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Energy Consumption, Income, Technological Progress, and Carbon Emissions Empirical Evidence from Malaysia (1970 – 2012)

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ABSTRACT

Alarms over climate change have raised concerns that major economic variables are coupled with carbon emission. The objective of this study is to examine the dynamic linkages among carbon emissions, energy consumption, income, gross fixed capital formation, labour force, technological progress, and trade openness in Malaysia from 1970 to 2012 using vector error correction model. The co-integration test shows the existence of long-run relationship among the variables. Results reveal that real GDP, trade openness and technological progress are relevance policy variables that have long-run impacts on carbon emissions reduction in Malaysia. The causality results find that there is a short-run and long-run Granger causality running from technological progress to carbon emissions reduction. There is no causality from any direction between carbon emissions and real GDP (income), and between carbon emissions and energy consumption in the short – run. The finding of positive uni-directional short-run causality running from real GDP to energy uses implies that Malaysia is an energy dependence economy and more energy is required in the short-run to boost economic growth and development. This also implies decoupling of energy use and emission probably due to increasing proportion of green energy such as biomass, and dam-check proportion of green energy trend. Impulse response function (IRFs) reveal that shock to technological progress has negative impact on carbon emissions in Malaysia whereas the VDCs find that the impact of labour force on the forecast error variance of carbon emission would be highest for the next ten years followed by energy consumption.

Keywords: Energy consumption, Income, Technological progress, and Carbon emissions

INTRODUCTION

A vast majority of climate scientists have come to the consensus that current global warming is man-made. The diffusion of carbon dioxide into the atmosphere is a leading cause of global warming (Fodha and Zaghdoud, 2009). There is trade-off between economic growth and the environment as implied by the environmental Kuznets curve (EKC). In terms of environmental pollution, the EKC implies an inverted- U relationship exist between pollutants and income. In other word, countries at the lower level of income tend to pollute more as they strive to increase national income. Upon attaining a certain threshold level of income, pollution level decrease. The environmental Kuznets hypothesis was subjected to empirical test by Grossman and Krueger (1991) who study the environmental impacts of the North American free trade agreement and established the existence of environmental Kuznets curve (EKC) phenomenon in the case of North America. Following this seminal findings, many studies have validated the EKC hypothesis. For example, see Shafik & Bandopadhyay (1992), Grossman & Krueger (1993 & 1995), Panayotou (1993 & 1997), Selden & Song (1994), Cropper & Griffiths (1994), Cole et al. (2004), Torras & Boyce (1998), and Bhattarai & Hamming (2004).

In line with the above, the nature of causal relationship between carbon emissions, energy consumption and economic growth has been one of the most debated and wide ranging issues within

energy literatures. For examples, see Soytas et al. (2007), Akbostanci et al. (2009), Haliciogu (2009), Chandran et al. (2009), Fodha & Zaghdoud (2010), Jaunky (2010), Esteve & Tamarit (2012), Jalili & Mahmud (2009), Narayan & Narayan (2010), Sabori et al (2012), Azlina & Mustapha (2012), Mugableh (2013). Most of these past studies have generally focussed on the existence of bi-causality or the presence of EKC phenomenon without taking into consideration capital, labour (population), and technological progress. This study expands on previous studies by examine the impacts of energy consumption, income, trade openness, labour force, gross fixed capital formation, and technological innovation on carbon emissions.

The structure of this paper is as follows. In the next section we provide a brief overview of the Malaysian economy followed by literature review, data analysis and results, and conclusion.

OVERVIEW OF THE MALAYSIAN ECONOMY

Malaysia is an upper-middle income developing economy with a population of about 30 million, located in South-East Asia. The country is blessed with human resources, natural resources, and primary energy resources such as crude oil, natural gas, coal and renewable energy. The energy sector is one of the major sectors of growth for the economy that has contributed about 20 percent to gross domestic product (EIA, 2012). The country's has experienced rapid economic growth for the past four decades and high growth rate of energy consumption. GDP at 2005 constant price grew at an average of 6.3 percent between 1970 and 2012 while the annual growth rate of energy uses (kt of oil equivalent) was 6.5 percent between the periods. The growth in energy consumption is as a result of development and growth in the manufacturing sector, improvement in standard of living, increases in income, increases in the number of vehicles, high growth rate of urban population and growth of the service sector.

Carbon emission has being a major threat not only to developed economies but to the World and Malaysia in particular. Carbon emissions in Malaysia has grown from 14601.99 (kt) in 1970 to 198348.03 (kt) in 2009 (World Bank). The annual growth rate of carbon emissions in Malaysia from 1970 to 2012 was 7 percent. Malaysia carbon emission performance has been ranked very low by climate change performance index report and earth policy institute in 2012, according to the reports, climate change performance ranked Malaysia 49th out of 61 most polluted countries in the World while earth policy institute ranked Malaysia 27th most polluted country in the World with a carbon emission of 54 million tons and an average emission growth rate of 13 percent for the past five years. The trend in the growth rate of carbon emissions in Malaysia is higher than the growth rate of real gross domestic product and growth rate of energy uses, this called for great concerns. We discovered that the percentage growth rate of gross expenditure on research and development (GERD) to GDP has a negative relationship with carbon emission. Percentage of Gross expenditure on research and development (GERD) to GDP is proxy as technological progress (innovation). A number of indicators have been mentioned in the literatures to proxy technological progress (innovation) such as percentage of GERD/GDP, number of researchers, number of Patents, R&D Personnel, High technological exports, Innovation Index, ICT expenditures, Technology balance of payment, Government expenditures on R&D, Higher education R&D Personnel (OECD, 2011), and Tuah, Nadaraja and Jaafar (2009). Malaysia GERD in nominal term is estimated at RM500 million in 1992 increased to RM549.3 million in 1996, RM3.6 billion in 2006 and further grown to RM9.42 billion in 2011 (MASTIC). In term of percentage to GDP, GERD has increased from 0.22 percent in 1996 to 1.07 percent in 2012 but fell from 0.69 percent in 2002 to 0.64 percent in 2006. Since 2009, Malaysia has exceeded the targeted GERD/GDP of 1 percent set by the economic planning unit (EPU) to be achievable by 2015.

Our contributions to energy literature are in two fold; firstly, we employed VECM that is able to capture both the short and long-run relationship, impulse response that is able to capture the effects of shocks in the variables and variance decomposition method. Secondly, we provide empirical evidence for the inclusion of technological progress (innovation) as additional determinant of carbon emissions.

LITERATURE REVIEW

Theoretical literature begins with the work of Kuznets (1955) who postulated that an inverted-U shaped curve exists between economic growth and environmental quality. He posits that at a lower level of income, countries tend to pollute more than at a higher level of income. This position is what is later

known as the popular Environmental Kuznets Curve (EKC) hypothesis. Normally in research environment, theoretical issues are examined through empirical testing of the so called theory that has been propounded. Halicioglu (2009) investigate the causal relationship between carbon emissions, energy consumption, income and foreign trade in the case of Turkey. The study used time series data spanning 1960-2005 adopting the bound test method of cointegration and discovered that carbon emissions depends on energy consumption, income level and foreign trade while income plays a dominant role in the determination of the country' level of carbon emissions. Hossain (2010) examined the dynamic causal relationships between carbon emissions, energy consumption, economic growth, trade openness and urbanization for Newly Industrialized Countries (NIC) with time series data covering from 1971 to 2007. The study find no evidence of long run causal relationship but there exist short run unidirectional causal relationship running from economic growth and trade openness to carbon emissions.

Jalil et al (2011) investigate the impact of financial development, economic growth and energy consumption as its affect the level of environment through pollution in the case of china between 1953 and 2006. The methodology involves the autoregressive distributive lag bounds test technique. The result showed the existence of a negative relationship between financial development and environmental pollution in china and that environmental pollution is best explained by income, energy consumption and trade openness. Omri (2013) examined carbon emissions, energy consumption and economic growth for Middle East and North African countries using data spanning 1990-2011. The results found that bi-directional causal relationship exist between energy consumption and economic growth and from economic growth to carbon emissions.

Lean et al (2010) investigate the relationship between carbon emissions, energy consumption and economic growth in Malaysia between 1970 and 2008. The study finds a unidirectional causality running from economic growth to electricity generation. Sabori et al (2012) investigate the relationship between economic growth and carbon emissions for Malaysia. The study used data spanning 1980-2009 testing the Environmental Kuznets Curve (EKC) hypothesis in an autoregressive distributive lag econometrics technique. The study revealed the existence of a long run relationship between per capita carbon emissions and real per capita output and such, EKC hypothesis is supported by the result of the study.

DATA ANALYSIS AND RESULTS

This study utilize annual secondary data from 1970 to 2012, data on carbon emissions (Kt) (C2), energy use (kt of oil equivalent) (E), real gross domestic product (GDP) (Y), real gross fixed capital formation (proxy as capital) (K), total labour force (L), openness (measured as the ratio of total trade(real export plus real import) to real GDP (O),and technological progress (T) is proxy as percentage of gross expenditure on research and development to current GDP, the value converted to real value by deflation via CPI . All data were transformed into natural logarithms except technological progress which is in percentage. Data on Malaysia GERD is collected from Malaysia Science and Technology Information centre official portal, data from 1992 to 2012 were only available, GERD/GDP ratio of 0.22 in 1996 is use as baseline to calculate previous years from nominal GDP. The sources of data collected are from the World Bank, *World* Development *Indicators* (WDI) database, Malaysia energy hub, and Malaysia science and technology information centre official portal.

Descriptive statistics

The summary of the descriptive statistics of the sample of variables, all the variables were first transformed into natural logarithms except technological progress (T) proxy as percentage of gross expenditure on research and development to GDP . The mean range from 2.0968 to 11.3637, output (Y) has the highest mean, and standard deviations range from 0.1569 to 0.3946. Capital has the highest standard deviation followed by carbon emission, energy demand, output, technological progress, openness, and labour force. The descriptive statistics shows that all the variables, carbon emissions, energy consumption, capital, labour, openness, and real GDP are characterized as leptokurtic and skewed expect technological progress. Tang and Tan (2013) also discovered that energy consumption, GDP, and energy price in Malaysia are spherically distributed (Jarque–Bera, Skewness and Kurtosis statistics), unlike technological innovation (proxy as number of patent).

Stationarity Test

We perform stationarity test using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) , Dickey-Fuller GLS, Kwaitkowski-Phillips-Schmidt-Shin (KPSS), and Ng-Perron unit root tests to ascertain the order of integration of each series. The results of the five unit root tests are consistent and find that all the variables are non-stationary at levels, but are stationary at first differences. At five percent significance level, the results suggest that carbon emissions, energy consumption, real GDP, real capital, labour force, trade openness, and technological progress were integrated of order one, I(1)process.

Test for Co-integration

Co-integration is the statistical implication of the existence of a long – run relationship between economic variables. The test stipulates that if variables are integrated of the same order, a linear combination of the variables will also be integrated of that same order. We test for the existence of long run relationship among variables using the Johansen co-integration test. The Johansen co-integration test result indicates the rejection of null hypothesis of zero cointegration at 95 percent critical level. Therefore, we conclude that there is a long run relationship between carbon emission and other variables. From the results of the normalized cointegrating vectors, by normalizing the coefficient of C2 to one, the cointegrated coefficients are all statistically significant at 5% significance level. Carbon emission (C2) is positively related to energy consumption (E), real capital (K) and labour force (L) whereas the inverse hold for real GDP in the long-run. Trade openness and technological progress have a long-run negative relationship with carbon-emissions; the implication is that one percent increases in trade openness and technological progress would reduce carbon emission by 31 percent and 8 percent respectively. Our finding are in line with Shahbaz, Lean,Shahbir (2012), Say and Yucel (2006), Halicioglu (2009), and Sharif Hossain (2011). Sharif Hossain (2011) found a long-run insignificant negative relationship between trade openness and carbon emission in Malaysia.

Granger Causality Tests Based on VECM

Type of Causality								
	Short - run							Long run
Dependent Variable	$\sum \Delta \ln C2_{t-1}$	$\sum \Delta \ln E_{t-1}$	$\sum \Delta \ln Y_{t-1}$	$\sum \Delta \ln K_{t-1}$	$\sum \Delta \ln L_{t-1}$	$\sum \Delta \ln O_{t-1}$	$\sum \Delta T_{t-1}$	ECT_{t-1}
$\Delta \ln C2_t$	-	2.1489	3.2229	0.5465	1.6434	7.7963**	5.2746*	-0.0027
$\Delta \ln E_t$	0.9477	-	5.7207*	4.8764	0.6543	3.2130	5.9514**	0.0076
$\Delta \ln Y_t$	1.9633	0.6453	-	12.8295***	1.4534	6.8621**	5.4749*	0.0814***
$\Delta \ln K_t$	2.4029	0.3803	4.8771*	-	1.3131	2.4458	2.9804	0.1422
$\Delta \ln L_t$	0.9789	7.0228**	15.3827***	8.6355***	-	9.1287***	5.8214**	0.0297**
$\Delta \ln O_t$	3.4764	5.1091*	15.5116***	9.2391***	1.7283	-	9.4223***	0.0770**
ΔT_t	0.2617	1.3641	1.3592	3.2716	1.5548	5.7896**	-	-0.2425**

Causality inference: O ⟶ C2, T ⟶ C2, Y ⟶ E, T ⟶ E, T ⟶ Y, E ⟶ L, Y ⟶ L, K ⟶ L
O ⟶ T, E ⟶ O, K ⟶ O, TL ⟶ KY, O ⟷ Y, T ⟷ O

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

According to Granger (1969), if 'Y Granger causes X' and 'X does not causes Y', then a Uni-directional causality exists from Y to X. If 'Y Granger causes X' and 'X causes Y', it is said that bi-directional causality exists between Y and X, and if 'Y does not Granger causes X' and 'X does not Granger cause Y', then Y and X are statistically independence. Granger (1988) further stated that when set of variables are cointegrated, there must be a unidirectional or bidirectional causality and that short–run and long-run relationship must exist between them.

The significance of the lagged error-correction term ECT_{t-1} indicates long-run causality while the significance of the lagged explanatory variables represents the short-run causality. The VECM Granger causality finds positive uni-directional short run causality running from trade openness and technological progress to carbon emissions without any feedback effects. This support the argument that technological development helps to reduce carbon emissions by developing new sophisticated technologies that uses less energy and emits less emission during production or usage. Trade openness has significant impact on carbon emission and this result are supported by Shahbaz, Hye, Tiwari, Leitao (2013), Shahbaz, Lean, Shabbir (2012), and Sharif Hossain (2011). Hossain (2011) discovered that trade openness has no impact on carbon emissions for newly industrialized countries but he found a short-run Granger causality from trade openness to carbon emissions for Malaysia. The results of no

causality between carbon emissions and real GDP contradict the findings of Izyan, Azlina and Nik (2013) for Malaysia but consistent with the findings of Saboori, Sulaiman, and Mohd (2012) for Malaysia, Soytas, Sari and Ewing (2007) for United States, Omri (2013) for MENA countries, and Ghosh (2010) for India. In the short-run, bi-directional Granger causality relationship exists between technological progress and trade openness, between real GDP and real capital, and between trade openness and real GDP. The finding of positive uni-directional short-run causality running from output to energy uses implies that Malaysia is an energy dependence economy and more energy is required in the short-run to boost economic development. Our findings are in line with previous studies by Ang (2008), Lean and Smyth (2010), and Azlina&Nik (2012) that found unidirectional causation from output to energy uses in Malaysia. The short-run relationship also showed that there are uni-directional Granger causality running from energy, real GDP, and capital to labour force. A uni-directional short-run Granger causality runs from technological progress to real GDP without a feedback indicates that an increases in technological innovation leads to an increases in economic growth. This result is consistent with the view that technological advancement is a major driver of economic growth and development. The results of our long-run analysis found that the coefficients of ECT_{t-1} is negatively signed and statistically significant at 5% level of significance for technological progress (T), the implication of this result is that in the long-run there is a uni-directional causality running from real gdp, real capital, real openness, labour force, and energy demand to technological progress. The long-run equilibrium deviation has a significant impact on the growth of carbon emission in Malaysia. The speed of convergence to the long-run equilibrium at -0.2425 (24.25%) per year is considered relatively low speed. In other words, it will take less than five years to achieve long-run equilibrium whenever there is a deviation from the long-run steady state. The causal relationship detected among the variables shows that labour force is neutral in the short-run and may not have impact on carbon emissions growth in the short-run.

Variance decompositions test (VDCs) and the Impulse response functions (IRFs)

In order to analyse the dynamic properties of the system and the dynamic interaction of the various shocks in the post sample period, we employ generalized impulse response and generalized variance decompositions of Koop et al. (1996) and Pesaran and Shin (1998). Impulse response function (IRF) is a dynamic system that investigates the responses of current and future values of each variable to an impulse in another variable. If the system of the equation is stable impulse will converge to zero. Variance decomposition or forecast error variance decomposition determines the amount of the variation in a variable that can be explained by exogenous shocks in another variable. The generalized VDC and IR do not have the problem of orthogonality because it not sensitive to the ordering of variables in the VAR unlike the Cholesky VDC and IRF.

The generalized impulse responses of carbon emissions to one standard deviation innovation showed that shocks to E, Y, K, O, and L have positive and significant initial impacts on carbon emission. The initial positive impact of E is slightly higher than other variables but maintain a negative impact on carbon emission after the seven years period. Shock to technological progress has negative and significant initial impact on carbon emission and this is in line with our Granger causality test and long-run relationship. Carbon emission response higher to his own shock than any other variables, the point represented by t = 2 throughout the ten years period show that the impulse response converge to zero. Generalized impulse response of energy uses to one standard deviation innovations indicates that shocks to all variables have positive and significant initial impacts to energy uses. Energy consumption responds negatively to own shock after the seven years period, and also response negatively to shock in technological progress only at the fourth and fifth year period. Since the system is stable, all sequences eventually converge to zero. The generalized impulse responses of income to one standard deviation innovations revealed that shocks to C2, E, L, K, O, and T respectively have positive and significant initial impact on income. The response of income to his own shock is more than other variables. The generalized impulse responses of technological progress to one standard deviation innovations show that shocks in E, Y, K, and O have positive initial impacts on technological progress while carbon emission and labour force have negative impacts on technological progress.

Generalized Variance Decomposition (GVDC)								
Dependent Variable	Horizon	ΔLC2	ΔLE	ΔLY	ΔLK	ΔLL	ΔLO	ΔT
ΔLC2	1	100.0000	0.0000	0.0000	0.000000	0.0000	0.0000	0.0000
	3	89.6014	0.4442	5.2717	0.4181	0.0683	4.1146	0.0817
	5	86.0946	0.6575	3.9245	2.2259	3.3462	3.6115	0.1399

	8	73.6193	2.9963	4.3749	4.5462	11.3122	2.5289	0.6221
	10	66.6729	5.7698	5.6334	4.9335	13.7991	2.3244	0.8668
ΔL	1							
E		43.3053	56.6947	0.0000	0.0000	0.0000	0.0000	0.0000
	3	48.4469	44.7817	3.4122	0.7257	1.1779	0.8881	0.5676
	5	51.1379	26.6576	3.3274	4.9935	12.7257	0.6544	0.5035
	8	38.2672	15.9311	14.5816	7.2425	16.9927	1.0317	5.9532
	10	29.8459	13.6664	24.5252	6.3425	14.6679	0.9364	10.0156
ΔL	1							
Y		35.8179	6.1616	58.0204	0.0000	0.0000	0.0000	0.0000
	3	59.2356	1.9077	29.4885	1.6322	0.2222	5.6823	1.8316
	5	54.6526	1.7885	22.9459	4.9871	8.5728	3.3779	3.6753
	8	38.7812	1.9254	29.9295	5.8088	10.8305	1.8277	10.8969
	10	30.4387	2.2179	36.2350	4.9273	9.5829	1.4773	15.1209
ΔT	1	0.0032	1.2085	12.9709	6.2337	8.8467	0.0005	70.7365
	3	3.0529	13.1018	10.7866	5.1033	16.4266	3.7970	47.7317
	5	11.5641	9.1618	9.1747	10.2731	27.3039	1.7627	30.7596
	8	14.4721	15.4234	5.3606	14.2361	31.2063	0.9526	18.3488
	10	13.1004	18.0591	5.5818	15.1747	31.9927	0.8110	15.2803

From the table above, in the short-run, the forecast error variance of real GDP is the highest of all variables and explains about 4 percent of the forecast error variance of carbon emissions while in the long-run the impact of labour force is the highest and explain about 14 percent of the forecast error variance of carbon emission. Carbon emission accounts for 0.6 percent and 5.7 percent of the forecast error variance of energy uses in both the short-run and long-run respectively. The initial impact of carbon emission on the forecast error variance of energy uses is about 43 percent, which is higher than any other variable in the system. In the short-run and long-run, the impact of carbon emissions on the forecast error variance of energy uses is the highest followed by real GDP. The initial impact of income on forecast error variance of technological progress is 12.9 percent, this is the highest within the time range, increases to 12 percent at his peak in the fourth period, and later falls to 5.58% at the end of the tenth periods. The impact of labour on the forecast error variance of technological progress is highest for all horizon and range from approximately 9 percent to 32 percent.

CONCLUSION

This paper investigates the dynamic linkages among carbon emissions, energy consumption, income, gross fixed capital formation, labour force, technological progress, and trade openness in Malaysia from 1970 - 2012 using vector error correction model (VECM). The methodology adopted start with descriptive statistics, stationarity test using unit root methods such as Augmented Dickey-Fuller approach, Philip-Perronand other methods, followed by multivariate cointegration test developed by Johansen and Juselius (1990), Granger causality test in vector error correction model (VECM), impulse response function and variance decomposition method. The co-integration test found the existence of long-run relationship among the variables. Our results revealed that real GDP, trade openness and technological progress are relevance policy variables that have long-run impacts on carbon emissions reduction in Malaysia. The causality results found that there is a short-run and long-run Granger causality running from technological progress to carbon emissions reduction. There is no causality from any direction between carbon emissions and real GDP (income), and between carbon emissions and energy consumption in the short – run. . The finding of positive uni-directional short-run causality running from real GDP to energy uses implies that Malaysia is an energy dependence economy and more energy is required in the short-run to boost economic growth and development.Variance decompositions (VDCs), and Impulse response function (IRFs) were performed for a period of ten years, the IRFs found that shock to technological progress has negative impact on carbon emissions in Malaysia whereas the VDCs reveal thatthe impact of labour force on the forecast error variance of carbon emission would be the highest for the next ten years followed by energy consumption. Malaysia has the highest number of foreign workers in Southeast Asia (NAMM), constituting 30 percent of the labour force, and less than seven percent of them are skilled workers (Malaysia fact book). Policies shift in labour force by employing high skilled workers and re-training existing workers may have a long-run impact on carbon emissions abatement. Reduction in energy uses by replacing fossil fuels with alternative renewable sources of energy has long-run impact on carbon emissions reduction.

Government should increases the annual allocation of GERD/GDP from the current one percent of GDP to more than two percent in order to be able to achieve the Kyoto protocol obligations.

REFERENCES

Al-Mulali, Lee, Mohammed,&Sheau-Ting (2013).Examing the link between Energy consumption, Carbon dioxide emission and Economic growth in Latin America and the Caribbean. Renewable and Sustainable Energy Reviews 26: 42-48.

Al-mulali, Usama and Che, NormeeChe Sab. **(**2013). Energy Consumption, Pollution and Economic Development in Sixteen Emerging Countries, Journal of Economic Studies, 40, 7-7.

Akbostancı, Serap, &Tunc. (2009).The relationship between income and environment in Turkey: Is there an environmental Kuznets curve? Journal of Energy Policy 37 (2009) 861–867.

Ang,JB. (2007). CO2 emissions, Energy consumption, and Output in France .Energy Policy; 35:4772–8. [26]

Ang, JB. (2008). Economic development, Pollutant emissions and Energy consumption in Malaysia. Journal of Policy.

Azlina, A.A. &NikMustapha, N.M. (2012).Energyconsumption,economic growth and pollutant emissions nexus: the case of Malaysia.ProcediaSoc.Behav.Sci.65, 1–7.

Bowden, N.& Payne, J.E. (2010). Sectoral analysis of the causal relationship between renewable and non-renewable energy consumption and real output in the US. *Energy Sources, Part B: Economics, Planning and Policy*, 5(4), 400-408

Cheung & Lai (1995). Cheung, Y.W. and Lai, K.S. (1995) Lag order and Critical values of the Augmented Dickey-Fuller test.*Journal of Business and Economic Statistics*, 13: 277-280.

Cole, M.A. (2004), Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages. Ecological Economics 48 (1), 71–81.

Esteve&Tamarit (2012).Is there an environmental Kuznets curve for Spain? Fresh evidence from old data *Economic Modelling*, *Volume 29, Issue 6*, *November 2012*, *Pages 2696-2703*

Fallahi, F. (2011). Causal relationship between Energy consumption (EC) and GDP: A Markov-switching (MS) causality. Energy ;36:4165–70.

Friedl, B. &Getzner, M.(2003). Determinants of CO2 emissions in a Small Open Economy. Ecological Economics; 45:133–48.

Fodha, M. &Zaghdoud, O.(2010). Economic growth and Pollutant emissions in Tunisia: An Empirical Analysis of the Environmental Kuznets curve. Energy Policy 2010;38:1150–6.

Ghosh, S. (2009).Electricity supply, Employment and Real GDP in India: Evidence from Cointegration and Grangercausality tests. Energy Policy ;37:2032e7.

Granger, CWJ.(1988).Some recent Development in a Concept of Causality. J Econom 1988;39:199–211.

Halicioglu, F. (2009).An econometric study of CO2 emissions, Energy consumption, Income and Foreign trade in Turkey . Energy Policy;37:1156–64.

Glasure, Y. &A. Lee (1998). Cointegration, error-correction and the relationship between GDP and energy: The case of South Korea and Singapore. Resource and Energy Economics 20 (1), 17–25

Hossain, S.M.(2011).Panel estimation for CO2 emissions, Energy consumption, Economic growth, Trade openness and Urbanisation of Newly industrialized countries. Energy Policy 39, 6991–6999.

IEA (2009).International Energy Agency, Paris. *Energy Policy of IEA Countries: Portugal 2004 Review*.

IEA (2012) International Energy Agency, Paris. *Energy Policy of IEA Countries: Portugal 2009 Review*.

Izyan, NW.Azlina, AA.andNik, HM. (2013). Energy Consumption, Economic growth and CO2 emissions in selected ASEAN Countries. Prosiding PERKEM VIII, 758-765.

Jalil, A.&Feridun, M.(2011). The impact of Growth, Energy and Financial Development on the Environment in China: A Cointegration Analysis. Energy Economics;33:284–91.

Kanjilal, K.&Ghosh, S. (2013). Environmental Kuznets curve for India: evidence from tests for cointegration with unknown structural breaks. Energy Policy 2013 .

Kuznets, S. (1955).Economic growth and income inequality. The American Economic Review 1955;45:1–28.

Lean, HH.&Smyth, R.(2010). Multivariate Granger causality between electricity generation, exports, prices and GDP in Malaysia. Energy;35:3640–8.

Lee, C.-C.and Chang, C.-P. (2007) The impact of energy consumption on economic growth: Evidence from linear and nonlinear models in Taiwan. *Energy*, 32: 2282-2294.

Menyah, K., Wolde-Rufael, Y., 2010Energy consumption, pollutant emissions and economic growth in South Africa.Energy Economics 32:1374-1382.

Mugableh, M.I, (2013). Analysing the CO2 Emissions Function in Malaysia: Autoregressive Distributed Lag Approach.Procedia Economics and Finance, Volume 5, 2013, page 571-580.

Narayan, P. K. &Smyth, R. (2008). Energy consumption and real GDP in G7 countries: New evidence from panel cointegration with structural breaks. Energy Economics 30 (5), 2331–2341.

Narayan, PK. & Narayan, S. (2010) Carbon dioxide emissions and economic growth: panel data evidence from developing countries .Energy Policy 2010;38:661–6.

Lean, HH. &Smyth, R. (2010).CO2 emissions, electricity consumption and output in ASEAN. Applied Energy ;87:1858–64 .

OECD. (2011). Main Science and Technology indicators.

Omri, A. (2013). CO2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. Journal of Energy Economics 40:657-664.

Omri, A. (2014) Causal relationships between energy consumption, foreign direct investment and economic growth: Fresh evidence from dynamic simultaneous-equations models. Energy Policy 67:913-922.

Shahbaz, M. & Lean, HH. (2012). Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia Energy Policy; 40:473–9.

Shahbaz, M. Lean, HH. & Shabbir, MS. (2012).Environmental Kuznets curve hypothesis in Pakistan: cointegration and Granger causality. Renewable and Sustainable Energy Reviews 2012; 16:2947–53.

Shahbaz, M., Hye, Tiwari, &Leitao (2013). Economic growth, energy consumption, financial development, international trade and carbon dioxide emission in Indonesia. Renewable and Sustainable Energy Reviews 25: 109-121.

Say,N.P.&Yucel, M. (2006).EnergyconsumptionandCO2 emissions in Turkey: empirical analysis and future projection based on economic growth .Energy Policy 34,3870–3876.

Saboori, B.Sulaiman, JB. & Mohd, S. (2012). Economic growth and CO2 emissions in Malaysia: a cointegration analysis of the environmental Kuznets curve. Energy Policy 51:184-191.

Shobhakar Dhakal (2009).Urban energy use and carbon emissions from cities in China and policy implications. Energy Policy, 37 (2009) 4208–4219.

Soytas, U., Sari, R., (2003), Energy consumption and GDP: causality relationship in G-7 countries and emerging markets. Energy Economics 25, 33–37.

Soytas, U., Sari, U.&Ewing, BT. (2007).Energy consumption, income and carbon emissions in the United States. Ecological Economics ;62:482–9.

Tang, C.F. and Shahbaz, M. (2012) multivariate granger causality between electricity consumption, economic growth, financial development, population, and foreign trade in Portugal.

Tiwari, AK.,Shahbaz, M. & Hye MQA (2013), The environmental Kuznets curve and the role of coal consumption in India: cointegration and causality analysis in an open economy. Renewable and Sustainable Energy Reviews 2013 (forth- coming issue).

Tuah H, Nadaraja D, and Jaafar Z (2009), Benchmaking Malaysia Innovation Capacity. JEL Classification Number 31, Q32,Q47.

Warr, B. S. & Ayres,R. U. (2010). Evidence of causality between the quantity and quality of energy consumption and economic growth, *Energy*, 35, 1688-1693.

World Bank (2013).World Banks Report, retrieved @ data.worldbank.org.

World Bank, (2007).World Development Indicators, Washington, DC.