Exploring EKC, trends of growth patterns and air pollutants concentration level in Malaysia: A Nemerow Index Approach

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Abstract. The present study examines an Environmental Kuznets Curve (EKC) hypothesis by analyzing annual data of air pollutants concentration and per capita GDP as economic indicator over the (1996-2010) period in Malaysia. Nemerow Index Approach (I) used to generate a measures of air pollution. The results show that ambient air quality indicators supports the EKC hypothesis which stated that pollution levels increase as a country develops, but begin to decrease as rising incomes pass beyond a turning point. Also, the I result is justifying that most pollutants are showing value less than 1.

1. Introduction

Now-a-days world is facing the challenge of global warming and climatic change issues at large extent. Most economies are looking towards efficient methods of production in order to cut down emissions. The concept of sustainable development arose in the 1970s. Since then there have been discussions in different forums on how to formulate a sustainable development policy which curtails emissions while ensuring continuous progress at the same time.

Many developed countries are adopting new ways and environment-friendly technologies to conserve the deteriorating environment. Rapid population growth and consequent urbanization is adversely effecting the quality of the environment as well as the biodiversity of species[1]. The Malaysian economy is characterized by a trend towards increased liberalization, greater openness to world trade, a higher degree of financial integration and greater financial development [2]. Following the conventional trend, changes in economic structure is triggering rapid urbanisation resulting in the advent of a set of new environmental challenges [3]. These emerging environmental challenges are characterised by rise in air pollution caused by land transportation, industrial emissions and open burning [4]. Malaysian government’s efforts at protecting the environment are appreciated not only at the local level, but also at regional and international levels.

In Malaysia, the real GDP has grown by an average of 4.5% per annum during (1996-2010) period. This growth rate has helped improve the quality of life for Malaysians and supported widespread advances in education, health, infrastructure, housing and public amenities. Furthermore, there is overall economic improvement and changes in consumption patterns and living standards.

In the early days of abundant resources and minimal development pressures, Malaysia imparted little attention to growing environmental concern but at present, the aim of attaining the status of an industrial country by the year 2020 and the associated rapid economic growth has made it conscious of sustainable development because of rising industrial pollution and the degradation of environment. Depletion of fisheries, air and water pollution, and contamination by industrial wastes have become more serious in
Malaysia in recent years. Out of all the environmental problems Malaysia is facing today, air pollution is the most serious issue that has been affecting human health, agricultural crops, forest species and ecosystems.

The aim of this study is to investigate the relationship between GDP growth rate and ambient air quality, using the concept of Environmental Kuznets Curve (EKC). The relationship yields an inverted U-shaped curve signifying the process of increase in pollution until economic growth reaches a certain point, and then decreases while the growth continues. Many researchers are interested in the relationship between economic growth and environmental quality [5], [6]. Several studies have employed the Environmental Kuznets Curve (EKC) hypothesis which justifies the belief that economic development and environmental degradation can be expressed as inverse U-curve [7], [8], [9]. EKC assumes that environmental pollution increases when per capita income is at a relatively low level, but it will start decline when per capita income reaches a certain point (turning point). Besides, the application of EKC has some implications in choice of variables. [10], [11] discussed the sensitivity of the results to the nations and states, the emission vs ambient concentrations and policy implications. While [12], argued that the choice of methodology and functional form can affect the right application of EKC.

Besides, [13], [14] have analysed the relationship between economic growth and water pollution. Their findings confirmed that there is a simultaneous relationship between pollutants and economic growth in Malaysia. They have explained that it follows the concept of the EKC. Also, the SO\textsubscript{2} and PM\textsubscript{10} supported EKC in Malaysia. In addition, they provide justification that pollution is one of the determinant of income in Malaysia [15].

The structure of this paper is as follows: section 2 explores the methodology and data sources while result findings are presented in section 3. The paper draws some concluding remarks in Section 4.

2. Data Sources and Methodology

In the paper current available annual data for the economic and environment activities is used. The data for real GDP was collected from DOSM while annual average concentration of five air pollutants: carbon monoxide (CO), nitrogen dioxide (NO\textsubscript{2}), sulfur dioxide (SO\textsubscript{2}), particular matter (PM\textsubscript{10}) and ozone (O\textsubscript{3}) was retrieved from annual report of Ministry of Natural Resources and Environment Malaysia. These pollutants indicate the quality of ambient air as concentration level from 1996-2010.

In order to examine the development-environment relationship in Malaysia, we have considered the standard EKC model [16]. The Nemerow index \(I\) is introduced as an integrated indicator for overall environmental quality\[17], [18]. Specifically, this index reflects both maximum and average values of pollutant concentrations relative to some objective levels (such as the Malaysian Air Quality standards). It is calculated in Equation 1.

\[
I = \sqrt{\frac{\text{Max}^2 - \text{Avg}^2}{2}}
\]  

(1)

where; \(I_i\) is the pollution index relating the observed concentration \(C_i\) of pollutant \(i\) with its objective concentration \(S_i\), \(I_i = C_i/S_i\); \(\text{Max} I_i\) is the maximum value of all the indices \(I_i\); \(\text{Avg} I_i\) is the average of all indices. If \(I > 1\) then overall environmental quality does not comply with objectives; whereas if \(I < 1\), then quality is better than the set objective. In order to indicate the major pollutants, the parameter of \(K\) is further introduced in this study. \(K\) represents the percentage shares of the polluting substance (See Equation 2).

\[
K_i = (I_i/I) \times 100
\]

(2)

\[
I = \sum_{i=1}^{n} I_i (i = 1, 2, 3, ..., n)
\]

Certainly, both \(I\) values (Equation 1) and \(K\) values (Equation 2), are very much determined by the denominator, the set objectives. It is argued that Malaysia and many other developing countries have chosen less stricter environmental objectives than the EU and USA. Therefore, the rationality of the \(I\) index and \(K\) parameter is arguable. However, Malaysian Ministry of Environment has published the standard values for concentration level.
3. Findings Analysis
The overall results show that only the Nemerow index PM$_{10}$ maintains a level higher than the critical value $I=1$. However the air Nemerow index has been declining in the past 15 years, indicating the air quality improvement in Malaysia. Among the five pollutants, the quality of NO$_2$, SO$_2$ and CO is better than the objective level without showing any significant change. Furthermore, the results of the contributory percentage of all five pollutants concentration show that SO$_2$ has a significant decrease in its contributory percentage from 15% in 1996 to 3% in 2010. This could be attributed to the use of better fuel quality EURO-2M, stricter enforcement by the DOE as well as wide usage of natural gas for industrial combustion process and vehicles.

Besides, the result shows the shape of the relationship between per capita GDP and air quality in Malaysia (Appendix A1). The O$_3$ curve shows an upward trend but after reaching at 19000 RGDP level, it shows declining trend. While the plot of the SO$_2$ index has a significant downward U-shaped curve trend. Moreover, CO, PM$_{10}$ and Nemerow indices show an inverted U-shaped relationship clearly in terms of turning or critical point. The critical or turning point for Malaysian economy is 17,000 RM, which is quite near to the world mean value (5,000-8,000 USD) [19].

4. Conclusion
The results show that there is consistency between air pollutants and EKC hypothesis. However, SO$_2$, CO and PM$_{10}$ indices have declined as GDP growth rate is increasing. In fact, the downward and EKC patterns of the ambient air can also be explained by the government’s environmental regulations and the citizens’ environmental consciousness. The air pollutants support the EKC, as most of them have gone through the turning point, and their environmental qualities are being improved with the economic development. Besides, we have found that policies should be formulated according to the characteristics of each individual pollutant. Also, the findings show that EKC takes various shapes depending on the type of pollutant. Thus, environmental and energy policies need to be ‘customized’ for each substance, rather than standardization. Figure1 shows the five stages of relationship among GDP and air pollution. We can relate that Malaysian air quality has trend towards improvement to show better policies in order to cut down pollution.

![Figure 1. Relationship between air pollution & level of development](image)

For further research, we can employ simultaneous equation model by using quarterly data in order to have more clearer picture of each pollutant. Due to time lag we have just simply applied the Nemerow index approach which is not enough to disclose the exact application of EKC theory in Malaysian economy.
Appendix A1: The relationship between per capita GDP and air quality in Malaysia.

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