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Analysis of the Impact of Industrialisation on the Green Economy Development in Malaysia Using STIRPAT Model

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Abstract

The objective of this study is to investigate the impact on carbon emission by applying Regression on Population, Affluence and Technology (STIRPAT) in Malaysia over the period of 1970 – 2013. After testing using the unit root test, cointegration approach was applied to examine the cointegration relationship between the variables. Cointegration results indicate a co-movement between variables in the long-run. The results from the Granger causality test show that the urban population unidirectional causality influences carbon emission. On the other hand, the urban population together with industry have also a unidirectional causality towards gross domestic product. Furthermore, the regression results show that urban population is the significant cause of an increase in carbon emission. Based on the results, the study offers some directions to reduce the carbon emission and provides policy reference for the development of green economy. The government should consider these when constructing long-term strategies for carbon abatement.

Keywords: *carbon emission, energy consumption, green economy, industrialisation, urbanisation*

1.0 Introduction

Low carbon economy (LCE) was first published by the British government that published its national strategy to reduce carbon emission and curb global warming (UK Department of Transport, 2003).

About 90% of generation of electricity in Malaysia is mainly produced using liquid natural gas (LNG) and coal, heavily relies on fossil fuels (EPU, 2006).

Table 1 Energy mix

Year	Gas (%)	Coal (%)	Others (%)	Total (GWh)
2002	77	9	14	69,280
2005	70	22	8	94,299
2010	56	36	8	137,909

Source: Ninth Malaysia Plan (9MP)

As the level of carbon dioxide keeps increasing and causes global warming, countries need to introduce the generation of electricity generation with an energy mix that is sustainable. Data from United Nations indicates that Malaysia recorded 187 million tons of carbon emission or 7.2 tons per capita in 2006. During the United Nations Climate Change Conference 2009 (COP 15) at Copenhagen, Denmark, the Prime Minister declared that Malaysia has agreed to reduce its carbon dioxide emission intensity of its Gross Domestic Products (GDP) by 40 per cent by 2020 compared with 2005 levels (BERNAMA, 2009).

The government launched the green technology policy (Ministry of Energy, Green Technology & Water, 2012) and use renewable energy (RE) as an energy alternative. Malaysia's green technology policy focuses on reduction of carbon emission, reduction in fossil fuelled power and an increase in renewable power.

The Malaysian Government has promoted Fifth-Fuel Policy since the 8th Malaysia Plans to sustain the energy demand. In the 11th Malaysia Plan, the government will strengthen the policy, regulation and institutional framework to encourage industries to adopt green technology in their products and services and accelerate the development of green technologies. Moreover, the government would also like to create a green market and targeted at least 20% of government procurement will be green by 2020. Government green procurement (GGP) will be introduced to create demand for green products and services, encourage the raise on quality and standard of products to meet the green requirement, complement the existing eco labelling scheme for green products certification. The green certification will be strengthened by the MyHijau Mark programme and the Green rating system and standards.

The 11th Malaysia Plan announced that the energy generation capacities through renewable sources, including biomass, solar and mini hydro. On the other hand, the renewable energy supply in Malaysia are categorised into biomass, solar, small hydro, solid waste and biogas. Figure 1 presents the renewable energy mixed in 2012.

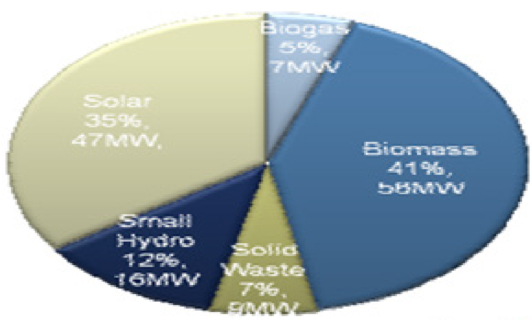

Figure 1 Renewable energy mix year 2012
Source: SEDA (2012)

Malaysia plans to generate 2,000 megawatts (MW) of electricity from RE sources by 2020, enhanced by the introduction of two new mechanisms, namely net-metering and utility-scale solar (USS). See Table 2. Solar photovoltaic (PV) is estimated to have a cumulative capacity of 55 MW in 2015. Malaysia's plan was to achieve 985MW, i.e. 5.5% share of RE mix by 2015. RE power capacity will be increased in Malaysia with strong growth in the solar PV, biomass and biogas markets, and 4,000 MW by 2030.

Table 2 Malaysian national RE targets

Year	Cum. RE capacity	RE power mix (vs peak DD)	Cumulative CO² avoided
2010	73 MW	0.50%	0.3 M.T.
2015	985 MW	5.5%	11.1 M.T.
2020	2,080 MW	11%	42.2 M.T.
2030	4,000 MW	17%	145.1 M.T.

Source: SEDA

By 2050, it is expected that RE sources will play an important role for a cumulative capacity of 11.5 GW, out of which 9GW from solar photovoltaic (PV). Solar power will be the long-term global source of energy supply. Solar power generation possesses advantages of low greenhouse gasses (GHG) emission, low maintenance cost, and low operation voice, therefore it is considered the best choice for future electricity generation (Hosseini & Wahid, 2014).

In the meantime, there are also vast investment opportunities in the solar photovoltaic (PV) panel manufacturing. Among recent investments received from China were Comtec Solar, JA Solar, Jinko Solar and Xinyi Solar. This is timely and in line with the aim of Malaysia to become No. 2 in solar PV manufacturing by 2020, second only to China.

Beyond policy-making, there are also enforcement issues of the environmental authorities with the industry. Mohamad and Aripin (2006) cited 5 issues and challenges in performing enforcement of Environmental Quality Act and Regulations, i.e. limitation in (i) Approach with Industrial Enterprises that can create a stronger feeling of commitment towards environmental; (ii) Knowledge of Inspection Officers with careful thinking besides understanding the whole law; (iii) The Constitution and The Environment Law on the challenge involved the federal Department of Environment (DOE) and the state Environmental Protection Department (EPD) to work together; (iv) Logistic problem in accessing the pollution area; and (v) Public perception on the action taken by the officer.

Past studies has focused on factors contributing to the economic performance of Malaysia, however there is still gap of study on the trade-off of economic development with the environment. Therefore, this study will be use STIRPAT model for the effects of urbanisation, industrialisation and economic development on carbon emission in Malaysia.

The objective in this research is to study the relationship of determine the relationship between urban population, gross domestic product and industry development with carbon emission in Malaysia. This is an important study, as Malaysia has a relatively high carbon emission per capital, the study will determine the relationship between urban population, gross domestic product and industry development with carbon emission in the country. Besides, this study will provide information to the Government to stimulate sustainable economic development, especially promotion of investment low carbon economy.

2.0 Literature Review

A reformulation into a stochastic equation was presented by Dietz and Rosa (1997) employs the STIRPAT model (STochastic Impacts by Regression on Population, Affluence, and Technology). Analysis by York, Rosa, and Dietz (2003) shows that population as well as urbanisation is a major driver of both carbon emission and the energy footprint. There is no evidence of an environmental Kuznets curve, and carbon emission increase with affluence, but at a declining pace. A study by Jalil and Mahmud (2009) on a cointegration analysis for China proved that there is one way causality runs through gross domestic product to carbon emission.

In the past decade, there are growing number of studies focusing on relationship among carbon emission/ pollutant emission/ energy consumption, population/ urbanisation, output/ economic growth/ financial development, and trade openness in Malaysia. Earlier studies investigate the impacts of output or economic growth to energy consumption. Ang (2008) explores relationship among output, energy consumption, and pollutant emission for Malaysia over the period 1971 – 1999, and found pollution and energy use positively affect output in the long-run. The results from Islam, Shahbaz and Alam (2011) suggest that energy consumption is influenced by economic growth and financial development, both in the short and the long-run. Azlina and Mustapha (2012) using a time series data from 1970 to 2010 found unidirectional causality running from economic growth to energy consumption, from pollutant emission to energy consumption and from pollutant emission to economic growth.

More recent studies started to look into the impacts of population especially those in the urban centres to carbon emission. The findings of Majid and Othman (2013) shows that carbon emission is more sensitive toward the changes in population and the most important are inverse relationship between carbon emission and population. The results from Shahbaz, Loganathan, Muzaffar, Ahmed, and Jabran (2016) showed that economic growth is a major contributor to carbon emission, trade openness leads affluence and hence increases carbon emission, while causality analysis suggests that the urbanisation Granger causes carbon emission.

3.0 Methodology

The STIRPAT model was analysed empirically in the study, which aims to study the impact of economic development level, population scale, and technical level on carbon emission. The total sum of carbon emission is defined as the dependent variable. Because the carbon emission is changed by the economic development level, population size and the level of technology, these factors are defined as explanatory variants. The analysis has been carried-out in the software programme package EViews 9. Sample data are collected during the years from 1971 to 2013 by World Bank.

Description of STIRPAT Model

STIRPAT formerly known as IPAT environmental stress equation, namely I = PAT, where I is the environmental pressure, P is the population, A is the degree of affluence, and T is the technology.

$$I = P \times A \times T \tag{3.1}$$

where I represents environmental impact

The equation could identify which driving force is more evident of the influence of environmental stress among the humanity driving forces of population, degree of affluence, technology, etc. STIRPAT is indicated as random form of the IPAT equation which randomly regression analysis the influence of environmental pressure by the driving forces of population, affluence and technology.

$$I = a\ P^b A^c T^d e \tag{3.2}$$

where, a is the model coefficients, b, c, d are the driving force indexes, e is the error.

In practice, in order to test the impact of human factors on the environment, the logarithm of both sides of the equation is taken for the corresponding logarithmic equation: By using logarithms, the analysis of the changes in the percentage is conducted, that is the influence of change of one variable on the other variable is displayed in percentage.

In the logarithmic form, the coefficients of the driving force (b, c, d) indicate that if other factors remain unchanged, the environmental impact change in percentage caused by 1% changing of factors (P or A or T) of the driving force. By using this model, the case of total time series data is to analysed for the impact of carbon emission environmental pressures caused by the human driving forces such as urban population, the level of affluence and technology degree, etc.

$$\ln(I) = a + b\ln(P) + c\ln(A) + d\ln(T) + e \qquad (3.3)$$

where:
Environmental pressure ln(I) is the natural logarithm of carbon emission,
Population ln(P) is the natural logarithm of urban population,
Affluence ln(A) is the natural logarithm of gross domestic product,
Technology ln(T) is the natural logarithm of industrialisation.

In this study, the environmental stress equation is where C is the carbon emission, U is the urban population, GDP is the gross domestic product, and I is industrialisation.

$$\ln(C) = a + b\ln(U) + c\ln(GDP) + d\ln(I) + e \qquad (3.4)$$

where:
ln(C) denotes the natural logarithm of carbon emission (kilotons of carbon emission)
ln(U) denotes the natural logarithm of urban population
ln(GDP) denotes the natural logarithm of gross domestic product, GDP (current US$)
ln(I) denotes the natural logarithm of industrialisation (Industry, value added (% of GDP))

The Selection of Indicators and Data Sources

For the selection of appropriate indicators in the model, U is to take the urban population of residence in Malaysia, and A is indicated by gross domestic product (GDP). Given that the current industrial structure of Malaysia especially export sector is still relied by the secondary industry, the industrial value added can be seen as the level of technology variable T, and the corresponding I can be seen as energy consumption capita GDP (A) = GDP of Malaysia/ total population in Malaysia. Industrial technology level (T) = industrial GDP of Malaysia / GDP of Malaysia.

There are three steps involved in estimating the relationship between the variables. The first step is to test the stationary of the series or their order of integration in all variables. A time series is not stationary if the mean and the variance of time series is increasing over time depending on the time. Otherwise, a time series is said to be stationary if the mean and its variants are fixed. In this study, Augmented Dickey Fuller (ADF) test was used to determine the stationary state of the series. The second step is to investigate the existence of long run relationships between the variables. All variables should be cointegrated at the same level. Cointegration test is an extension of the stationary test. Cointegration relationship can be estimated through two test by Johansen test, the trace (Trace Test) and maximize the value-Eigen Test (Maximum Eigenvalue Test). To be able to realise the connection between the urban population, gross domestic product, value added (industry) and carbon emission, the Granger test has been conducted, that applies to relation of the carbon emission, and urban population.

4.0 Result and Discussion

Carbon emission variable is logarithmic, LNC, Urban Population URBANPOP variable is logarithmic, LNU, Gross Domestic Product GDP variable is as well logarithmic, LNGDP, and Industry Value Added variable is also as well logarithmic, LNI.

The results of unit root test included ADF are shown in Table 3. The results show that the p-value is higher than 1% significance level, which leads to conclusion that the null hypotheses about the existence of a unit root are rejected for all the variables (CO2, URBANPOP, GDP and INDUSTRY). The result indicates that each of the variables has no unit root and is stationary at the 1% significance level at the first difference. The variables in level are now suitable for the cointegration analysis.

Table 3 Unit root (stationary) test results

Variables	**Augmented Dickey-Fuller (ADF) (1st Difference**
CO2	−7.708 (0.000)***
URBANPOP	−5.224 (0.000) ***
GDP	−5.110 (0.000) ***
INDUSTRY	−6.129 (0.000) ***

Note: Values in brackets are probability values (*p*-values).
Values in brackets are probability values (*p*-values).
*** indicates significance at 1% level.
** indicates significance at 5% level.

Thus, Johansen cointegration analysis can be applied to proceed to the main research objective. Table 4 shows the results of the cointegration test to evaluate the long term relationship. The empirical results of Johansen trace statistics and Johansen maximum eigenvalue statistics suggest evidence of one or more cointegrating relationship between the variables, at 5% level of significance. It is found that most of the statistics reject the null hypothesis of no cointegration. Therefore, there appears to be clear evidence in favour of a long-run relationship between the variables. These results show that there exists a long run relationship between carbon emission, urban population, GDP, and Industry.

Table 4 Cointegration test results

Null hypothesis No. of CS(s)	Trace statistics	5% Critical value
None	204.192	95.754
A most 1	112.464	69.819
A most 2	70.707	47.856
A most 3	34.507	29.797

Following the estimation of long-run coefficients, it can be tested what is direction of causality between the variables under investigation. The result of Granger causality test (Granger causality test for natural logarithm of urban population and carbon emission, and industrialisation and gross domestic product) with level of significant of 5%, we reject the hypothesis that the change urban population does not affect of carbon emission. The hypothesis that the change of urban population does not affect GDP is rejected at level of significant of 5%, and there is unidirectional causality running from urban population to GDP. Furthermore, the hypothesis that the change of value added (Industry) does not affect GDP is rejected at level of significant of 10%, and there is unidirectional causality running from value added (Industry) to GDP.

In another words, the results of Granger causality does not indicate causality relationship between GDP and carbon emission, between value added (Industry) to carbon emission, and between value added (Industry) to urban population. Meanwhile, there is unidirectional causality run from urban population to carbon emission, and this finding is similar to a global study by York et al. (2003) and a Malaysian study by Shahbaz et al. (2016). The results also found that urban population and value added (industry) have a relationship with gross domestic product.

Both urban population and value added (Industry) granger cause to gross domestic product. Thus, the export-driven, Multi-national corporations (MNCs)-led industrialisation was likely using clean technology that resulted in gross domestic product but not causing environmental degradation. MNCs have strong scientific research power in developing Low Carbon Economy in Malaysia. In order to shorten the gap with the international advanced level and achieve carbon emission reduction, it is necessary to increase the intensity of support e.g. in financial terms, to adoption of low carbon technology among small and medium sized industries (SMIs).

Though urban population brought gross domestic product, urban population also caused impacts to pollutant emission. This evidence proves that Malaysia needs to further urbanise without causes an environmental degradation. For instance, urban centres must be equipped with efficient public transport infrastructure that discourages use of single-occupied-vehicles on top of incentivised energy-efficient (EE) vehicles.

Table 5 Granger causality test results

	Source of Causation (*F*-statistics)			
Dependent variables	**LNC**	**LNU**	**LNGDP**	**LNI**
LNC	–	4.042 (0.026)	0.776 (0.468)	0.361 (0.700)
LNU	0.608 (0.550)	–	1.290 (0.288)	1.156 (0.326)
LNGDP	2.303 (0.115)	4.987 (0.012)	–	2.725 (0.079)
LNI	0.138 (0.872)	1.732 (0.191)	0.067 (0.936)	–

Notes: Values in brackets are probability values (*p*-values).

Result of the regression analysis is obtained, by putting the data of data of carbon emission in Malaysia from 1971 to 2013, using least squares method and EViews 9 estimation model. The result is shown as follows:

$$\ln C = -14.791 + 1.596 \ln U + 0.020 \ln GDP - 0.073 \ln I$$

$$(0.958) \quad (0.170)^{***} \quad (0.079) \quad (0.244)$$

$$R2 = 0.985 \quad \text{Adj } R2 = 0.984 \quad F = 858.715^{***}$$

*** indicates significance at 1% level

For this model, under the 1% significance level, the explanatory variables together have great goodness of fit. That leads to conclusion that lnGDP and lnI are not significant in the model and that variable lnU is significant. The significance results can be seen in the fact that urban population is the cause of increase in carbon emission.

Further analysis is drawn as follows: The growth of urban population will increase environmental pressure in Malaysia, which is to say the more urban population, the more carbon dioxide they emit. It can be seen from the model; for each 1% increase of urban population, it can lead to 1.596% increased emission of carbon. The total Population is 29.5 million in Malaysia in the year 2013 (an increase of 0.2% of total population from 2012), of which urban population increased to 21.6 million, an increase of 0.7% of Urban population ratio from the year before. It caused much pressure on the environmental protection.

5.0 Conclusions

This study examined the link between urban population, gross domestic product, industrialisation and carbon emission in Malaysia using the data set covering the period spanning from 1971 to 2013. The unit root test show all the variables were stationary at level.

The cointegration test found that the variable was cointegrated at 5% significance level. Granger causality test found that no granger cause between industrialisation to urban population and industrialisation and economic development to carbon emission. There is uni-directional causality from urban population to carbon emission. Beside urban population, industrialisation also granger cause to gross domestic product in Malaysia. Therefore, it can be concluded that urban population and industrialisation are important factors that contribute to gross domestic product, while urban population causes environmental degradation. The finding of this study proved that green technology policy implementation in Malaysia is important to make sure that urban population give no adverse effect on carbon emission. Results of Regression model evaluation shows that change of 1% in urban population would increase the carbon emission for 1.596%. This result shows how to predict future carbon emission based on the speed of urban population growth.

The government should implement sustainable power generation as well as green technology. The government should initial public transportation policy in urban centres to improve environmental quality. Once public transportation is operated efficiently, the government may also apply stricter measures against single-occupied vehicles (SOVs). The government also should continue to introduce new policies that encourage renewable energy.

Recommendations to achieve low carbon emission green economy will require the joint efforts of government, business and individual residents, the environmentally unsustainable practices will affect the development of Malaysia transformation to a sustainable low carbon economy. (1) The Government should fully unleash the potential of renewable energy e.g. solar energy, biomass energy and hydropower that will be greatly alleviated the growth rate of carbon emission. Malaysia, with its proactive government policies and right manufacturing ecosystem, is all set to become the second-largest solar photo voltaic (PV) panel manufacturer in the world.

(2) The Government should encourage green technology innovation, and improve energy efficiency. In another words, Malaysia must take actions to establish modes of production, transportation patterns encouraging low-carbon development. Ultimately Malaysia could realise the Malaysia sustainable development amidst economy, society and natural environment.

The results should be taken with a restriction considering that time series are evaluated from 1971 to 2013. Future research will examine the casual relationship between gross domestic products and carbon emission in Malaysia in a longer period, involved other variables such as energy consumption and trade openness.

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