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# Impact of Malaysian Industrial Energy Use on Carbon Dioxide Emissions

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### ABSTRACT

Environmental issues such as global warming and climate change have negative effects on Mother Nature resulting in floods, landslides, erosion and extreme heat. Otherwise, the positive effect on the economy subsequent to disaster is through the substitution of capital. Currently the Malaysian energy policy highly promotes energy efficiency and focuses on high value added sectors that produce less CO<sub>2</sub> emission. This study attempts to identify the impact of Malaysian industrial energy use on CO<sub>2</sub> emission by analyzing energy intensity and CO<sub>2</sub> emission intensity. This study found that the transportation sector produced the highest value added but has the highest CO<sub>2</sub> emission. The findings of this study will prompt energy policy makers to examine the sector and promote low carbon energy use among its users. At the same time the high value added (productivity) sectors should be encouraged to produce less CO<sub>2</sub> emission to protect the environment. In order to reduce CO<sub>2</sub> emission, the energy intensive sectors will also have to reduce energy consumption by adopting energy efficient technology that produces less CO<sub>2</sub> in the future.

*Keywords:* CO<sub>2</sub> emission intensity, energy efficiency, energy intensity, sectors, value-added

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### INTRODUCTION

Rising production of goods and services will consume more energy such as electricity ; gas, petroleum product, coal and crude oil that will affect the environment. Energy is one of the main resources used by a country for economic development as well as social progress (Ayenagbo *et al.*, 2011). Energy has

changed the level of value added through production activities as well the lifestyle of households all over the world. Direct and indirect energy consumption has a negative impact on the environment as a result of direct and indirect CO<sub>2</sub> emissions (Munskgaard *et al.*, 2000).

In Malaysia, CO<sub>2</sub> emissions as consequences of energy consumption are not new issues but discussions have intensified in the last two decades. Due to these conditions, the government has promoted strategies to reduce the amount of energy consumption as well as to reduce CO<sub>2</sub> emission through energy efficiency in order to protect the environment as stated in the 10<sup>th</sup> Malaysia Plan. Therefore, Malaysia has declared that it attempts to reduce carbon dioxide 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 it has an interest in reducing the CO<sub>2</sub> emission (Bari *et al.*, 2012).

The trade-offs between economic growth and environmental degradation is of grave concern which has to be addressed before it reaches a point of no return. It is very important to save the environment through efficient energy management and consumption before the quality of environment becomes irreversible (Panayotou, 2003). In order to combat this worsening environment problem particularly with regards to CO<sub>2</sub> emission, the strategy is to concentrate on sectors that contributed the highest CO<sub>2</sub> emissions. The main objective of this study is to identify the high-impact

sectors that contributed to economic growth but are at the same time contributing the highest CO<sub>2</sub> emission. This paper begins with a methodology to measure the CO<sub>2</sub> emission intensity by sector by applying an input output analysis. Then, the results and findings regarding the CO<sub>2</sub> emission by sector are presented. Lastly, a conclusion and policy implications are discussed.

## **ECONOMIC GROWTH AND THE ENVIRONMENT**

Awareness of environmental problems is one of the challenging issues faced by Malaysians although Malaysia experiences the least environmental problem in Asia. The country has recorded positive economic growth in recent years through structural change in industrialization, agriculture, tourism, and export activities. Economic growth has caused pollution in many sectors, for instance there is increasing air pollution from industrial activities and motor vehicle emissions as well as water pollution from raw sewage. The continuous rise and accumulation of pollution could have many damaging effects. One of the damaging is global warming due to the increase in CO<sub>2</sub> emission. Global warming is not only felt by us. Extreme heat due to global warming might also harm plants and animals living in the sea as well as those on land. It could also change the world climatic patterns, causing floods, drought and an increase in damaging storms.

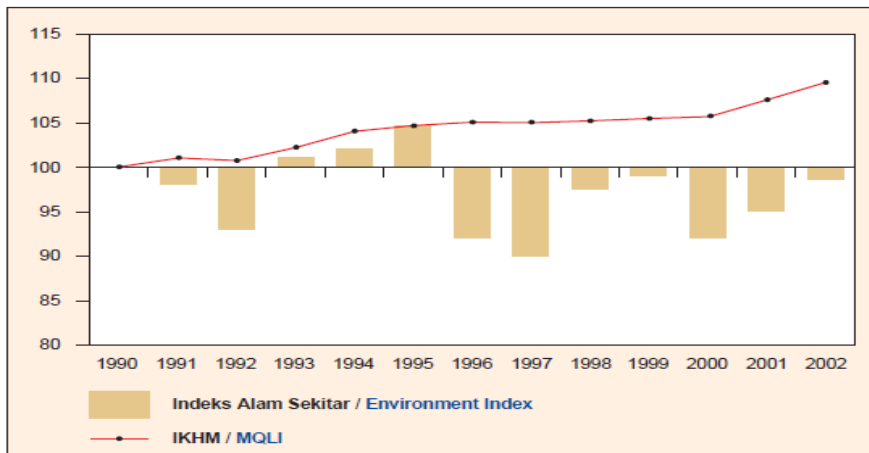
In terms of well-being and health, human diseases such as malaria and dengue could spread, and crop yields could decline.

Longer-lasting and more intense heat waves could cause more deaths and illnesses as well as increase hunger and malnutrition. All of these disasters are mainly caused by human activities and it will continue to increase if there is no appropriate control. Disasters such as floods, landslides, erosion and extreme heat often occur in Malaysia and these can destroy many things such as houses, cars, home appliances and infrastructure.

Most floods that occur from October to March are a result cyclical monsoons that are characterized by heavy and regular rainfall during the local tropical wet season. However, floods that occurred from December 2006 to January 2007 in Southern Johor was due to global warming and unplanned development, for example inadequate drainage in many urban areas. Meanwhile, landslides that occur in many parts of Malaysia are due to deforestation. Development activities at hill sites and areas abandoned for a long period affect

the maintenance of the slopes thus causing landslides.

Disasters have negative effects on the economy since it results in reconstruction activities such as repairs and replacements increasing the demand for electrical appliances, cement, wood products, medicine, transportation and others. An increase in the demand for these goods will result in the continued growth in production activities in the short and long run thus causing an increase in CO<sub>2</sub> emission. An increase in CO<sub>2</sub> also causes disasters which have an impact on the supply of resources such as food, shelter, clothing and energy that serve human needs. However, disasters also have positive effects in certain cases but they are insignificant by comparison. Hallegatte and Dumas (2009) suggested that disasters may have positive economic effects through the substitution of capital which refers to productivity effects. They investigated the effects by using a model which embodied technical change.



Source: Malaysia Quality of Life, 2004, Economic Planning Unit (EPU), Malaysia

Fig.1: Malaysia quality of life and environmental index, 1990-2002

Malaysia's environmental index is shown to be moving in the opposite direction to that of the Quality of Life index. The Malaysia Quality of Life Index (MQLI) trend shows that it is increasing rapidly indicating that Malaysia's economy is growing at a positive rate from 1997 to 2002 but during the same period the environment index has decreased. Environmental index dropped by 4.3 percent per annum from 1990 to 2007 and this should not be ignored nor taken lightly. An increase in economic activities has caused degradation in environmental quality.

Empirically, the relationships between economic growth, energy consumption and environmental quality have been widely analyzed over the last two decades. The validity of economic growth and environment can be tested, by applying the environmental Kuznets curve (EKC) hypothesis. The empirical studies differ substantially and are not convincing enough to present policy recommendations that can be applied across countries. An evaluation of the empirical studies suggests that most studies focus either on the economic growth–energy consumption nexus or economic growth–environmental pollutants where little attempt has been made to test these two links under the same framework.

#### **FRAMEWORK OF THE STUDY**

Literature on the relationships between economic growth, energy consumption and environmental degradation has been reviewed by Zhang and Chen, (2009) on three strands. The first strand focuses

on the relationship between economic growth and environmental pollutants by applying the environmental Kuznets curve (EKC) hypothesis of Grossman and Krueger (1991). The second strand of the study is the relationship between economic output and energy consumption. This means that economic growth and output may be determined together, because economic growth is directly related to energy consumption as higher economic development needs more energy consumption (Halicioglu, 2009). The third strand is a combination of these two strands which examines the relationships between three variables: economic growth, energy consumption and environmental degradation.

The EKC approach is useful in examining the dynamic relationships between economic growth, consumption of energy and environmental degradation. For example, Ang (2007) applied the vector error-correction and co-integration modeling technique to examine the dynamic causal relationship between growth, energy consumption and emission for France and used exactly the same technique for Malaysia (Ang, 2008). Ang (2007) concluded that France is an economy independent in energy corresponding to its policy to achieve energy independence in the long term. However, Malaysia is an energy dependent economy due to its rapid industrialization that requires high and more efficient energy consumption and he concluded that output growth of Granger causality test causes energy consumption

in Malaysia. But, there is weak evidence of causality running from carbon emissions to income in the long run, but no feedback link is observed.

The rapid economic development through urbanization, industrialization and other land-use activities since the 1980s later caused water, air and land pollution, which has continued to become serious environmental problems in Malaysia (Khalid, 2007). A number of authors maintain that fundamental solutions to many environmental problems should be considered in combination with current energy consumption patterns (e.g. Duchin & Lange, 1994; Duchin, 1996, 1997, 1998).

This study uses an input-output model (IO) as it helps to reduce the effect of price distortion and makes interpretation of the results easier. Most importantly, this model can determine to what extent each sector consumes energy and generates CO<sub>2</sub> emission. For example, Cruz (2002) suggested that such an approach provides a consistent and systematic tool to appraise the impact of measures regarding the achievement of both pollution control and sustainable development for Portugal. Regarding reports that energy intensities and CO<sub>2</sub> emissions are derived from fossil fuel use, Alcantara and Padilla (2006) presented an approach that allows the identification of the “key” productive sectors responsible for CO<sub>2</sub> emission.

Tunc *et al.* (2006) estimated CO<sub>2</sub> emission for the Turkish economy using an extended I-O model with 1996 data in order to identify the sources of CO<sub>2</sub> emission. Lise

(2006) stated that the emission growth in Turkey, over a period of 23 years between 1980 and 2003, was almost 80% as a result of the growing economy, 13% as a result of structural change towards more energy-intensive sectors and 13% as a result of an increase in the carbon intensity of energy, while decreasing energy intensity offset these increases by 7%.

Mongelli *et al.* (2006) suggested that developing countries may become a shelter for the production of non-environmental-friendly commodities using an extended I-O model. In this case, the comparative advantage from the so-called Pollution Haven Hypothesis due to freer international trade may change the economic structure and consequently the trade patterns of the countries linked by trade relationships.

Chung *et al.* (2009) estimated the energy and GHG emission intensity in Korea using an extended I-O model and concluded that energy consumption and environmental counter measures to reduce GHG did not slow down economic activities.

Using an I-O table constructed by the Malaysian Department of Statistics (DOS), this study depicts the Malaysian economy into energy sector that consists of 3 energy and 37 non-energy types. Unfortunately, there have been limited studies done on the impact of production sectors on the environment in Malaysia, particularly by applying the input-output analysis. Therefore, the significance of this study is that it covers in detail the production sectors which have contributed the highest value-added in GDP with the highest CO<sub>2</sub>

emission generation. Jaafar *et al.* (2008) applied an input-output analysis in their study and found that electricity generation has a negative impact on the environment in Malaysia.

## METHODOLOGY

This study focuses on CO<sub>2</sub> emission because it is the most listed factor in the Intergovernmental Panel on Climate Change (IPCC) (revised in 1996) that affects climate change. This study uses the emission factor as recommended in IPCC guidelines (Module 1) for the assessment of the amount of CO<sub>2</sub> emission caused by energy consumption. CO<sub>2</sub> emission factor is calculated based on the following models:

$$f_i = C_i / e_i \quad (1)$$

where  $f_i$  is the CO<sub>2</sub> emission factor of energy consumption by sector i.e. petroleum product.  $C_i$  is the CO<sub>2</sub> emission from energy consumption by sector and  $e_i$  is the energy consumption by sector.

In order to estimate the CO<sub>2</sub> emission intensity, the following equation is used:

$$M = (m_i \# r_i) f (I-A)^{-1} \quad (2)$$

Equation (2) estimates the CO<sub>2</sub> emission intensity (multiplier) in the Malaysian economic sectors by using the extended input-output model introduced by Leontief and Ford (1972).  $M$  denotes CO<sub>2</sub> emission intensity (multiplier),  $m$  is a 11x40 matrix of fuel mix in the production sectors, i.e. demand for 11 energy types per unit of total demand for energy for all production sectors;  $r$  is a 1x40 vector of energy

intensities, i.e. total energy consumption per unit of production in all 40 sectors;  $f$  is a 11x1 vector of CO<sub>2</sub> emission per unit of consumption for each of the 11 energy type;  $(I-A)^{-1}$  is the 40 x 40 Leontief inverse matrix. Whereas  $f$ ,  $m_i$ ,  $r_i$ ,  $(I-A)^{-1}$  are factors of behavior of the sector in the economy, i.e. demand for inputs in the energy supply sector and other production sectors.

In order to estimate generation of CO<sub>2</sub> emission in Malaysia, the following model is used:

$$E_i = M.V \quad (3)$$

Where  $E_i$  denotes a vector of total CO<sub>2</sub> emission in the production sectors as a consequence of production of goods and services;  $V$  denotes the value added in as described in Equation (3).

This study uses the 40-sector classification input-output table for Malaysia for 2005 published by the Department of Statistics (DOS), in current prices. The 40 sectors consist of 37 non-energy sectors and 3 energy sectors which are petroleum products (motor petrol, gasoline, diesel, kerosene, LPG, refinery gas, non energy, aviation fuel and fuel oil), coal and natural gas and electricity. Energy consumption data for 2005 are obtained from the National Energy Balance of Malaysia Energy Centre (PTM, 2006) and the Ministry of Energy, Water and Communications Malaysia while the data concerning CO<sub>2</sub> emission factor is derived by calculating the energy consumption and CO<sub>2</sub> emission in Malaysia as recommended by IPCC, Module 1 (revised in 1996).

## RESULTS AND FINDINGS

### *Comparative CO<sub>2</sub> emission intensity of Malaysia*

Malaysia's CO<sub>2</sub> emission intensity is higher than world average as shown in Fig.2. CO<sub>2</sub> emission intensity is measured in tonnes of CO<sub>2</sub> emitted from the use of energy to produce a unit of GDP (US\$1,000). The CO<sub>2</sub> emission intensity of developed countries such as the United States, Singapore, Japan and United Kingdom are lower because the main sector of these nations mostly come from the service sector, which uses less energy to produce per unit of GDP compared to the developing countries such as Malaysia, which is based on manufacturing goods. Thus, the emission intensity is higher than those countries which import manufactured goods.

In order to measure whether Malaysia has employed clean or polluted technology

in its production sectors it is pertinent to do it by comparing the CO<sub>2</sub> emission intensity of Malaysia and the developed countries because most of developed countries like the U.S., UK, Japan and Singapore are already using clean technology in their production activities. Developed countries have dominated the boundaries of technology that have innovated and adopted new technologies the earliest (World Bank, 2008). Therefore, CO<sub>2</sub> emission intensity of developed countries can be used as a benchmark in order to measure the level of CO<sub>2</sub> emission intensity of Malaysia. In this case, Malaysia should reduce CO<sub>2</sub> emission intensity so that its level is at par with CO<sub>2</sub> emission intensity of developed countries.

In order to reduce energy intensity and CO<sub>2</sub> emission intensity, most developed countries have adopted strategies such as improving energy efficiency in the

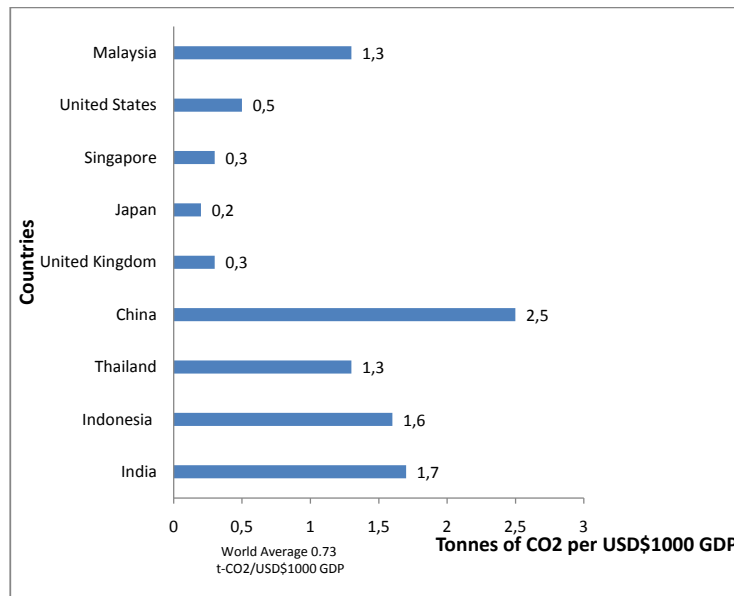


Fig.2: CO<sub>2</sub> emission intensity for selected countries, 2010 (in T-CO<sub>2</sub>/US\$1000GDP)

manufacturing sector and production. Some developed countries have moved from manufacturing sector towards services sector and import products that are energy intensive to produce and increased their GDP at a rate higher than CO<sub>2</sub> emission. Countries such as the United States and United Kingdom are outsourcing their production to other developing countries such as China as a solution to reducing global energy use and global GHG emission but this may not be to the best interest of developing countries as they will bear the highest CO<sub>2</sub> emission intensity. Therefore, Malaysia requires technology transfer, skills and knowledge in order to improve energy efficiency in the country. Consequently, producers and consumers should share the benefits and costs of this initiative.

#### *CO<sub>2</sub> emission intensity (multiplier) in Malaysia*

In this study CO<sub>2</sub> emission intensity is estimated first in order to quantify CO<sub>2</sub> emission by production sectors. CO<sub>2</sub> emission intensity is the ratio of CO<sub>2</sub> emission produced to GDP or value-added (units of CO<sub>2</sub> per Malaysian Ringgit, MYR). This intensity is used to estimate CO<sub>2</sub> emission based on the amount of energy used by each sector and it may also be used to compare the environmental impact of different sectors. In this study the production sector has been divided into energy and non-energy groups. The energy group consists of primary energy (crude oil, coal and natural gas), petroleum product and electricity, while the non-energy group consists of

agriculture, manufacturing, transportation and services sectors.

In the total production sector the average value of the total energy intensity and CO<sub>2</sub> emission intensity caused by energy consumption in Malaysia in 2005 was found to be 64.5 (toe/M-MYR) and 0.272 (T-CO<sub>2</sub>/M-MYR), respectively. The sectors that are below both average values are considered to be those that have improved energy efficiency and produced environmental friendly products because they use less energy and less CO<sub>2</sub>-intensive technology in the production activities. However, sectors that have above both average values are considered as those sectors that used more energy and CO<sub>2</sub>-intensive technology. Therefore, those polluted sectors are encouraged to take appropriate action to reduce their CO<sub>2</sub> emission production voluntarily so that their CO<sub>2</sub> emission intensity is reduced to the below average value.

From this analysis, we have traced energy consumption for every Ringgit Malaysia as the main source that caused the increase in CO<sub>2</sub> emission intensity. Estimating the energy intensity and CO<sub>2</sub> emission intensity becomes the crucial step in appropriately understanding the energy consumption structure and generation of CO<sub>2</sub> emission. Table 1 presents the four categories of energy intensity and CO<sub>2</sub> emission: High-High, High-Low, Low-High and Low-Low. The sectors in the category of High-High are Electricity, Manufacture of yarn and cloth, Manufacture of other textiles, Other chemical industries, Other



TABLE 1  
Energy intensity and CO<sub>2</sub> emission intensity by category

Category	High-High			High-Low			Low-High			Low-Low		
	Energy intensity (toe/M-RM)	CO <sub>2</sub> emission intensity (tCO <sub>2</sub> /M-RM)	Energy intensity (toe/M-RM)	CO <sub>2</sub> emission intensity (tCO <sub>2</sub> /M-RM)	Energy intensity (toe/M-RM)	CO <sub>2</sub> emission intensity (tCO <sub>2</sub> /M-RM)	Energy intensity (toe/M-RM)	CO <sub>2</sub> emission intensity (tCO <sub>2</sub> /M-RM)	Energy intensity (toe/M-RM)	CO <sub>2</sub> emission intensity (tCO <sub>2</sub> /M-RM)	Energy intensity (toe/M-RM)	CO <sub>2</sub> emission intensity (tCO <sub>2</sub> /M-RM)
Crude petrol, natural gas and coal												
Petroleum products			79	0.197							27	0.063
Electricity	328	0.367										
Agriculture											25	0.101
Mining					64	0.316						
Manufacture of oils and fats										40	0.264	
Manufacture of other foods										46	0.236	
Manufacture of yarns and cloth	91	0.403										
Manufacture of other textiles	77	0.392									33	0.203
Manufacture of wearing apparels											50	0.266
Manufacture of wood product												
Manufacture of industrial chemical			124	0.216								
Manufacture of paints and lacquers											43	0.174
Manufacture of drugs and medicines					61	0.33						
Manufacture of soap etc.											45	0.193
Other chemical industries	91	0.439										
Manufacture of others products					56	0.304						
Other non-metallic manufacture	86	0.515										
Manufacture of cement etc.	208	0.93										
Iron and steel industries	86	0.403										
Manufacture of non-ferrous metals											34	0.19
Structural metal industries					55	0.301						
Other metal industries					59	0.38						

TABLE 1 (continue)

Sector	High-High		High-Low		Low-High		Low-Low	
	Energy intensity (toe/M-RM)	CO2 emission intensity (tCO2/M-RM)	Energy intensity (toe/M-RM)	CO2 emission intensity (tCO2/M-RM)	Energy intensity (toe/M-RM)	CO2 emission intensity (tCO2/M-RM)	Energy intensity (toe/M-RM)	CO2 emission intensity (tCO2/M-RM)
Manufacture of industries machinery					41	0.222		
Man. of household machinery					17	0.125		
Manufacture of radio, television etc.					18	0.14		
Man. of electric appliances etc.					16	0.114		
Man. of other electric machinery					26	0.158		
Manufacture of motor vehicle					47	0.269		
Construction			49	0.309				
Wholesale and retail trade					46	0.154		
Transportation	101	1.162						
Communication					38	0.145		
Real estate					39	0.166		
Business services					38	0.225		
Education					32	0.108		
Private non-profit institution					23	0.078		
Recreation					48	0.122		
Recycling					6	0.033		
Others services					42	0.168		

Source: Calculation from equation 2.

non-metallic manufacture, Manufacture of cement, Iron and steel industries and Transportation sector.

The Electricity sector has the highest energy intensity at about 328 toe/M-MYR and generates about 0.367 T-CO<sub>2</sub>/M-MYR. For example, in order to produce 1 million Ringgit of electricity about 328 toe of energy was used and will generate 0.367 T-CO<sub>2</sub> of CO<sub>2</sub> emission. On the other hand, the transportation sector uses about 101 toe of energy in order to produce one million Ringgit, but it has produced the highest CO<sub>2</sub> emission of about 1.162 T-CO<sub>2</sub>/M-MYR. This comparison shows that the sector with the highest energy intensity does not necessarily generate the highest CO<sub>2</sub> emission. However sectors such as the transportation sector are typically characterized by industries that do not employ environmental-friendly processes or those that have carried out combustion processes on a big scale. Consequently, sectors in this category have to take the necessary actions in order to reduce their energy intensity and CO<sub>2</sub> emission intensity.

The sectors in the High-Low category include Petroleum products, Manufacture of industrial chemicals and Construction. These sectors with higher energy intensity but with lower CO<sub>2</sub> emission intensity than the average are employing low CO<sub>2</sub> emitting energy use technology or employing combustion technology while consuming much more energy than the other sectors. These sectors managed to reduce CO<sub>2</sub> emission for every million Ringgit of output with high energy use i.e. above average

value of both energy intensity but produce below than the average value of CO<sub>2</sub> emission intensity. Although those sectors have higher energy intensity they can reduce the CO<sub>2</sub> emission intensity below than average value of CO<sub>2</sub> emission intensity.

In the Low-High category, the sectors include Manufacture of oils and fats, Manufacture of drugs and medicine, Manufacture of other products, Structural metal industries, other metal industries and Manufacture of motor vehicles. These sectors used low energy intensity but produced high CO<sub>2</sub> emission intensity. These sectors should be given attention because despite their low energy consumption, they were generating high CO<sub>2</sub>. This means that these sectors have been employing extremely intensive CO<sub>2</sub> emission technology typically characterized by industries that used processes that were not eco-friendly in terms of energy use or they carried out combustion process on a large scale. These sectors succeeded in reducing their energy use but they produced high CO<sub>2</sub> emission for every million Ringgit of output.

On a positive note, most production sectors in Malaysia are in the Low-Low category because most of them use processes that are environmental friendly in terms of energy use. They carry out combustion process on a small scale due to their lower energy intensity and their CO<sub>2</sub> emission intensity is lower than average value as shown in Table 1. The sectors in this category are Primary energy products, Motor vehicles, Wood products, Mining, Foods, Chemical industries, Soap products,

Non-Ferrous metal, Electric and electronic products and Machinery and Services. These sectors can reduce their energy use and produce low CO<sub>2</sub> emission for every million Ringgit of output. These sectors consumed below than average value of energy intensity and produced below than average CO<sub>2</sub> emission intensity.

#### *Value-added and CO<sub>2</sub> emission*

By employing CO<sub>2</sub> emission intensity, we can quantify the CO<sub>2</sub> emission generated by value-added of each sector in the economy. The relationship between value-added and CO<sub>2</sub> emission for each sector is shown in Fig.3. The sector classification is shown in the Appendix. The regression line is plotted and the slope indicates CO<sub>2</sub> elasticity of value-added which is smaller than unity. If the sector is above the regression line, its actual CO<sub>2</sub> emission factor will be larger than the one predicted by the regression line and measures to reduce CO<sub>2</sub> emission are imperative. Further, the average value of value-added and CO<sub>2</sub> emission for all sectors in 2005 are used as the origins of the coordinate system as shown in the figure. The value-added of a sector that lies to the right of the ordinate axes is higher than the average value. On the other hand, the value-added of a sector that lies to the left of the ordinate axes is lower than the average value.

Fig.3 also shows the relationship between GDP by sector (value-added) and CO<sub>2</sub> emission intensity in 2005. Firstly, this scatter plot is divided into 4 quadrants: quadrants I, II, III and IV. The sectors that

lie in quadrant I indicate that they produce lower GDP with higher CO<sub>2</sub> emission such as sectors (16), (3) and (11), while the sectors that lie in quadrant II indicate that they produce higher value-added with higher CO<sub>2</sub> emission. These sectors include Transportation (32), Business services (35), Wholesale and retail trade (31), Other products (17), Construction (30), Other electric machinery (28), Real estate (34), Primary energy (1), Other services (40) and Agriculture (4). The sectors that lie in quadrant III produce lower value-added with higher CO<sub>2</sub> emission are Mining (5), Manufacture of oils and fats (6), Manufacture of other foods(7), Manufacture of yarn and cloth (8), Manufacture of other textiles (9), Manufacture of wearing apparels (10), Manufacture of industrial chemicals (12), Manufacture of paints and lacquers (13), Manufacture of drugs and medicines (14), Manufacture of soap (15), other non-metallic manufacture (18), Manufacture of cement (19), Iron and steel industries (20), Manufacture of non-ferrous metal (21), Structural metal industries (22), Other metal industries (23), Manufacture of industrial machinery(24), Manufacture of household machinery (25), manufacture of radio, television (26), Manufacture of motor vehicles(29), Recreation (38) and Recycling (39), while quadrant IV indicates that the sector produces higher value added with lower CO<sub>2</sub> emission. They are Communication (33), Education (36) and Manufacture of electrical appliances (27).

Most of the sectors are in quadrants II and III rather than quadrants I and IV. The

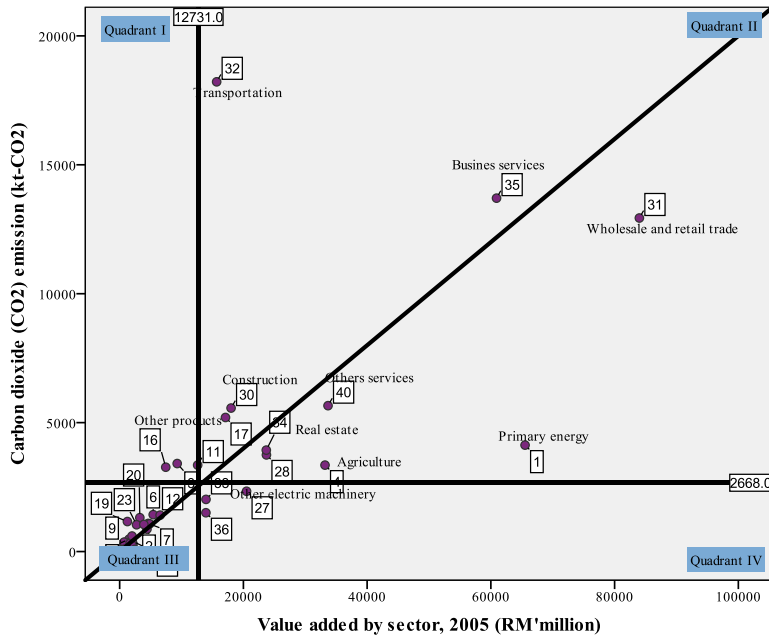


Fig.3: Distribution of CO<sub>2</sub> emission for 40 sectors in 2005

sectors that lie in quadrants I and II should be given most attention since they contributed high CO<sub>2</sub> emission more than the average values of CO<sub>2</sub> emission (2,668 kt-CO<sub>2</sub>) but below than average values of value-added (RM12,731 million) for the sectors that lie in quadrant I. However, the sectors that lie in quadrant II should be examined closely due to their high contribution of value-added as well as CO<sub>2</sub> emission. These sectors include Transportation (32), Construction (30) and Manufacture of other products (17). They contribute highly to CO<sub>2</sub> emission intensity and produce high output compared to Wholesale and retail trade (31) and Business services (35) which produce the highest value-added but generate lower CO<sub>2</sub> emission. However, Business services (35) and Wholesale and retail trade (31) should reduce their CO<sub>2</sub> emission generation

so that they can move down to quadrant IV which is better.

The sectors that lie in quadrant III should not be a big problem because their value-added and CO<sub>2</sub> emission are relatively lower than average values. Therefore, those sectors should find alternative ways to increase their value-added and at the same time maintain or reduce their CO<sub>2</sub> emission so that they can move to the right to quadrant IV. The sectors that lie in quadrant IV are considered as clean sectors because they succeeded in reducing CO<sub>2</sub> emission to below than average value and producing environmental-friendly products with less CO<sub>2</sub> intensive technology compared to the sectors that lie in quadrants I and II. The sectors that lie in quadrant IV are Manufacture of electrical appliances (27), Communication (33) and Education (36).

## CONCLUSION AND POLICY IMPLICATIONS

This study examined the structure of CO<sub>2</sub> emission intensity in each sector in the Malaysian economy. In the energy sector, Electricity produced the highest CO<sub>2</sub> emission, while in the non-energy sector Transportation produced the highest CO<sub>2</sub> emission in 2005. Malaysia's effort in protecting the environment based on energy use is by not encouraging new energy intensive sector but to promote energy efficient and high production industries. Based on an estimation of 40 sectors, the sector with high CO<sub>2</sub> emission intensity must be considered seriously, particularly the sectors that are located in quadrant II as plotted in Figure 3. For example, the sectors that lie above the average value of value-added and CO<sub>2</sub> emission have to reduce their CO<sub>2</sub> emission intensity and these sectors should focus primarily on energy conservation and efficiency improvement rather than environment-friendly energy use. In contrast, the sectors that have less than average value of GDP and CO<sub>2</sub> emission should be supported as strategic industries since they have a comparative advantage from the perspective of Malaysian energy and environment.

Analyzing energy intensities and CO<sub>2</sub> emission intensities is becoming an essential step in correctly understanding the structure of energy use. Moreover, in recent years global warming has become an issue of concern particularly for those countries such as Malaysia which experience high growth rate in energy consumption and

CO<sub>2</sub> emission.. Hence energy use and CO<sub>2</sub> emission structure should be taken into account in policy-making. Intensity of each sector should be closely studied and analyzed for a better understanding so that an Environmental Policy can be formulated. In the future, energy consumption for the sectors located in QI and QII will be increasing. Therefore, the generation of CO<sub>2</sub> emission will rise. Thus these sectors may not have achieved their voluntary target in reducing their CO<sub>2</sub> emission even though demand in the sectors continue to grow.

Based on the results and findings, our study uncovered some problems that have to be solved for future benefits. However, the government is struggling to find the best strategy to address environmental issues particularly in CO<sub>2</sub> emission produced by the Transportation sector. For example, a policy should be enacted to forbid old vehicles especially lorries and buses from using the roads because old engines may cause incomplete combustion that generate more CO<sub>2</sub> compared to new vehicles. The polluting sectors which are located in QI and QII should be charged with higher carbon tax due to their higher CO<sub>2</sub> emission (above average value). By imposing a carbon tax, producers will strive to reduce CO<sub>2</sub> emission by improving energy efficiency.

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