis is also integrated with improved time series econometrics approach. Most of the literature started to adopt the concept of unit root, cointegration, and causality in both individual and panel analysis. However, the results are not consistent in comparison among the literatures (refer to subsection 2.4 for detail explanation). Furthermore, policy recommendation from this line of research might be complicated as energy consumption is affecting both economic growth and CO_2 emission at the same time.

As economic growth and energy consumption may not be enough to explain the emission of CO_2 in practice, several variables were introduced and included such as foreign trade (Jalil & Mahmud, 2009; Nasir & Rehman, 2011; Halicioglu, 2009), employment and investment (Ghosh, 2010). These studies are difficult to be concluded as one and compare because they adopt different variables in their studies.

A recent work by Lee and Brahmasrene (2013) included tourism in investigating the relationship between economic growth and CO_2 emission. However, their study did not consider the EKC hypothesis, particularly the inverted-U shape relationship between economic growth and CO_2 emission. Furthermore, they included FDI as additional variable based on their hypothesis in which FDI changes with GDP and inversely related with CO_2 emission. They found that tourism is significantly affecting economic growth and CO_2 emission.

Up to date, this study is the first attempt to include tourism in exploring the relationship between economic growth, energy consumption, and CO_2 emission within the EKC framework. Based on the above point of arguments under research background, it is plausible to hypothesize that increased tourism does not necessary lead to increased CO_2 emissions. It can even help to reduce CO_2 emissions and boost the economy at the same time. The hypothesis is shown below:

$$CO_2 = f\,(GDP,\ GDP^2,\ EC,\ T)$$

$$\qquad\qquad +\qquad -\qquad +\quad -/+$$

3.2 Data and Model Specification

To test for the long run relationship among CO_2 emission, tourism, economic growth, and energy consumption, a panel econometric regression is specified as follow:

$$C_{it} = \beta_{0i} + \beta_{1i} E_{it} + \beta_{2i} Y_{it} + \beta_{3i} Y^2_{it} + \varepsilon_{it} \quad (1)$$

$$C_{it} = \beta_{4i} + \beta_{5i} E_{it} + \beta_{6i} Y_{it} + \beta_{7i} Y^2_{it} + \beta_{8i} T_{it} + \varepsilon_{it} \quad (2)$$

where i= 1,…,N denotes the country and t= 1,…t denotes the time period. C is CO_2 emission (measured in metric tons per capita), E is energy consumption (measured in kg of oil equivalent per capita), Y and Y^2 are GDP and GDP squared (measured in constant 2005 U.S.$ per capita), T is the indicator for tourism (measured in international tourism receipts per capita in current U.S.$) and ε_t is the regression error term. β_0, β_1, until β_8 are parameters to be estimated. All variables in Eq. (1) and (2) are in natural logarithm form for econometric analysis. The data is collected for all G20 countries from 1995 to 2010. The data is retrieved from the World Development Indicators (WDI), World Bank.

However, Argentina, Saudi Arabia, and Ireland consist of incomplete data set. To maintain the stability of the panel data and for the sake of balanced estimation, the 3 countries are omitted from this study. Thus, a total of 40 countries are included in this study. As pointed out by Lean and Smyth (2010), panel estimation has the advantage of including more observation, more variability, more degree of freedom, and more efficient estimation.

Eq. (1) is the common EKC framework with energy consumption as additional variable. Eq. (2) is the new attempt to introduce tourism indicator into the EKC framework. The purpose of this separate estimation is to examine the common EKC hypothesis and the effect of tourism in this nexus.

To better investigate the role of tourism, specifically the multiplicative effect between energy consumption and tourism, eq. (2) is modified as follow to examine whether the interaction or the multiplicative effect has significant influence on the model. This also triggers the possibility of the role energy efficiency in reducing CO_2 emission and maintaining economic growth at the same time. In other word, how energy is used in tourism sector might have significant impact on the model. The expression can be represented as follow:

$$C_{it} = \beta_{9i} + \beta_{10i} E_{it} + \beta_{11i} Y_{it} + \beta_{12i} Y^2_{it} + \beta_{13i} T_{it} + \beta_{14i} EXT_{it} + \varepsilon_{it} \qquad (3)$$

From Eq. (3), if β_{14} is positive and significant, tourism and energy consumption are complements in CO_2 emission. If β_{14} is negative and significant, tourism and energy consumption are substitutes in CO_2 emission. If β_{14} is insignificant, this implies the two variables are independent to each other in CO_2 emission. [1]

[1]See Compton and Giedeman (2011) for more on the interaction effects.

The variables of CO_2 emission, tourism, energy consumption and GDP are based on the population (per capita). This follows the recent trend in literatures because it is believed that variables measured in per capita is more appropriate than the total. Also, to promote consistency, all data are from a single source, which is the WDI, World Bank. This is because different data from different sources may have different measurements on the data, even for the same variable.

The World Bank serves as an important source of secondary data for research especially for economic studies. It is widely used by previous literatures in this line of research. Therefore, the results from this study should be able to be used to compare with previous findings.

From Eq. (1), it is expected that β_1 has positive sign as higher energy consumption leads to increase in GDP and CO_2 emission. As proposed by the EKC hypothesis, β_2 should be positive whereas β_3 should be negative. Based on the finding by Lee and Brahmasrene (2013), β_4 should be negative. If all the variables are of expected sign, then the validity of the EKC hypothesis is proven where there is an inverted-U shape curve for income and CO_2 emission. Other than that, the sign of tourism implies the possibility to reduce CO_2 emission without sacrificing the economic growth.

Due to the availability of data especially on tourism which starts from the mid 1990s, this study employs panel time series analysis to yield a more accurate result. Previous study suggests that panel analysis is more appropriate if compared to individual time series analysis for a short span of data (Al-Iriani, 2006).

All tests and models in this study are conducted by using Eviews 8.0.

3.3 Panel Unit Root Test

Spurious regression is a potential and common problem especially in time series analysis. The solution is to test for the stationarity of the data and make the data stationary by differencing if they are not. Therefore, in most of the time series and panel analysis, the empirical analysis always starts with the testing of unit root of the variables.

In this study, three panel unit root tests are used to enhance the robustness of result. The three tests are Levin, Lin, and Chu (LLC) developed by Levin, Lin, and Chu (2002), Im, Pesaran and Shin (IPS) proposed by Im, Pesaran, and Shin (2003), and Fisher-ADF by Maddala and Wu (1999). The null hypothesis for all three tests is the existence of unit root (the variables are non-stationary), while the alternative hypothesis for the three tests is that there is no unit root in the series (the variables are stationary).

The LLC test has the following basic ADF specification:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X'_{it}\delta + \varepsilon_{it} \qquad (4)$$

where $\alpha = p - 1$, but allow the lag order for the difference terms, p_i to vary across cross-section. The test derives estimates of α from proxies for Δy_{it} and y_{it} which are standardized and free of autocorrelations and deterministic components.

The estimation begins with two additional equations, regressing both Δy_{it} and y_{it-1} on the lag term Δy_{it-j} (for j=1,…,p_i) and the exogenous variable X_{it}. The coefficient from these two estimations are denoted as $(\hat{\beta}, \hat{\delta})$ and $(\dot{\beta}, \dot{\delta})$. $\Delta \bar{y}_{it}$ is defined by taking Δy_{it} and removing the autocorrelations and deterministic components using the first set of estimations:

$$\Delta \bar{y}_{it} = \Delta y_{it} - \sum_{j=1}^{p_i} \hat{\beta}_{ij} \Delta y_{it-j} - X'_{it}\hat{\delta} \qquad (5)$$

Likewise, $\bar{y}_{it-1}$ is defined using second set of coefficients:

$$\bar{y}_{it-1} = y_{it} - \sum_{j=1}^{p_i} \dot{\beta}_{ij} \Delta y_{it-j} - X'_{it}\dot{\delta} \qquad (6)$$

Next, the proxies are obtained by standardizing both $\Delta \bar{y}_{it}$ and $\bar{y}_{it-1}$, dividing by the standard error from equation (4). Lastly, an estimate of α can be obtained from the pooled proxy equation:

$$\Delta \tilde{y}_{it} = \alpha \tilde{y}_{it-1} + \varphi_{it} \qquad (7)$$

Levin, Lin, and Chu (2002) showed that under the null, a modified t-statistic for the resulting $\hat{\alpha}$ is asymptotically normally distributed:

$$t_{\alpha}{}^{*} = \frac{t_{\alpha} - (N\tilde{T})S_{N}\hat{\sigma}^{-2}se(\widehat{\alpha})\mu_{m\tilde{T}}{}^{*}}{\sigma_{m\tilde{T}}{}^{*}} \rightarrow N(0,1) \qquad (8)$$

Where t_{α} is the standard t-statistic for $\hat{\alpha} = 0$, $\hat{\sigma}^2$ is the estimated variance of the error term φ, $se(\widehat{\alpha})$ is the standard error for $\hat{\alpha}$, and:

$$\tilde{T} = T - (\textstyle\sum_i p_i/N) - 1 \qquad (9)$$

The average standard deviation ratio, S_N is the mean of the ratios of the long run standard deviation to the innovation standard deviation for each individual. The estimation is based on kernel technique. $\mu_{m\tilde{T}}{}^{*}$ and $\sigma_{m\tilde{T}}{}^{*}$ are the adjustment for the mean and standard deviation.

Unlike LLC test, the IPS test combines individual unit root test to derive a panel based result. This characteristic is the same for Fisher-ADF test. The IPS test begins with the ADF regression for each cross section which is similar with equation (4). After estimating the separate ADF regressions, the average t-statistic for α_i, from the individual ADF regression, $t_{iT_i}(p_i)$:

$$\bar{t}_{NT} = (\textstyle\sum_{i=1}^{N} t_{iT_i}(p_i))/N \qquad (10)$$

is then modified to desired test statistics. Under the circumstance where the lag order is equal to zero$(p_i = 0 \text{ for all } i)$, Im, Pesaran, and Shin (2003) provided simulated critical values for $\bar{t}_{NT}$ for different number of cross sections N, series length T, and for models with intercept, or intercept and linear trend.

For common case where the lag order in equation (4) could be non-zero for some cross sections, Im, Pesaran, and Shin (2003) showed that a properly standardized $\bar{t}_{NT}$ has an asymptotic standard normal distribution as follow:

$$W_{\bar{t}_{NT}} = \frac{\sqrt{N}\left[\bar{t}_{NT} - N^{-1}\sum_{i=1}^{N} E\left(\bar{t}_{iT}\left(p_i\right)\right)\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} Var\left(\bar{t}_{iT}\left(p_i\right)\right)}} \rightarrow N(0,1) \qquad (11)$$

Maddala and Wu (1999) proposed a panel unit root test based on Fisher (1932). The Fisher ADF test combines the p-values of the test statistics for a unit root in each residual cross sectional unit. This non-parametric test has a chi-square distribution with 2N degree of freedom, where N is the number of cross sectional units. This test has the advantage over the test proposed by Im, Pesaran, and Shin (2003) that it does not depend on different lag length in the individual ADF tests. With Monte Carlo simulations, Maddala and Wu (1999) showed that their test is more superior to Im, Pesaran, and Shin (2003). The test statistic can be derived as follow:

$$\lambda = -2\sum_{i=1}^{N} \log_e \pi_i \qquad (12)$$

where π_i is the p-value of the test statistic for unit i.

3.4 Panel Cointegration

From the panel unit root tests above, if the variables are integrated at the same order, then the existence of cointegration or long run relationship can be examined by using Pedroni (1999; 2004) and Kao (1999) tests. Both tests are based on the Engle-Granger (1987) cointegration test which examines the residuals of a spurious regression performed using I (1) variables. From the test, the variables are said to be cointegrated if the residuals are I (0). Otherwise, the residuals will be I (1).

Based on the test proposed by Engle-Granger (1987), Pedroni (1999, 2004) and Kao (1999) extended the framework to test for cointegration involving panel data. In total, the Pedroni test provides seven statistics to test the null hypothesis of no cointegration in the heterogeneous panel. The tests are divided to either falling within the dimensions (panel tests) or between dimensions (group tests).

The within dimensions tests pool the autoregressive coefficient across different countries in the panel. The between dimensions tests are less restrictive that allow for heterogeneity of the parameter across countries. Specifically, Pedroni test considers the following regression:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{2i,t} + \cdots + \beta_{Mi} x_{Mi,t} + \varepsilon_{i,t} \qquad (13)$$

for t=1, …, T; i=1,…, N; m=1,…, M; where y and x are assumed to be I (1). The parameter α_i and δ_i are individual and trend effects which may be set as zero if needed.

Under the null hypothesis of no cointegration, the residuals, $\varepsilon_{i,t}$ will be I (1). The residuals are obtained from equation (11) and tested whether the residuals are I (1) by running the following regression:

$$\varepsilon_{it} = p_i \varepsilon_{it-1} + \mu_{it} \quad (14)$$

or

$$\varepsilon_{it} = p_i \varepsilon_{it-1} + \sum_{j=1}^{p_i} \varphi_{ij} \Delta\varepsilon_{it-j} + v_{it} \quad (15)$$

for each cross section. The Kao test follows the basic approach as the Pedroni tests, but it specifies cross section specific intercepts and homogeneous coefficients on the first-stage regressors.

3.5 Panel Dynamic Ordinary Least Square (DOLS)

Given the existence of cointegration among the variables, a panel version of Dynamic Ordinary Least Square (DOLS) is used to estimate eq. (1), eq. (2) and eq. (3). This panel version of DOLS involves augmenting the panel cointegration regression equation with cross section specific lags and leads to eliminate the endogenity and serial correlation, which is different from another alternative known as the Fully Modified Ordinary Least Square (FMOLS).

The DOLS was first introduced by Saikkonen (1992) and Stock and Watson (1993). Kao and Chiang (2000) extended the DOLS estimator to panel data set known as the pooled DOLS. In the work of Kao and Chiang (2000), they used Monte Carlo simulations to compare OLS, FMOLS and DOLS estimators. They concluded that DOLS outperforms the other two estimators for both homogeneous and heterogeneous panels. They added that the role of leads and lags helps to reduce the bias of DOLS. Hence, they summarized that DOLS estimator is more promising than OLS and FMOLS in estimating cointegrated panel regression.

Kao and Chiang (2000) described the pooled DOLS estimator in which OLS is used to estimate an augmented cointegrating regression:

$$y_{it} = \beta X_{it} + \sum_{j=-q_i}^{r_i} \Delta X_{it+j}\delta_i + \mu_{it} \qquad (16)$$

Where y_{it} and X_{it} are the data purged of the individual deterministic trends. Note that the short run dynamics coefficients δ_i are allowed to be cross section specific. Let Z_{it} be the regressors formed by interacting the ΔX_{it+j} terms with cross section dummy variables, and let $W_{it}' = (X_{it}', Z_{it}')'$, then the pooled DOLS estimator can be written as follow:

$$\binom{\beta_{DP}}{\gamma_{DP}} = \left(\sum_{i=1}^{N}\sum_{t=1}^{T} W_{it}W_{it}'\right)^{-1}\left(\sum_{i=1}^{N}\sum_{t=1}^{T} W_{it}y_{it}'\right) \qquad (17)$$

3.6 Generalized Method of Moments (GMM)

This study further adopts the approach of panel GMM to estimate eq. (1) to eq. (3) to compare with the results from DOLS above and enhance the robustness of results. Eq. (3) is transformed into the following dynamic panel model with added interaction term compared to eq. (2) according to Arellano and Bond (1991):

$$\Delta C_{i,t} = \alpha + \beta_1 \Delta Y_{i,t} + \beta_2 \Delta Y^2{}_{i,t} + \beta_3 \Delta E_{i,t} + \beta_4 \Delta T_{i,t} + \beta_5 \Delta EXT_{i,t} + \tau_t + \varphi_i + \varepsilon_{i,t} \quad (18)$$

Where i and t are panel transformation represent time period and cross sectional unit respectively; α is a parameter reflecting the speed of convergence; τ_t is a period-specific effect for all the countries; φ_i captures the unobserved country-specific effect, and $\varepsilon_{i,t}$ is the white noise disturbance term.

Equation 18 then can be simplified as follow:

$$C_{i,t} - C_{i,t-1} = -\alpha C_{i,t-1} + \beta X_{i,t} + \tau_t + \varphi_i + \varepsilon_{i,t} \quad (19)$$

Where $C_{i,t} - C_{i,t-1} = \Delta C_{i,t}$; $X_{i,t}$ is a set of independent variables consist of GDP, GDP^2, energy consumption, tourism, and the interaction term with associated parameter, β.

From Arellano and Bond (1991), a strong autoregressive property exists in the residual. To deal with this problem, this effect can be taken into consideration by assuming that $\mu_{it} = \rho\mu_{it-1} + \varepsilon_{it}$, where $|\rho| < 1$, ε_{it} is a white noise disturbance term. After rearrangement, equation (19) becomes:

$$C_{i,t} = (1-\alpha+\rho)C_{i,t} - \rho(1-\alpha)C_{i,t-2} + X_{i,t}\beta - \rho X_{i,t-1}\beta + \tau_t - \rho\tau_{t-1} + (1-\rho)\varphi_i + \varepsilon_{it} \qquad (20)$$

The country specific effect can be eliminated by using first difference transformation. From equation (20), the lagged difference in the dependent variable may result in endogeneity of the independent variables, X. A number of studies have neglected the consistency problem from the simultaneous presence of the country specific effect and the lagged dependent variable or any regressor that are correlated with this country specific effect. This would be the case if equation (19) is estimated using fixed or random effect models.

Blundell and Bond (1998) argued that the persistence in the explanatory variables may have impact on the asymptotic properties of the differenced estimator. Hence, an estimator in level is added to solve this problem.

To deal with this econometric problem, they proposed the use of instrumental variables. The first step is to remove the period specific effect, τ_t, by subtracting its cross average in period, t, from each variable. Then, the equation is modified into first difference to get rid of the individual effect. The equation is as follow:

$$\Delta C_{it} = (1-\alpha+\rho)\Delta C_{it-1} + \rho(1-\alpha)\Delta C_{it-2} + \Delta X_{it}\beta + \rho\Delta X_{it-1}\beta + \Delta\varepsilon_{it} \qquad (21)$$

Arellano and Bond (1991) proposed regressing equation (19) by using GMM in lagged level of endogenous variables as instruments. By doing this, the disturbance term is not serially correlated and the levels of the explanatory variables are weakly exogenous. In other word, they are not correlated with future error term.

Next, the following moment conditions are used to estimate the difference estimator:

$$E[C_{it-s}(\varepsilon_{it} - \varepsilon_{it-1})] = 0 \qquad for\ s \geq 2, t = 3, \dots, T \qquad (22)$$

$$E[X_{it-s}(\varepsilon_{it} - \varepsilon_{it-1})] = 0 \qquad for\ s \geq 2, t = 3, \dots, T \qquad (23)$$

The above moment conditions have two important properties. First, the residual is serially uncorrelated. Next, correlation may exist between the levels of explanatory variables and the country's specific residual, but correlation does not exist between difference in the explanatory variables and the residual. The results yield the stationarity properties. Due to this, the GMM does not require the testing on the unit roots. The above explains the difference between GMM and DOLS.

The additional moment conditions for the estimation in levels can be shown as follow:

$$E[(C_{it-s} - C_{it-s-1})(\varphi_i + \varepsilon_{it})] = 0 \quad for\ s = 1 \qquad (24)$$

$$E[(X_{it-s} - X_{it-s-1})(\varphi_i + \varepsilon_{it})] = 0 \quad for\ s = 1 \qquad (25)$$

Summarizing from the above, the GMM estimator can be done by estimating the moment conditions from equation (22) to (25).

3.7 Panel Granger Causality

The existence of a cointegration relationship among the variables from the Pedroni and Kao tests indicates the variables have an error correction representation, with an Error Correction Term (ECT) incorporated into the model (Engle & Granger, 1987). Hence, a vector error correction model (VECM) is formed to reintroduce the information lost in the differencing process. The VECM allows for long run equilibrium as well as short run dynamics (Jayaraman, Choong, & Kumar, 2011).

VAR and VECM are common approaches to examine the Granger causality among variables. If the variables are found to be I (1) with no cointegration, a VAR in first order can be conducted. If the variables are cointegrated, then the VECM is applied.

For time series data with short sample (as in this study), panel analysis has the advantage of containing more observations by pooling the data across section, leading to higher power for the Granger causality test (Pao & Tsai, 2010). The unrestricted VECM can be derived as follow:

$$\Delta C_t = \beta_1 + \sum_{i=1}^{p} \delta_{1i}\, \Delta C_{t-i} + \sum_{i=1}^{p} \emptyset_{1i} \Delta\, E_{t-i} + \sum_{i=1}^{p} \omega_{1i} \Delta y_{t-i} + \sum_{i=1}^{p} \gamma_{1i}\, \Delta {y^2}_{t-i} + \sum_{i=1}^{p} \omega_{1i} \Delta T_{t-i} + \tau_{11}\, ECT_{t-1} + \varepsilon_{1t} \qquad (26a)$$

$$\Delta E_t = \beta_2 + \sum_{i=1}^{p} \delta_{2i}\, \Delta C_{t-i} + \sum_{i=1}^{p} \emptyset_{2i} \Delta\, E_{t-i} + \sum_{i=1}^{p} \omega_{2i} \Delta y_{t-i} + \sum_{i=1}^{p} \gamma_{2i}\, \Delta {y^2}_{t-i} + \sum_{i=1}^{p} \omega_{2i} \Delta T_{t-i} + \tau_{21}\, ECT_{t-1} + \varepsilon_{2t} \qquad (26b)$$

$$\Delta y_t = \beta_3 + \sum_{i=1}^{p} \delta_{3i}\, \Delta C_{t-i} + \sum_{i=1}^{p} \emptyset_{3i} \Delta\, E_{t-i} + \sum_{i=1}^{p} \omega_{3i} \Delta y_{t-i} + \sum_{i=1}^{p} \gamma_{3i}\, \Delta {y^2}_{t-i} + \sum_{i=1}^{p} \omega_{3i} \Delta T_{t-i} + \tau_{31}\, ECT_{t-1} + \varepsilon_{3t} \qquad (26c)$$

$$\Delta y^2{}_t = \beta_4 + \sum_{i=1}^{p} \delta_{4i}\, \Delta C_{t-i} + \sum_{i=1}^{p} \emptyset_{4i} \Delta\, E_{t-i} + \sum_{i=1}^{p} \omega_{4i} \Delta y_{t-i} + \sum_{i=1}^{p} \gamma_{4i}\, \Delta y^2{}_{t-i}$$

$$+ \sum_{i=1}^{p} \omega_{4i} \Delta T_{t-i} + \tau_{41}\, ECT_{t-1} + \varepsilon_{4t} \qquad (26d)$$

$$\Delta T_t = \beta_5 + \sum_{i=1}^{p} \delta_{5i}\, \Delta C_{t-i} + \sum_{i=1}^{p} \emptyset_{5i} \Delta\, E_{t-i} + \sum_{i=1}^{p} \omega_{5i} \Delta y_{t-i} + \sum_{i=1}^{p} \gamma_{5i}\, \Delta y^2{}_{t-i}$$

$$+ \sum_{i=1}^{p} \omega_{5i} \Delta T_{t-i} + \tau_{51}\, ECT_{t-1} + \varepsilon_{5t} \qquad (26e)$$

This VECM enables the examination of the adjustment to the equilibrium due to a short run shock. Also, the Granger Causality test can be conducted using this VECM to address the last research objective and answer the last research question.

There are two types of causality from Eq. (26a) to Eq. (26e). The first causality is via the error correction term (ECT), which captures the long run relationship, given that $\tau \neq 0$. Another type of causality is via the lagged dynamic terms, which represents the short run dynamics. Also, the significance of the ECT provides evidence of an error correction mechanism that restores the variables back to their long run equilibrium (Engle & Granger, 1987).

3.8 Conclusion

To determine the long run relationship among the variables (CO_2 emission, GDP, energy consumption, and tourism), the empirical analysis in this study begins with the panel unit root tests to check for the order of integration of each variable. The panel unit root tests are LLC, IPS, and Fisher-ADF. The results from the three tests are compared to enhance robustness.

After the unit root tests, the Pedroni and Kao tests are performed to detect the existence of cointegration among the variables. If the variables are cointegrated, it indicates that the variables "move together" in the long run. Also, another importance of this cointegration is that there should be at least one cointegrating vector or causality if the variables are cointegrated in the long run.

Given that the variables are cointegrated in the long run, the long run elasticity can be estimated by using panel DOLS and panel GMM. By using these 2 methods, eq. (1), (2) and (3) are compared to enhance the robustness of results. However, the long run cointegration and elasticity do not indicate the direction of causality between the variables. To determine the direction of causality, VECM based Granger causality test is employed.

Depending of the results of unit root and cointegration tests, either VAR or VECM is employed to determine the direction of causality between the variables. Through the VECM, short run dynamics can be examined by the lagged difference terms while the long run relationship can be captured by the ECT in the VECM. Besides, the ECT also used to measure the speed of adjustment that restores the long run equilibrium. VAR is similar with VECM except the exclusion of the ECT in the model indicating the absence of long run equilibrium and causality.

The paragraphs above summarize the methodology process and procedure. All the results are reported and discussed in the following chapter.

CHAPTER 4

RESULTS AND INTERPRETATIONS

4.1 Panel Unit Root Test

Table 4.1 Panel Unit Root Tests Results

	LLC		IPS		Fisher ADF	
	Level (trend and intercept)	First difference (intercept)	Level (trend and intercept)	First difference (intercept)	Level (trend and intercept)	First difference (intercept)
C	0.634	-2.577***	2.710	-6.110***	60.744	177.267***
	(0.737) (1)	(0.005) (1)	(0.997) (1)	(0.000) (1)	(0.946) (1)	(0.000) (1)
E	1.451	-1.869**	2.912	-5.904***	61.792	170.813***
	(0.927) (1)	(0.031) (1)	(0.998) (1)	(0.000) (1)	(0.935) (1)	(0.000) (1)
Y	0.025	-5.416***	1.050	-4.917***	75.514	150.573***
	(0.51) (1)	(0.000) (1)	(0.853) (1)	(0.000) (1)	(0.621) (1)	(0.000) (1)
Y^2	-0.010	-5.452***	0.952	-4.982***	76.543	152.331***
	(0.496) (1)	(0.000) (1)	(0.829) (1)	(0.000) (1)	(0.588) (1)	(0.000) (1)
T	-0.757	-17.061***	-1.089	-7.260***	84.635	193.625***
	(0.225) (0)	(0.000) (1)	(0.138) (1)	(0.000) (1)	(0.340) (1)	(0.000) (1)

Note: LLC, IPS, and Fisher ADF indicate the Levin et al. (2002), Im et al. (2003), Maddala and Wu (1999) panel unit root and stationary tests. All three tests examine the null hypothesis of non-stationary. ** and *** represent the rejection of null hypothesis at 5% and 1%. The figures without bracket is the test statistic value, the first bracket shows the probability value, while the subsequent bracket shows the lag length selected based on SIC. The probability values for the Fisher ADF are computed using asymptotic χ^2 distribution, while the rest follow the asymptotic normal distribution.

Table 4.1 summarizes the results from the three panel unit root tests as mentioned in section 3.3. From the results, all the variables are non-stationary in their level forms. However, when the variables are tested by using their first difference, the results show the rejection of null hypothesis of non-stationary. In conclusion, the three tests reveal that all the variables are stationary in their first differences.

4.2 Panel Cointegration

Table 4.2 Panel Cointegration Results

A) Pedroni	
Panel cointegration statistics (within-dimension)	
Panel v-statistic	-0.873 (0.809)
Panel rho-statistic	2.450 (0.993)
Panel PP-statistic	-7.600*** (0.000)
Panel ADF-statistic	-5.013*** (0.000)
Group mean panel cointegration statistics (between-dimension)	
Group rho-statistic	4.685 (1.000)
Group PP-statistic	-11.537*** (0.000)
Group ADF-statistic	-3.351*** (0.000)
B) Kao	
ADF	-7.320*** (0.000)

Note: Both tests examine the null hypothesis of no cointegration for the variables. *** indicates the rejection of null hypothesis at 1%. The figures without bracket represent test statistic values. Probability values are shown in the bracket. The lag length is selected automatically based on SIC.

Table 4.2 shows the results from the two cointegration test as mentioned in section 3.4. From the Pedroni test, four out of seven test statistics reject the null hypothesis of no cointegration among the variables. This is further supported by the result from the Kao test in which the long run cointegration relationship is detected. This result indicates that the variables do not drift apart in the long run steady state relationship. In other words, all the variables are cointegrated in the long run.

4.3 Panel Long Run Estimates

Table 4.3 Panel DOLS and GMM estimates

Independent variable	DOLS			GMM		
	Eq. (1)	Eq. (2)	Eq. (3)	Eq. (1)	Eq. (2)	Eq. (3)
C(-1)				0.15***	0.13***	0.13***
				(0.000)	(0.000)	(0.000)
E	1.22***	1.20***	1.13***	1.14***	1.18***	1.02***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Y	0.55***	0.61***	0.83***	1.01***	0.92***	1.29***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Y^2	-0.04***	-0.04***	-0.05***	-0.06***	-0.06***	-0.08***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
T		-0.003	-0.17**		0.01**	-0.20***
		(0.64)	(0.045)		(0.016)	(0.000)
EXT			0.02*			0.03***
			(0.055)			(0.000)
Adjusted R^2	0.998	0.998	0.998			
S.E. of regression	0.029	0.027	0.025	0.040	0.037	0.037

Notes: Dependent variable is CO_2 emission. Pooled estimation is used for DOLS. Automatic leads and lags selection are based on AIC criterion. For GMM, White period instrument weighing method is used. Effect specification is based on cross section fixed (orthogonal deviation for eq. (1), first difference for eq. (2) and (3)). The figures without bracket indicate the coefficient estimates while the figures in brackets show the probability value. *, **, *** represent the significance level at 10%, 5%, and 1%.

Table 4.3 shows the results from panel DOLS and panel GMM. From eq. (1), the EKC hypothesis is supported with more energy consumption leads to more CO_2 emission. This is shown by the significance of all the variables at 1%. The expected signs are consistent with the EKC hypothesis above. This is true for both DOLS and GMM estimation. This finding is consistent with Ang (2007), Jalil and Mahmud (2009), Pao and Tsai (2010), and Nasir and Rehman (2011). Eq. (1) can be presented as follow:

DOLS: $C = 1.22E^{***} + 0.55Y^{***} - 0.04Y^{2***}$

GMM: $C = 1.14E^{***} + 1.01Y^{***} - 0.06Y^{2***} + 0.15C(-1)$

Referring to the estimated parameter by DOLS, 1% increase in energy consumption leads to 1.22% increase in CO_2 emission. This is similar with 1.14% estimated by GMM. As for GDP, 1% increase in GDP leads to 0.55% increase in CO_2 emission for DOLS and 1.01% for GMM.

When tourism indicator is added into the analysis as in eq. (2), the result is similar with the result from eq. (1) except for the effect of tourism. Specifically, both DOLS and GMM indicate that more energy consumption causes higher CO_2 emission (1.2% for DOLS and 1.18% for GMM). Next, more economic growth will lead to an increase in CO_2 emission (0.61% for DOLS and 0.92% for GMM). Other than this, the EKC hypothesis is also supported even when tourism is included. This is shown by the significance and expected sign of the square term of GDP. Eq. (2) can be presented in a long run equation as follow:

DOLS: $C = 1.20E^{***} + 0.61Y^{***} - 0.04Y^{2***} - 0.003T$

GMM: $C = 1.18E^{***} + 0.92Y^{***} - 0.06Y^{2***} + 0.01T^{**} + 0.13C(-1)^{***}$

However, from the DOLS estimation, the tourism indicator is negative but not significant. On the other side, the GMM estimation indicates that the tourism indicator is positive and significant at 5%.

To further investigate the role of tourism in this analysis, an interaction term is included as in equation 3. This is because the multiplicative[2] or interaction effect between energy consumption and tourism may have significant impact on the model. Furthermore, the sign and significance of the interaction term is able to tell whether tourism and energy consumption are complements, substitute or independent to CO_2 emission. According to the DOLS estimation, the result is similar with eq. (1) and (2) where more energy consumption and economic growth causes more CO_2 emission. Also, the EKC hypothesis is supported with the inclusion of tourism and interaction term. The long run estimates for eq. (3) is as follow:

DOLS: $C = 1.13E^{***} + 0.83Y^{***} - 0.05Y^{2***} - 0.17T^{**} + 0.02EXT^{*}$

GMM: $C = 1.02E^{***} + 1.29Y^{***} - 0.08Y^{2***} - 0.20T^{***} + 0.03EXT^{***} +$

$0.13C(-1)^{***}$

The interesting finding in eq. (3) is the role of interaction term and tourism indicator. First, from the DOLS, the interaction term is significant at 10% and it is

[2] See Gujarati and Porter (2009, p. 289) for the multiplicative effect arise from the interaction between two variables.

positive. This positive sign of interaction term indicates there is a complement effect exists between energy consumption and tourism. Second, the tourism indicator becomes significant at 5% and it is negative. This estimation of DOLS is supported by the estimation of GMM. From the GMM, energy consumption and GDP have the same effect as per DOLS. However, by comparing eq. (2) and (3) in GMM, it is noticed that the interaction term can transform the positive effect of tourism on CO_2 emission into a negative effect.

Hence, there is significant multiplicative effect between energy consumption and tourism and this effect has positive impact on the relationship between CO_2 emission, energy consumption and economic growth. This is shown by the result of eq. (3) estimated by either DOLS or GMM. The result form GMM further strengthens the existence and the impact of the interaction term or the multiplicative effect. In other words, tourism and energy consumption complement each other in the contribution of CO_2 emission.

The net effect[3] from energy consumption, tourism and the multiplicative effect can be calculated from eq. (2) and (3). As the tourism indicator in eq. (2) from DOLS is not significant, the estimation of GMM is used for the calculation of the net effect. From eq. (2), when GDP remains constant, the net effect of energy consumption and tourism on CO_2 emission is 1.19% (1.18% + 0.01%).

[3] See Gujarati and Porter (2009, p.290) for example of this net effect from interaction.

When the interaction term is added as in eq. (3), the net effect is 0.85% (1.02% - 0.2% + 0.03%). This indicates the multiplicative effect between energy consumption and tourism is able to reduce CO_2 emission. In other word, how energy is used in tourism sector has significant impact on the CO_2 emission. Based on this, it is plausible to propose that energy efficiency in tourism sector might have an important role in reducing CO_2 emission. Although the interaction term may not be the best indicator or proxy to measure energy efficiency, at least the finding above shows that there is a significant interaction effect between energy consumption and tourism. Moreover, this finding also shows that the effect of tourism and energy consumption on CO_2 emission is not independent.

Other than the net effect, additional analysis can be done based on the estimates from eq. (3). First, marginal effect can be determined by differentiating CO_2 emission with respect to tourism. This results in 0.02E – 0.17 for DOLS and 0.03E – 0.2 for GMM. Assuming that energy consumption remains constant, the marginal effect of CO_2 emission arises from additional tourism receipts is -0.15% for DOLS and -0.17% for GMM respectively. This implies that with the aid of the interaction effect, additional tourism receipt will result in a fall in CO_2 emission. Therefore, how energy is used in tourism sector may have a significant impact on CO_2 emission.

By comparing eq. (2) and eq. (3) from the GMM estimation, it is noticed that the sign of tourism changes with the inclusion of interaction term between tourism and energy consumption. Also from the marginal effect above, there may be a threshold level for the usage of energy in tourism and CO_2 emission. Hence, in order to determine the threshold level, we let the first difference derivative from the above paragraph equals to zero. By letting 0.02E – 0.17 (DOLS) and 0.03E – 0.2 (GMM) equals to zero, we obtain E=8.5 for DOLS and E=6.67 for GMM. As the variable is in natural log form, the procedure of anti natural log is required. As a result, the turning point estimated is $4914.77 for DOLS and $788.40 for GMM. This turning point indicates that the interaction effect between tourism and energy consumption is able to reduce CO_2 emission after tourism receipts per capita exceeds $4914 and $788.

By referring to table 1.2, the data in 2010 shows that only Luxemburg's tourism receipts per capita exceeds the turning point estimated by DOLS, which is $4914. On the other hand, the turning point estimated by GMM is more reasonable, which is valued at $788. Table 1.2 shows that the mean for tourism receipts per capita in the G-20 exceeds $788, which is valued at $962. The EU group shows an outstanding performance in their tourism receipts recorded at $1327 per capita in 2010. Despite, the mean for BRIC, OECD, and G-8 has not reach the threshold level. Comparing the turning point estimated by both DOLS and GMM with data in table 1.2, it can be concluded that GMM performed better than DOLS in this study. A possible explanation that explains why GMM's turning point is closer to the data is the significance level of Eq. (3) in table 4.3. Apparently in table 4.3, all the coefficients estimated by using GMM are significant at 1%. This is not true if Eq. (3) is estimated by using DOLS.

4.4 Panel Granger Causality Test

From the panel unit root tests and panel cointegration tests, the variables are stationary at first order and cointegrated in the long run. Thus, a panel VECM based Granger causality test is used to examine the direction of causality between the variables.

Table 4.4 Panel Granger Causality Test Result

Dependent variable	ΔC	ΔE	ΔY	ΔY^2	ΔT	ΔEXT	ECT
ΔC	-	26.191***	12.502***	1.166	4.169*	2.944*	-0.014***
		(0.000)	(0.000)	(0.291)	(0.052)	(0.071)	(0.009)
ΔE	1.58	-	11.71***	0.161	4.14**	1.75	-0.002
	(0.191)		(0.00)	(0.69)	(0.02)	(0.125)	(0.775)
ΔY	0.27	35.46***	-	1.92	31.79***	0.63	-0.004
	(0.60)	(0.000)		(0.11)	(0.000)	(0.43)	(0.289)
ΔY^2	1.80	0.04	1.85	-	0.16	0.29	-0.170
	(0.18)	(0.96)	(0.11)		(0.69)	(0.59)	(0.128)
ΔT	2.29	4.81**	3.49*	2.37	-	0.05	-0.007
	(0.13)	(0.01)	(0.06)	(0.12)		(0.82)	(0.164)

Note: The figures without bracket denote the F-statistic value for the dependent variables with first difference operator and coefficient for the ECT, while the figures in brackets indicate the probability value. This panel VECM Granger causality examines the null hypothesis of no

Granger causality from independent variable to dependent variable. *, **, and *** represent the rejection of null hypothesis at 10%, 5%, and 1%.

The result for the panel VECM based Granger causality test is shown above. From the results, a bi-directional causal linkage exists between economic growth and energy consumption, tourism and energy consumption and economic growth and tourism. Besides, there is unidirectional Granger causality running from energy consumption to CO_2 emission, from economic growth to CO_2 emission, and lastly from tourism to CO_2 emission.

Turning to the error correction term (ECT), the coefficient on the lagged ECT is negative and significant only when CO_2 emission is the dependent variable. This supports the results from the cointegration test for long run relationship. The ECT is not significant when other variables as dependent variable. This implies that in the long run, causality runs interactively through the ECT from economic growth, energy consumption and tourism to CO_2 emission.

Comparing the results from this study with previous literatures, the bi-directional causal relationship between economic growth and energy consumption is consistent with the work by Apergis and Payne (2010). This suggests there is a feedback effect between the two variables. This means that more economic growth requires more energy consumption and more energy consumption contributes to more economic growth in the G-20 countries.

The results from the panel VECM based Granger causality test also indicate that there is unidirectional Granger causality running from tourism to CO_2 emission. This matches the hypothesis in Chapter 1 and problem statement that the vehicles and transportations used to transfer tourist from one destination to another result in greater CO_2 emission. This further explains the bidirectional causality between tourism and energy consumption. As more tourism activities require more energy to be used in vehicles and transportations, thus more energy used will also contribute to tourism growth. Hence, energy related policies in tourism industry play an important role in emission reduction policy making in the G-20 countries.

Next, bidirectional causality is also identified between economic growth and tourism. This is consistent with Durbarry (2004) and Tang (2011). Previous findings such as Holzner (2011), Falk (2010), Bernini (2009) and so on had found that tourism boost the growth of an economy. As economy grows, it is possible to attract more tourists. Therefore, there is a feedback effect between tourism and economic growth. This finding could be used to convince policy makers to reduce CO_2 emission without affecting economic growth in the G-20 countries.

Lastly, the finding of unidirectional causality running from energy consumption to CO_2 emission supports the work by Zhang and Cheng (2009). This indicates more CO_2 emission will be released if more energy is being used due to the direct combustion of fossil fuel. Lastly the causality running from economic growth to CO_2 emission matches the finding by Nasir and Rehman (2011). This explains the phenomenon that most of the developed countries emit more CO_2 emission than other countries which have lower economic growth. As G-20 countries represent the most dominant countries in the world, they should take the initiative to commit to CO_2 reduction policy in order to relieve the problem of global warming.

CHAPTER 5

CONCLUSION AND POLICY IMPLICATION

5.1 Conclusion and Summary

One of the objectives of this study is to find out the role of tourism in the linkage between energy consumption, economic growth and CO_2 emission for the G-20 countries by using annual data from 1995 to 2010. To enhance the reliability of data, the EU is counted as separate entity. However, Argentina, Ireland and Saudi Arabia have missing data and the 3 countries are excluded in the study. Thus, the data actually consists of 40 countries.

Motivated by Lee and Brahmasrene (2013), this study examines the possibility of effort from the tourism industry that can help to reduce the emission of CO_2 emission, and at the same time, maintain sustainable economic growth. Hence, an interaction term is added into the analysis to capture the multiplicative effect between tourism and energy consumption. The reason of adding the interaction term is because the relationship between CO_2 emission with energy consumption and tourism could be non-addictive, but multiplicative. Interpreting in another way, the net effect on CO_2 emission might depend on the interaction between energy consumption and tourism. So instead of having individual effect on CO_2 emission, the two variables energy consumption and tourism could have a joint effect which would have a significant impact on the CO_2 emission.

To enhance the robustness of results, a panel DOLS is complemented with panel GMM to estimate and compare the long run coefficients as well as the expected signs. Summarizing the results from both tests, it can be concluded that: First, more energy consumption leads to more CO_2 emission. Second, the EKC hypothesis is supported where there is an inverted-U relationship between economic growth and CO_2 emission.

Next, CO_2 emission reduction could be achieved if energy is being used wisely especially is tourism sector. This is shown by the significance of the interaction term in the model. In the absence of the interaction term, tourism is found to be positively affecting CO_2 emission. But when the interaction term is added, the interaction or joint effect between energy consumption and tourism is able to transform the positive effect into a negative effect. This interaction effect also implies there is a threshold level in the usage of energy in tourism sector. When this threshold level is achieved, increasing tourism activities would reduce current CO_2 emission. Through differentiation, the threshold level of $4914 is found from DOLS and $788 from GMM. As discussed in section 4.3, the threshold level from the GMM is more acceptable if compared to the data in table 1.2. Therefore, GMM is said to be perform better than DOLS in this study.

The above finding on the interaction effect suggests an alternative rather than energy conservative policy to reduce CO_2 emission which may harm the economy of a country. This outlines a new direction of policy which can help to reduce CO_2 emission and at the same time, maintain sustainable economic growth.

Besides, to examine the direction of causality, a panel VECM based Granger causality test is performed. As a result, a bi-directional short run causal linkage exists between economic growth and energy use, tourism and energy consumption and economic growth and tourism. Also, there is unidirectional short run Granger causality flowing from energy consumption to CO_2 emission, from economic growth to CO_2 emission, and lastly from tourism to CO_2 emission. Lastly in the long run, causality runs interactively through the ECT from economic growth, energy consumption and tourism to CO_2 emission. This indicates that economic growth, energy consumption and tourism are long run determinants of CO_2 emission.

Up to date, this study is the first attempt to investigate the role of tourism in the EKC framework especially in the pollution-growth-energy nexus. To enhance the reliability of results, this study uses panel DOLS and panel GMM for long run estimation. Moreover, a panel VECM based Granger causality test is performed to examine the direction of causality. Detail explanation on the policy implication is in the next section.

5.2 Policy Implication

The most important finding from the results is the role of tourism in the relationship between energy consumption, economic growth and CO_2 emission. According to the panel DOLS and panel GMM, more tourism activity indeed results in more CO_2 emission especially the use of transportation. However, a significant interaction effect is found between energy consumption and tourism. The result of this effect is the transformation of positive effect of tourism on CO_2 emission into a negative one. This joint effect implies potential CO_2 emission reduction from tourism and energy related policy.

Comparing with previous literatures, the findings from the energy-pollution-growth nexus have conflicting policy implication. Most of the studies in this line revealed that energy consumption contribute to both CO_2 emission and economic growth. Thus, energy conservative policy to reduce CO_2 emission may eventually leads to a fall in economic growth. This finding from this study suggests an alternative to the energy conservative policy, which is to increase the energy efficiency in tourism sector. Many previous studies have shown that tourism is able to boost the growth of an economy as discussed in chapter 2. Hence, improving energy efficiency in tourism sector can help to reduce CO_2 emission and at the same time, maintain sustainable economic growth.

There are several suggestions in detail. First, is the use of biofuel. A report by International Energy Agency pointed out the potential of biofuels in reducing emission (IEA, 2012). The report also added that more than 50 countries and the EU have mandated or promoted biofuel blending to displace oil in domestic transport supply. Relating this to the finding in this study, it can be noted from table 1.2 that the EU's tourism industry is outstanding among other groups in the G-20. Also, their tourism receipts per capita exceed the threshold level estimated by GMM. Therefore, this practice could be expanded to other G-20 countries to reduce the emission of CO_2.

Second, is the change in tourist patterns and policies which include transport modal shift, the choice of closer destinations, spending on goods and services with favorable eco-efficiency, and increase in the length of stay.

Transport modal shift is the switch of mode of transport from vehicles that emit more emission to those that emit less. This also includes promoting public transports such as train and bus, as well as an integrated public transport system and infrastructure. However, other measurements such as the choice of closer destinations and increase in the length of stay require the initiative from the tourists' side. Hence, the G-20 countries should pay attention to the above suggestions when promoting their tourism industry.

Lastly, is the effort and better flight management. The measurements include replacing old and inefficient aircrafts, better flight and load management and etc. Replacing old and inefficient aircrafts with those with better and new engine may help to reduce fuel consumption. Similar with the above, these measurements are highly dependent on the airline companies and practitioners. As major economies in the world, the G-20 countries should lead the way in implementing and integrating the above practice.

From the above discussions and suggestions, it is advisable that the CO_2 reduction policy such as the Kyoto Protocol should take the role of tourism into consideration when formulating relevant policy and regulation. As mentioned above, the role of tourism especially with enhanced energy efficiency could help to reduce CO_2 emission, and at the same time, maintain sustainable economic growth. Apparently, this is a better alternative compared to energy conservative policy. As major economies in the world, the G-20 countries should take this responsibility to reduce CO_2 emission in order to reduce the rate of global warming as well as climate change.

5.3 Limitation of the Study

From the results above, even though the EKC hypothesis is supported, it may not be enough to explain the pattern of CO_2 emission in the real world. The EKC hypothesis proposed an inverted-U relationship between economic growth and CO_2 emission. However, according to the recent CO_2 emission trend, many countries still recorded a positive change in CO_2 emission compared to previous years.

There is a possibility that the economic growth has not reach the turning point for CO_2 emission to decline. It could also be flaw in the existing EKC framework and model. The linear model used in this study may not be adequate to analyze the relationship between economic growth and CO_2 emission. Even though the inclusion of the role of tourism in this study to the existing EKC framework is considered a new attempt in this line of research, further modification may be required from the estimation method and model to better understand the emission pattern of CO_2.

Besides, 3 countries are excluded including Argentina, Ireland, and Saudi Arabia due to incomplete data set. Also, due to data availability especially the indicator of tourism, the time period included in this study is from 1995 to 2010. The data on tourism indicator is unavailable before 1995 from the WDI, World Bank. Future research could search for other data source which provides longer data set especially for the tourism indicator.

This study uses the same indicator for tourism with Lee and Brahmasrene (2013) for comparison of finding, which is tourism receipt per capita. In fact, there are several ways to measure tourism activity for example tourist arrival and etc. As the inclusion of tourism in the EKC framework is considered a new area of research, future research could use different indicator for tourism to compare the result.

Lastly, the inclusion of interaction term between energy consumption and tourism in the model can be considered as a new attempt in this line of research. The findings indicate that the interaction term has significant impact on the emission of CO_2 emission. Furthermore, this interaction effect is able to transform the positive impact of tourism on CO_2 emission into a negative impact. This provides a fundamental theory and brings up the issue of energy efficiency in tourism sector. Even though the interaction term might not be the best indicator for energy efficiency, at least it shows that there is an interaction effect between energy consumption and tourism and most importantly, this effect has significant impact on the relationship between CO_2 emission, economic growth, energy consumption, and tourism.

5.4 Recommendation for Future Study

Based on the limitation above, future study could use a non-linear model to estimate the relationship between economic growth and CO_2 emission. This is because a linear model, even a dynamic linear model might not be enough to explain the relationship between economic growth and CO_2 emission. As the inclusion of tourism is a relatively new attempt in the EKC framework, this study begins with dynamic linear model to compare with previous EKC literatures.

Other than the non-linear model, future study could retrieve the data from other sources other than the World Bank. This is because the data for the tourism indicator from the World Bank starts from 1995 onwards. Data before 1995 is important to increase the accuracy and reliability of result.

As this study is a relatively new attempt to study the role of tourism in the EKC framework, different indicator for tourism could be used in the future for comparison purpose. There are several indicators for to measure tourism activity such as tourist's arrival.

Regarding the issue on energy efficiency especially in tourism sector, more research in the future could be done, i.e. using different indicator to capture the energy efficiency instead of using interaction term. The possible alternative is the Data Envelopment Analysis (DEA). DEA is a nonparametric method used to measure productive efficiency of decision making units. DEA adapts the multi-input and multi-output function which is different from the OLS estimator. Since the findings in this study are favorable to the hypothesis, it is worth to carry out or continue this research topic by using the alternative mentioned.

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