2011 International Conference on Economics and Finance Research
IPEDR vol.4 (2011) © (2011) IACSIT Press, Singapore

The Relationship between Income and Environment in UK's Road Transport Sector. Is There an EKC?

Nur Zaimah Ubaidillah
Faculty of Economics and Business
Universiti Malaysia Sarawak
Sarawak, Malaysia
unzaimah@feb.unimas.my

Abstract—**The hypothesis of Environmental Kuznet Curve (EKC) has become a phenomenon to determine the relationship between income and also environmental quality. Since transport sector has become one of the main contributors for air pollution in the United Kingdom (UK), the aim of this study is to determine the trend of emission from road transport in UK and the relationship with income. While most existing estimates of environmental Kuznet curve explores the relationship between environmental quality and income using carbon dioxide (CO2) emission as the measure of environmental degradation, we use a more sectoral specific indicator which is carbon monoxide (CO) emission. We find an inverted-U shape function of income for road transport in United Kingdom (UK). This indicates that reductions in emissions can be explained by the Environmental Kuznet Curve for road transport in UK.**

Keywords-component; CO_2, CO, GDP per capita, EKC

I. INTRODUCTION

Over the last decade, environmental sustainability has been an intense subject worldwide. Pertain to climate change and energy crisis, Kyoto Protocol is devised targeting to reduce greenhouse gas emissions mainly for 37 industrialized countries to an average of 5 per cent against 1990 levels from 2008 to 2012. Clearly, rapid growth of urbanization, industrialization and increase in traffic leads to massive environmental degradation which includes air pollution. (Azmi et al., 2009) Air pollution can cause negative effects including health consequences and disrupting the ecosystem's well-balanced. According to 1999 Charter on Transport, Environment and Health by World Health Organization (WHO), although the expansion of transportation yield to positive advantages, it also results in detrimental involuntary health issues including traffic crashes, exposure to air pollution, hearing impairment due to traffic noise, communities divide and reduce social support, affecting vulnerable groups as well as low-income citizens. Transport is an important tool of a country's progress. Rapid economic growth and increasing level of urbanization enhances a person's living standard hence it leads to a greater travel demands. This in turn highlights the important of transportation sector, the supply of transportation infrastructure and service. As a developed country, UK has adopted a well-managed transportation system in order to maintain environmental sustainability. Mohan and Tiwari (1999) elucidated that "a sustainable transport system must provide mobility and accessibility to all urban residents in a safe and environment friendly mode of transport." Concerns on air pollution in United Kingdom shifted from anthropogenic industries sources to the one associated with transportation sector primarily road sector. Health-damaging air pollutants main source is from fuel combustion, including fine and respirable particulate matter (PM2.5 and PM10), carbon monoxide (CO), sulphur dioxide (SO2), nitrogen oxides (NOx), volatile organic compounds (VOCs), ozone (O3), and atmospheric lead. (Mishra, 2003) Since this research focuses on the air pollutants in road transport under transportation sector, it is wise to highlight carbon monoxide (CO) as the main emission. The increase in population mainly in main cities led to urbanization, this in turns increases the number of private or passenger's vehicle which will emit higher pollutions. Greater income also induces people to personalize their travels. This is supported by Ramanathan (2000). Ramanathan (2000) explain that increase economic activities due to increase income demand greater passengers and freight mobility as well as more additions to transport infrastructure and equipment. This paper applies a data set on carbon monoxide for United Kingdom to indicate the level of emissions from transportation sector particularly road transport. The sample consists of 39 annual observations on each variable including carbon monoxide emissions and GDP per capita. Section 2 of the paper reviews the trends and patterns of road transport in the UK. Section 3 is the UK policies in transportation sector and section 4 discusses the literatures. Section 5 sets out the model, data and section 5 presents our results. In section 6, we conclude the paper.

II. TRENDS AND PATTERN OF ROAD TRANSPORT IN THE UNITED KINGDOM

The transportation sector is the main contributor of air pollution in United Kingdom. Therefore thorough and systematic attention should be given in this area of research. The pattern of road transport particularly the growth in the number of vehicles, closely follow the increase in population. Furthermore, for industrialized country, increase urbanization leads to a rise in standard of living and this increase the number of vehicle. First we analyzed the growth of licensed motor vehicles in UK for selected years.

Passengers car account for more than half of total vehicle in UK from 1970-2008. However, the number drops from 80 per cent in 2000 to 79 per cent in 2008. This is followed by LDV (Light Duty Vehicle) with approximately 1 per cent of motor vehicle share. Motorcycles share of motor vehicles is significantly declining from 7 per cent to 3 per cent in 2008. HGV (Heavy Goods Vehicle) shows a decline of 3 per cent from 1970-2008. [Other vehicles include special machines/special concessionary, special vehicle group and crown and exempt vehicles] Public vehicles recorded a share of less than 1 per cent. These trends indicated that Passengers Cars are much more preferable as modes of transport compared to other mode of transport. A further observation is illustrated in Figure 1 where trend of population, CO and number of vehicles are plotted from the period 1970-2008. Total number of vehicles is increasing with the rise of population. Emissions of CO has been steadily increasing from 1970-1992. CO emissions decline for the period 1974-75 due to the oil crisis which led to a hike in the price of motor fuel. The CO emissions experienced significant decline from 1993-2008 owing to an increase in the catalytic converters and fuel switching from petrol to diesel cars. Road transport particularly vehicles using petrol are important source of CO emissions. (AEA Energy & Environment, 2007) This fuel efficiency method or technology reduce the emissions of CO, NO_x and VOC by the usage of a three-way catalyst, in addition with the indirect exclusion of lead from vehicle exhaust as vehicles equipped with catalysts are required to function on unleaded fuel, are highly trusted to overshadow adverse consequences. The limitation from applying catalytic converters incorporates with the rise of CO_2, N_2O and NH_3 emissions. (Colvile et al., 2000). Figure 2 explains the relationship between between CO emissions and GDP per capita in UK from 1970-2008. The figure explains the EKC relationship between pollutant emission and income whereby CO emissions increase as GDP per capita increases until it reaches a turning point and decline.

III. LITERATURE REVIEW

For decades, economic growth has always been linked with environment degradation. Numerous studies on the relationship were explored and the Environmental Kuznet Curve (EKC) was introduced in 1955. Andreoni and Levinson (2000) explain that the plausible reason of the EKC can be justify by Arrow et al.'s (1995) whereby "the pattern which reflects the natural progression of economic development, from clean agrarian economies to polluting industrial economies to clean service economies". Andreoni and Levinson further elucidated that according to Suri and Chapman (1998), these circumstances could be facilitated by the condition where Developed Countries transferring their production processes which are pollution based to Less Developed Countries.

An opposite proponent against EKC is from Stern et al. (1996) stating that the fundamental problems in EKC parameters estimation depends on the notion which relies on a model of the economy whereby there is no feedback from the environmental quality to production possibilities, and trade has neutral effect on degradation of environmental. Stern (2003) explains that the scale effect of rising income per capita emissions can be overcome by growing middle income countries, the increasing income effects overwhelm the contribution of changes of technology in emission reduction. This explains that the varying impact of income and technological change between high and lower income countries. Jalil and Mahmud (2009) investigated the long run relationship between carbon emissions and energy consumption, income and foreign trade in the case of China using time-series data for the period 1970-2005. The results concluded that Environmental Kuznet Curve (EKC) exists and that CO_2 emissions are determined by income and energy consumption in the long run. Narayan and Narayan (2010) investigated the EKC hypothesis based on the short- and long-run income elasticity for 43 developing countries. The results, using the panel cointegration and the panel long-run estimation techniques, only Middle Eastern and South Asian panels, the income elasticity in the long run is smaller than the short run, indicating that carbon dioxide emission has decrease with an increase in income.

IV. MODEL AND DATA

EKC relationship explains the relationship between income and economic quality. Generally EKC hypothesis can be based on the following formula:

$$E = f(Y, Y^2) \quad (1)$$

Where E is an environmental indicator and Y is the income. In this study we investigate the existence of EKC at time series from 1970-2008. The time series model used in the study is formulated using Dinda (2004) and de Bruyn et al. (1998) as follows:

$$E_t = \alpha + \beta_1 Y_t + \beta_2 Y^2_t + \varepsilon_t \quad (2)$$

In this case, we use carbon monoxide per capita, CO emissions in UK as the environmental indicator. The income variable Y is the GDP per capita in constant US dollars. The different values for coefficients of income terms could indicate different functional forms. Among some of the possible alternatives, we can consider the following: $\beta 1>0$ and $\beta_2=0$ will indicate a monotonically increasing relationship between income and pollution. $\beta_1>0$, $\beta_2<0$ will indicate an inverted U-shaped relationship between income and pollution. We use carbon monoxide emissions data set which represents the emissions from fuel combustion from UK's transportation sector particularly road transport. The data estimated emissions of carbon monoxide (CO) are the total emissions by UNECE source category in thousand tonnes. The data estimates are chosen as it is the most suitable indicator for environmental degradation in road transport. We use GDP per capita data from World Data Bank (WDB) and Global Development Finance (GDF). These data are in real 2000 international US dollars.

V. EMPIRICAL FINDINGS

Table 1 summarizes the results of the unit root test by applying the Augmented Dickey Fuller test. ADF test results show that the null hypothesis of existence of a unit root cannot be rejected at levels however; the null of a unit root is rejected in first difference. Therefore, we can conclude that all series are I (1) at 5% significance level at first difference at trend and intercept. Given that CO_t, $GDPC_t$ and $GDPC^2_t$ share common integration properties, we can now proceed to testing for the presence of a common trend, or similarly, a long-run cointegrating relationship between the variables. Due to the sensitivity of Johansen Juselius test towards the lag length, we obtain the optimal lag length through nested likelihood ratio test on level VAR prior to conducting the cointegration test. The optimal lag length is found to be three. We perform the Johansen Juselius cointegration test to assess the cointegration evidence. However, according to table 2, the results of trace tests and maximum eigenvalue tests point to different conclusion. According to trace test, there are two cointegrating relationship at 5 % significance level, while maximum eigenvalue test does not provide any cointegration relationship. Therefore we can conclude that there is a unique long run relationship pollution and income variables. Our cointegration equation has the following form:

$$CO_t = \beta_0 + \beta_1 GDPC_t + \beta_2 GDPC^2_t \quad (3)$$

Estimated long run relationship between CO emission and income variables for UK's road transport sector can be written as:

$$CO_t = -0.3838 + \underset{(-25.8472)}{0.0000458 GDPC_t} - \underset{(24.1648)}{0.00000000107 GDPC^2_t} \quad (4)$$

The coefficients of the long-run cointegration relationships and the standard errors given in the parentheses show that coefficients of the cointegration vector are all statistically significant. We can interpret the cointegration relationships given in Eq (4) in terms of EKC hypothesis. For both of the estimated long-run relationships, it is found that $\beta_1 > 0$ and $\beta_2 < 0$. This result implies that the relationship between the CO emissions in UK's road transport and income follows an inverted U-shaped supporting the concept of EKC. The estimated turning point is $21,402 at 2000 constant price.

VI. CONCLUSION

Results of the time series model show that pollution and income variables are cointegrated meaning that a unique long run relationship between these variables exists. The estimated long run relationship follows EKC whereby the air pollution tends to increases as income increases until it reaches a turning point at income $21,402 and decline afterwards. Given these findings, we can conclude that EKC hypothesis supports the relationship between CO emission and income in the case of UK's road transport. We can justify that as income increase, the pollution increases as there is a high usage of fuel combustion due to increase usage of private or passengers' vehicle, however up to the certain point, awareness on the importance of clean air rises leads to improvement in technology, behavior and rules. These actions show the importance of reducing pollution as a result from road transport which might exacerbate if not contained. An important lesson obtained through the EKC analysis in this study is as a developed country, UK has proven to prioritized its obligations towards maintaining the preservation of environmental quality along with economic development by continuously devising and improving the policies on protecting the country against environmental degradation.

ACKNOWLEDGMENT

The author would like to thank University Malaysia Sarawak for the financial assistance grants.

REFERENCES

[1] Azmi, S. Z., Latif, M. T., Ismail, A.S., Juneng, L., & Jemain, A. A. (2009). Trend and status of air quality at three different monitoring stations in the Klang Valley, Malaysia. *Air Quality, Atmosphere & Health*, *3 (1)*, 53-64.

[2] Colvile, R. N., Warren, R., Mindell, J., & Hutchinson, E. (2001). The transport sector as a source of air pollution. *Atmospheric Environment, 35 (9),* 1537-1565.

[3] Mishra, V. (2003). *Health Effects of Air Pollution*. Background paper for Population-Environment Research Network (PERN) Cyberseminar, December 1-15, 2003.

[4] AEA Energy & Environment. (2007). *UK Emissions of Air Pollutants 1970 to 2005*.

[5] Shafik, N. (1994). Economic development and environmental quality: An econometric analysis. *Oxford Economic Papers*, 46, 757-773.

[6] Holtz-Eakin, D. & Selden, T. M. (1995). Stoking the fires? CO_2 emissions and economic growth. *Journal of Public Economics*, 57, 85-101.

[7] Xiangzhao, F., & Ji, Z. (2008). Economic analysis of CO_2 emission trends in China. *Chn Popu Res Envi*, 18 (3), 43-47.

[8] Say, N. P., & Yucel, M. (2006) Energy consumption and CO2 emissions in Turkey: empirical analysis and future projection based on economic growth. *Energy Policy*, 34, 3870-3876.

[9] Halicioglu, F. (2009). An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. *Energy Policy*, 37, 1156-1164.

[10] Zhang, M., Mu, H., Ning, Y., & Song, Y. Decomposition of energy-related CO2 emission over 1991-2006 in China. *Ecol Econ*, 68, 2122-2128.

[11] Apergis, N., & Payne, J. E. (2009). CO2 emissions, energy usage, and output in Central America. *Energy Policy,* 37, 3282-3286.

[12] Sharma, S. S. (2010) Determinants of carbon dioxide emissions: Empirical evidence from 69 countries. *Applied Energy*, 88, 376-382.

[13] Chang, C. (2010). A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. *Applied Energy*, 87, 3533-3537.

[14] Dinda, S. & Coondoo, D. (2006). Income and emissions: A panel based cointegration analysis, Ecological Economics, 57, 167-181.

[15] Jalil, A. and Mahmud, S. F. (2009). Environment Kuznets curve for CO2 emissions: A cointegration analysis for China. *Energy Policy,* 37, 12, 5167-5172.

[16] Narayan, P. K., & Narayan S. (2010). Carbon dioxide emissions and economic growth: panel data evidence from developing countries. Energy Policy, 38, 661–6.

[17] History of UK Transport Policy. (2010). Nottingham University.

[18] Air Pollution Fact Sheet Series. (2002). Atmosphere, Climate and Environment Information Programme. Manchester Metropolitan University. United Kingdom.

[19] Liu, G. (2006). A causality analysis on GDP and air emissions in Norway. Discussion Papers 447, Research Department of Statistics Norway, at: www.ssb.no/publikasjoner/DP/pdf/dp447.pdf.

[20] Climate Change Act. (2008). United Kingdom.

[1] Mohan, D. & Tiwari, G. (1999). Sustainable transport system: Linkages between environmental issues, public transport, non-motorised transport and safety. *Economic and Political Weekly, 34*(25), 1589-1596.

[2] Ramanathan, R. (2000). Link between population and number of vehicles. *Cities,* 17(4), 263-269.

[3] Department for Transport. (2010). *Vehicle Registration and Licensing Statistics*. United Kingdom.

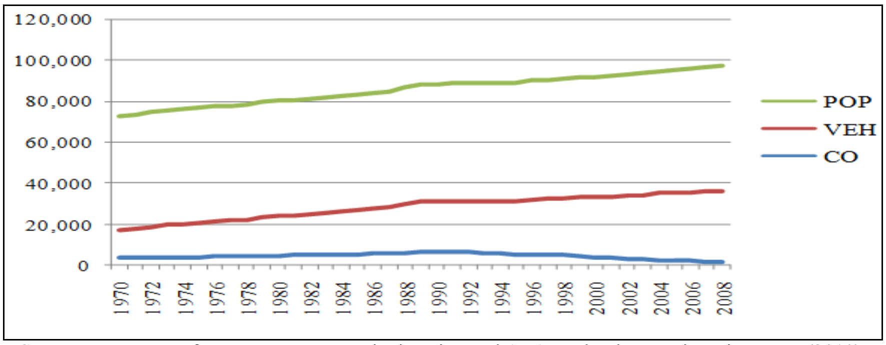
[4] World Data Bank (WDB) and Global Development Finance (GDF). (2010). United Kingdom Country Data Statistics.

[5] De Bruyn, S.M., van den Bergh, J.C.J.M., & Opschoor, J.B. (1998). Economic growth and emissions: Reconsidering the empirical basis of environmental Kuznets curves', *Ecological Economics*, 25.

[6] Dinda, S. (2004). Environmental Kuznets Curve Hypothesis: A Survey. *Ecological Economics*, 49, 431-55.

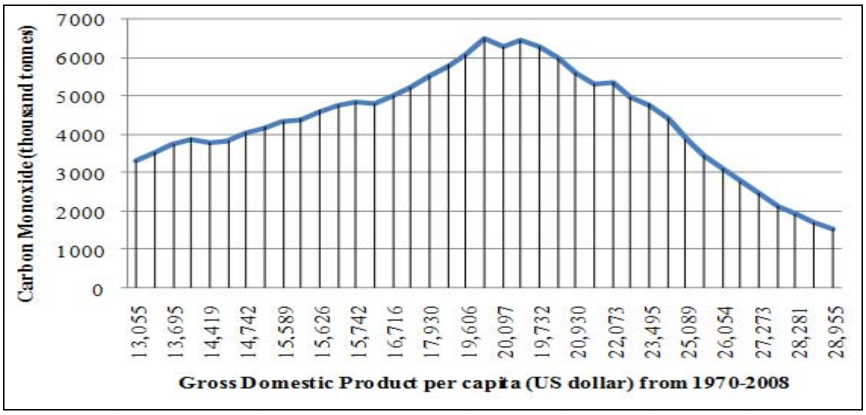
APPENDIX

Figure 1. Trends of Populations, Carbon Monoxide Emission and Number of Vehicles, thousands (1970-2008)



Source: Department for Transport UK, United Nation and AEA Technology and Environment (2010).

Figure 2. Environmental Kuznet Curve (EKC), 1970-2008.



Source: Data from Department for Transport UK, United Nation and AEA Technology and Environment.

TABLE I. AUGMENTED DICKEY FULLER TEST

Series	LEVEL & INTERCEPT	LEVEL & TREND & INTERCEPT	1ST DIFFERENCE & INTERCEPT	1ST DIFFERENCE & TREND & INTERCEPT
CO	-1.1379 (0.6900)	-1.1075 (0.9137)	-1.5564 (0.4941)	-3.6727 (0.0371)**
GDPC	1.0017 (0.9957)	-2.0428 (0.5594)	-3.8892 (0.0051)**	-4.1569 (0.0121)**
GDPC2	1.4493 (0.9988)	-1.5132 (0.8069)	-2.9537 (0.0489)**	-3.7809 (0.0294)**

(*) and (**) indicate 10% and 5% level of significance, respectively. H_0 = the series has a unit root. SIC is used to select the lag length.

TABLE II. JOHANSEN JUSELIUS COINTEGRATIONTEST

H_0	H_1	Trace Statistics	5% Critical Value	Max-Eigenvalue	5% Critical Value
r=0	r=1	32.5482**	29.7971	16.7847	21.1316
r≤1	r=2	15.7635**	15.4947	13.2663	14.2646
r≤2	r=3	2.4972	3.8415	2.4972	3.8415

(*) and (**) indicate 10% and 5% level of significance, respectively. The letter "r" represents the number of cointegrating equations.