ANALYSING CO₂ EMISSIONS DUE TO EXPENDITURE ON TRANSPORTATION BY MALAYSIAN HOUSEHOLDS

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ABSTRACT

The objective of this study is to analyse the impact of Malaysian household consumption on transportation sector towards CO₂ emissions by using Hybrid Input Output Table 1991, 2000, 2005 and 2010. Initially, this study calculates CO₂ emissions intensity for every sector. Results show that the sector with the highest CO₂ emission intensity was Transportation at 1.16 (T- CO₂/M-MyR). By using the hybrid I-O table, the average values of the total CO₂ emission intensity caused by energy consumption in Malaysia were found to 0.272 (T- CO₂/M-MyR). Transportation sector has contributed the relatively high of consumption and produces the highest of CO₂ emission in 1991, 2000, 2005 and 2010. Our analysis shows that continuously increasing consumption in Transportation sector will continue to affect the environment. Thus, through encourage consumers to use hybrid or solar car and impose higher carbon tax on old vehicles owners will reduce the CO₂ emission. By imposing a carbon tax, motor vehicle owners will strive to reduce their CO₂ emissions by consuming renewable energy or energy saving technique.

Field of Research: CO₂ emission, transportation, expenditure, input-output analysis

1. Introduction

Since its remarkable change from an agriculture country to an industrialized country, Malaysia has seen its GDP has grown from RM105 billion in 1990 to RM1,012 billion in 2014. There is a strong relationship between income and expenditure because when incomes increase, expenditure patterns tend to change (Sanne, 1998). Households benefited from the continued increase in disposable income arising from high export earnings and economic growth which also generated full-employment and income-earning opportunities among Malaysians. Moreover, the competitive credit provided further support to more household spending particularly on motor vehicles.

In general, consumption is obviously something good and the more the consumption the better enhanced is the lifestyle. With increasing consumption households have been able to extend out and enlarge their possibilities further than what was previously possible (Sachdeva et.al. 2015; Affredson, 2004). Based on Figure 1, household spending patterns is due to the introduction of GST in 1 April 2015. In Malaysia, most families having more children spend a lot of their total consumption expenditure on housing, food, transportation and travel, a consumption pattern that is different for small households with fewer children living in small houses and spending most of their money on transportation and travel. However transportation is not using a large part of total household expenditure as shown in Figure 1.
According to Department of Statistics (2015), about 13.8 percent of total private consumption comes from Transportation. However in term of energy consumption, Transportation sector consumed the highest energy as shown in Figure 2.


Figure 1: Type of Expenditure by Malaysian Households.

Figure 2: Final Energy consumed by Sectors
Energy consumption by the Transportation sector only competes with that by the Manufacturing sector. The energy consumption by the transportation sector represents energy used for all kinds of transportation except international marine bunkers. This sector covers road, air, railway and internal navigation. Demand of household on transportation sector has contributed the highest CO$_2$ emissions due to the number of private motor vehicles and public transportations on Malaysian roads has steadily increased thereby increasing the population and energy consumption as shown in Figure 3.

![Graph showing relationship between total of registered motor vehicles and population](http://worldconferences.net/home/)

Source: Ministry of Transportation and United Nation Statistic Division, WDI (2015)

**Figure 3:** Relationship between total of registered motor vehicles and population

Besides that, petroleum products used motor vehicle also cause side effects on the environment because its relies on non renewable energy such as petroleum products. The growth rate of motor car ownership in the established markets tends to slacken over time as the diffusion rate increases. It is the same trend seen for most other household durables as they near the point of dispersion. Increased transportation usage, combined with inadequate road systems, has caused unendurable traffic congestions in large cities such as Kuala Lumpur, Penang and other developing cities. This in turn has effected huge economic losses as well as worsened the environment in Malaysia. Private motor vehicles pollute environment by emitting CO$_2$ and other greenhouse gases (GHG) from fuel combustion, fuel supply, vehicle manufacture and disposal. Motor vehicle noise also disrupts animal habitats and migration routes. The road transportation is the most significant contributor to the environment impact in Malaysia which consumed about 36% of the total energy (Kamarudin et.al, 2009: Kim and Lee, 2012).
Nowadays, many countries struggle to emit zero carbon from energy consumption but this is very difficult to achieve. Although, carbon dioxide can be cleaned, this requires both short- and long-term investments (Radetzki, 2001) and is mainly for countries with high GDP. The trade-off between economic growth and environmental degradation is a dire concern before it reaches a point of no return. It is very important to save the environment through efficient energy management and consumption before the drop in quality of the environment becomes irreversible. With rapid development, transportation sector has contributed significantly to development of socioeconomic of the country and its contradiction to quality of environment. Recently, the transportation sector accounts for 28% of total CO₂ emissions, of which 85% comes from road transport (Mustapa and Behket, 2016). However, the threat posed by the generation of CO₂ emissions was not appreciated but has grown until today where it now appears as serious global warming causing climate changes (IPCC, 2006).

Household activities are among the major contributors to the generation of CO₂ emissions through burning of fossil fuels for private motor vehicles. In recent years, the number of private motor vehicles on Malaysian roads has steadily increased thereby increasing the consumption of fossil fuels. Moreover, Malaysia has shown its concern for the environment in its declaration to reduce the amount of carbon dioxide in the air by up to 40 percent by the year 2020 in comparison to the 2005 level even though Malaysia is a non-annex 1 country in the Kyoto Protocol. According to the National Energy Balance (2015), the trend of energy consumption and production will continue to rise in the next few years. In that case, a shortage of energy will occur in the future if the consumers use energy inefficiently and the amount of CO₂ emissions also will increase.

This study aims to analyse the impact of Malaysian household consumption on transportation sector towards CO₂ emissions using Hybrid Input Output Table 1991, 2000, 2005 and 2010. This paper is
organized as follows. Section 2 presents a literature review of energy consumption and CO₂ emission by Transportation setor. Section 3 describes an overview of the model employed in this study. Section 4 presents results and findings. Conclusions and Policy implications of the results are discussed in Section 5.

2.0 Literature Review

The relationships between population, economic growth, energy consumption and environmental have been greatly analyzed over last two decades. Meadows et al. (1992) stated that far from being a hazard to the environment in the long term, economic growth emerges to be necessary to maintain and improve the environmental quality. Population density, energy consumption and economic growth have positive relationship to CO₂ emissions both in the short-run and long-run (Ohlan, 2015). Many studies have analysed the CO₂ emissions and implementing various policies and planning to reduce CO₂ emissions. Therefore, various studies done are reviewed in order to reduce CO₂ emissions. Benders et al. (2006) used a simple method to estimate changes in consumption that were assessed during the period of survey by suggesting to the households the way to use energy efficiently. Several researchers applied an econometric model for environment analysis. For instance, Shahbaz et.al (2013) studied the linkages among economic growth, energy consumption, financial development trade openness and CO₂ emission by using Zizot-Andrew unit root test and ADRL found that the variable are cointegrated. Rawshan et.al, (2015) found that economic growth influences energy demand and CO₂ emission. While Shahbaz et.al (2016) found that relationship between urbanization and CO₂ emissions is Ushaped.

Increase in population size will affect the environment through energy consumption by transportation sector because the relationship between them very significant in various countries. Brand and Boardman (2008) found that about 43% of total GHG emission is responsible by 10% of household in UK from personal travel. Achour and Belloumi (2016) studied the causal relationships between transportation energy consumption and CO₂ emission generated by transportation using Johansen Multivariate counteratation approach. Alipour (2016) found that that there is a positive relationship between urbanization and CO₂ emissions is Ushaped.

The study use the methods of input output analysis and hybrid analysis that are combinations of the two units are monetary and physical unit (Leontief, 1966). The use of input output analysis for energy requirement was applied by Bullard and Hurendeen (1975) and Wright (1974). Then followed with the overview on input output energy requirement by Peet (1993) and emissions as external multiplier to the model as mentioned by Miller and Blair, (2009). The Hybrid analysis is also work intensive and requires complete data that worked in method of firm calculation by Van Engelenberg et al (1994) which already proposed by Bullard et al (1978) followed by Vringer and Blok, (2000) and Vringer et al.,( 2006).

Then this analysis growing used for energy analysis and environment as worked by Suh et al. (2004); Vringer and Blok (1995a, 2000); Lenzen and Dey (2002). Chung et al (2009); Liu et al, (2010); estimated energy intensity and GHG emission intensity in Korea using Hybrid input output analysis (HIO), Liang et.al (2010) proposed HPIOMEA. Zhou and Kojima (2009); Chen and Zhang (2010) came across with the GHG emission embodiment. Wiedenhofer et.al (2013) found that energy requirements are influenced by urban form, income and demographics. Wang and Yang (2016) found that declining energy intensity contributes the most to emission reductions, followed by
residential lifestyle in Beijing. Households are the most significant contributors to the generation of CO₂ because of the direct impact of their energy consumption and the indirect impact of their demand for products and services (Park and Heo, 2007; Reinders et al., 2003; Yuan et al., 2015).

Among all final demand factors, the impact of household consumption on energy consumption and CO₂ emission has drawn significant attention in recent years particularly on transportation sector. There are very limited study on energy consumption and CO₂ emissions using Input Output Model. Chen and Chen (2015) discussed that transportation sector consume more energy compared to Service sector because flow of indirect energy of this sector is high. Literature has uncovered the energy consumption caused by household consumption, and more importantly, emphasized the indirect energy consumption accounting for a large proportion in the total energy consumption. Fan and Lei (2016) found that the primary positive drivers of carbon emissions in the transportation sector and negative drivers are the transportation intensity and energy structure.

In Malaysia, there are limited studies and reports on topics that apply hybrid input-output analysis (HIOA). In other words, the process of analysis was used to calculate the energy requirement of the energy intensive products while the input–output analysis was applied to calculate that of other products. Moreover, HIOA is an important method in the analysis of energy, especially for resources to meet energy demand and the impact of final use energy by sectors such as the energy consumed by households direct and indirect.

3.0 Methodology

CO₂ emissions intensity by sectors

The basic I-O model extended into environmental I-O analysis considers additional intersectoral flows, for instance natural resources (energy) and pollution (green house gas) in addition to the conventional economic flows. In this study, in order to extend a standard I-O model into an environmental input-output (E-I0) model, the direct CO₂ emission matrix (W) was introduced. In order to calculate indirect CO₂ emission by the household, the CO₂ intensity or multiplier in equation (1) was used by using the extended input-output model first introduced by Leontief and Ford (1972) and later extended by others, for example Munskgaard et al. 2000; Cruz (2002), Kim (2002) and Chung et al. (2009). The basic environmental I-O model can be represented using the equation as follows:
Equation (1) can be represented in matrix form:

\[
W = (m \# r) f
\]

where \( W \) denotes a scalar of CO\(_2\) emission intensity for sector 1 to sector 40, \# denotes element by element multiplication (cell by cell), \( f \) is transpose of an 1x11 vector of CO\(_2\) emissions per unit of energy consumption of each of the 11 energy types or considered as CO\(_2\) emission factor; \( m \) is a 40x11 matrix of energy mix or energy consumption in the production sectors for sector 1, i.e. demand for 11 energy types per unit of total demand for energy for all production sectors; \( r \) is a 40x1 vector of total energy intensity for sector 1, i.e. total energy consumption per unit of all 40 sectors.

### Total CO\(_2\) emissions by sectors

Firstly, the quantity of CO\(_2\) emission for each industry can be expressed in matrix form as follows:

\[
E_c = W \cdot (I - A)^{-1} \cdot C
\]

Equation (2) can be represented in matrix form:

\[
E_c = \begin{bmatrix}
W_{11} & W_{113} & W_{140} \\
W_{13} & \cdot & \cdot \\
W_{40} & \cdot & \cdot \\
\end{bmatrix}
\begin{bmatrix}
(l-a_{11}) & -a_{113} & -a_{140} \\
- \cdot & \cdot & \cdot \\
- \cdot & \cdot & \cdot \\
\end{bmatrix}
\begin{bmatrix}
C_{11} & C_{113} & C_{140} \\
C_{113} & C_{113} & C_{1340} \\
C_{140} & C_{1340} & C_{4040} \\
\end{bmatrix}
\]
where $E_c$ is denoted as a scalar of total CO$_2$ emission from the production sectors, $W$ is a 40x1 vector of CO$_2$ emission intensities, i.e. total CO$_2$ emission per unit of production sector in all 40 sectors; $(I-A)^{-1}$ is the 40 x 40 Leontief inverse matrix, $C$ (Private consumption). With the last equation, changes in the total emission of CO$_2$ can be attributed to changes in the factors $W$ (CO$_2$ emission intensity), $L$ (Leontief inverse), and $C$ (private consumption).

**Data sources**

This study utilized two kinds of data:

The first set of data was based on four Malaysian input-output tables for the years 1991, 2000, 2005 and 2010 from the Department of Statistics (DOS).

The second set of data regarding the energy consumption for the years 1991-2015 were taken from the National Energy Centre (PTM).

The CO$_2$ emission factors were calculated on the basis of the carbon contents of the fuels (as shown in the IPCC revised 1996-Module 1- Tier 1).

**4.0 . Results and Discussion**

High embodied energy intensity will affect CO$_2$ emission intensity through energy consumption. The results from quantifying the CO$_2$ emission intensities show that the sector with the highest CO$_2$ emission intensities. The regression analysis can be applied to determine the relationship between CO2 emissions intensity and household consumption for 2010 based on private consumption (Final demand, 2010). By using the hybrid I-O table, the average values of the total CO$_2$ emission intensity caused by energy consumption and household expenditure in Malaysia were found to 0.272 (T-CO$_2$/M-RM) and RM 8, 787,622 thousand, respectively as shown in Figure 5. This figure has divided into quadrant of low-high (Quadrant I), high-high (Quadrant II), low-low (Quadrant III) and high-low (Quadrant IV). Most of the sectors lie on average values except for Cements and Transportation sector. The main concern of this study is Transportation sector due to it has the highest CO$_2$ emission intensity at 1.16 (T-CO$_2$/M-MyR) even household consume less on this sector.
In an effort to reduce CO2 emissions, CO2 emissions intensity must be reduced in initial stage. The way how to reduce CO2 emissions intensity through the changes of lifestyle, use solar power, greentech product and encourage people to consume renewable energy. This study also applied the regression analysis to estimate the relationship between consumption and CO2 emission produced as shown in figure 6, 7, 8 and 9 based on Equation 2. The result from Equation 2 shows that in the case of total energy use in 1991, 2000, 2005 and 2010, the average values of consumption by sector and CO2 emission intensity of the 40 economic sector including energy and non energy sector were shown in every figure. Those figures show the relationship between consumption by sector and CO2 emission produced in by consumption.

Every scatter plot have divided into four quadrants i.e. quadrant I, II, III and IV. Most of sector lays in quadrant II and III compared to quadrant I and IV. The sector that lies in quadrant I indicates that this sector contributed high consumption with low CO2 emission while the sector that lies in quadrant II indicates that this sector contributed high consumption with high of CO2 emission. The sector that lies in quadrant II indicates that this sector contributed low in consumption with low CO2 emission. The sector that lies in quadrant IV indicates that this sector contributed high in consumption with low in CO2 emission.

The sectors lies in quadrant I and II are produced high CO2 emission products. Figure 6 show the relationship between consumption and CO2 emission from consumption in 1991 as shown in. From this figure, it shown that there was less sectors that lies in quadrant I and IV. Most sectors lies in quadrant II and III. By observing the quadrant II, transportation has contributed the relatively high of consumption and produces the highest of CO2 emission. In 1991, transportation sector is the most polluted due to the highest of CO2 emissions intensity even the consumption by households less than consumption on real estate and wholeslae and retail trade (Figure 6).
Figure 6: Distribution of 40 sectors from the private consumption, 1991

However figure 7 shows the relationship between CO2 emissions and consumption by households in 2000. Average value of consumption and CO2 emissions increased by 98% from 1991 to 2000, the sectors that lie in that scatter diagram have much remain unchanged if compared to figure 6. The transportation still contributed the relatively high of consumption and produces the highest of CO2 emission in 2000.

Figure 7: Distribution of 40 sectors from the private consumption, 2000

Figure 8 shows the transportation still contributed the relatively high of consumption and produces the highest of CO2 emission in 2005. However average value of consumption and CO2 emissions increased by 44.8% and 92.8%, respectively.
Figure 8: Distribution of 40 sectors from the private consumption, 2005

More sectors in Quadrant II in 2005 have moved near to Quadrant IV in 2010 (as shown in Figure 9). Transportation still contributed the highest CO2 emissions in 2010. However, the transportation still contributed the relatively high of consumption and produces the highest CO2 emissions in 2010. Private Consumption increase about 51 percent from 2005 to 2010. Based on National Account, private consumption contributed 91 percent in GDP 2015 after export.

Figure 9: Distribution of 40 sectors from the private consumption, 2010

Most of sectors are located in quadrant III and IV indicates that this sector low dependence on energy source and characterized by industries that use environmental friendly process in terms of energy use because this sector are remain below the horizontal average value line for CO2 emission.
This distribution is very important in order to identify the energy intensive sectors because more energy use will produce more CO2 emission. This study estimates that consumption in Transportation sector still contributes the highest CO2 emissions in the future. Based on data of Private Final Consumption Expenditure 2016, expenditure by households on Transportation increased by 36% from 2010 to 2015 compared to from 2005 to 2010 consumption on that sector increased by 29%. From this figure, it shown that expenditure on Transportation continues to increase causing level of CO2 emissions also rise. In addition, Malaysian transportation sector has generated about 28% of total CO2 emission which is 85% comes from road transportation.

5.0 Conclusion and Policy Implication

The trend of private consumption shows that when consumer income rises, the consumption pattern also changes particularly demand on transportation, wholesale and retail trade, construction and electricity (National Account 2016). From this figure 6, 7, 8 and 9, demand on motor vehicles is the highest after wholesale and retail trade and this sector produced the highest of CO2 emission. Based on National Energy Balance (2014) energy consumption of that sector still relatively high particularly on road transportation which is contributed the largest share of total CO2 emissions by 82% (Mustafa and Bekhet, 2016). Based on this analysis, CO2 emissions intensity of Transportation is difficult to reduce due to growing of Malaysian economy and demands on motor vehicles continued to grow. The conclusion can be made, Malaysia is difficult to achieve its target of reducing its CO2 intensity, and however Malaysia can achieve the target if it’s gradually change to renewable energy such as bios, solar power, nuclear and hydropower as well as educate people to change their lifestyle and behaviour towards green tech and environmentally products.

Malaysian is still not aware on climate change and global warming. Management of public transportation also must be efficience because its can encourage people to use public transportation particularly bus and taxi. Moreover, public transport only contributed about 5% of total CO2 emissions of the the road transportation sector in Malaysia and motorcar as well as motorcycle contricuted by 52% and 15%, respectively (Mustafa and Bekhet, 2016). From this percentage, most of Malaysia prefers to use private transportation rather than public transporatation for travelling. This study also provides information to the government and policy makers in identifying the sectors that consume a large amount of energy and produce a large amount of CO2 emissions.

In this study, energy consumption shown to be is increasing for the sectors Transportation. Therefore, CO2 emissions will rise. This sector has not been able to achieve their voluntary targets in reducing their CO2 emissions due to increasing in demand of motor vehicles. With this information, the government can encourage consumers to use hybrid or solar car and impose higher carbon tax on old vehicles owners so that they become more concerned about the current environment level. The old engine may cause incomplete combustion that generates more CO2 compared to new vehicles. By imposing a carbon tax, motor vehicle owners will strive to reduce their CO2 emissions by consuming renewable energy. A measure such as this need to be taken as this sector is still high CO2 emissions and high CO2 emission intensity. The findings of such future study have the potential to indicate the best way in the short term to curtail or control growth in CO2 emissions as domestically, consumption is the highest contributor to GDP compared to government spending. This responsibility to protect the environment rests on the household due to its important place in the economy.
References


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