“Exploring the environmental Kuznets curve for CO2 and SO2 for Southeast Asia in the 21st century context”

AUTHORS	Patrick Wijaya Tjoek Pei-Ing Wu https://orcid.org/0000-0002-5097-2727

ARTICLE INFO	Patrick Wijaya Tjoek and Pei-Ing Wu (2018). Exploring the environmental Kuznets curve for CO2 and SO2 for Southeast Asia in the 21st century context. *Environmental Economics*, *9*(1), 7-21. doi:10.21511/ee.09(1).2018.01
DOI	http://dx.doi.org/10.21511/ee.09(1).2018.01
RELEASED ON	Tuesday, 23 January 2018
RECEIVED ON	Friday, 10 November 2017
ACCEPTED ON	Friday, 15 December 2017

JOURNAL	"Environmental Economics"
ISSN PRINT	1998-6041
ISSN ONLINE	1998-605X
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

Patrick Wijaya Tjoek (Indonesia), Pei-Ing Wu (Taiwan)

Exploring the environmental Kuznets curve for CO_2 and SO_2 for Southeast Asia in the 21st century context

Abstract

This study aims to investigate the relationships between economic development and environmental degradation regarding the emissions of CO_2 and SO_2 in Southeast Asia (SEA). The pooling data consist of 10 countries, Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Singapore, the Philippines, Thailand, and Vietnam, in the period 2003–2012. Furthermore, income elasticity of CO_2 and SO_2 emissions is computed for each country to observe the sensitivity of environmental degradation through the emissions of CO_2 and SO_2 brought by economic development.

The results indicate that CO_2 displays an inverted U-shape pattern, whereas SO_2 has decreased at an increasing rate since 2003. It is expected that SO_2 will increase as the SEA economies further develop. The turning points for both CO_2 and SO_2 indicate that the current SEA income level has not reached the turning point. The income elasticities show that income elasticities for CO_2 are positive for all 10 countries. Both Singapore and Malaysia are classified as countries with high income. However, Singapore, with 0.64%, has the highest income elasticity, and Malaysia, with 0.15%, has the second lowest. There is no indication that wealthy countries have a significant impact on CO_2 through economic development. Income elasticities for SO_2 of each country are all negative. This suggests that SO_2 is an inferior good. Brunei, with 8.41%, has the most sensitivity toward change in SO_2 emissions, whereas Myanmar, with only 0.58%, is the least sensitive to SO_2 emissions.

Keywords: carbon dioxide, environmental Kuznets curve, income elasticity of emission, panel data, Southeast Asia, sulfur dioxide.
JEL Classification: O13, O53, Q56.
Received on: 10th of November, 2017.
Accepted on: 15th of December, 2017.

Introduction

The connection between the environment and economy has been long debated, and is one of the most controversial issues within the literature of economics. Ever since the late 1970's, economists and researchers alike have acknowledged the existence of a strong correlation between environmental integrity and economic development. The relationship between the environmental condition and economic development is called the environmental Kuznets curve (EKC). The EKC hypothesis suggests that countries can eventually overcome environmental degradation by passing a certain point in economic development.

The genesis for EKC was in the early 90's, when the World Bank, in cooperation with Grossman and Krueger (1991), investigated the impact of free trade policy within Canada, Mexico, and the United States. Their key discovery was that free trade among these countries has boosted their economic development, but left a considerable negative impact in each countries' pollution rate. Other past research mostly found that economic development has had substantial negative side effects on the environment through ill use of resources, including combustion, extraction, and processing production (Millimet et al., 2003; Anand, 2014; Frankel & Orszag, 2001). But the EKC provides hope for countries in reaching their "turning point", which makes the groundbreaking claim that after a certain point, countries will be able to "sustainably" grow without further hurting the environment while also "consistently" growing economically. The environmental protection begins as a luxury good in the early economic development stage, and becomes an ordinary good that everybody can afford as economic development progresses (Carson, 2009).

Countries in Southeast Asia (hereafter SEA) in the 21st century have played a crucial role in contributing substantial economic benefit to the world. In a period of just two decades, the gross domestic product (hereafter GDP) growth rate of the entire SEA has become 5.5% annually in comparison with the world's 2.9% (World Bank, 2003–2012). In addition to being one of the fastest growing regions globally, the SEA region provides many of the developed countries with their most integral partners in terms of global supply chain and trade. The production of 80% of global commodities resides in the ten countries of SEA, including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Singapore, the Philippines, Thailand, and

Patrick Wijaya Tjoek, Writer and Post-Graduate Alumni, Department of Agricultural Economics, National Taiwan University, Indonesia.
Pei-Ing Wu, Professor and Chair, Department of Agricultural Economics, National Taiwan University, Taiwan.

Vietnam, which all provide ample contribution to the global economy. Among these ten countries, only three countries, Singapore, Malaysia, and Brunei, are considered as developed countries. The current noticeable change within the SEA demographics is the alleviation of the poverty rate within each of the ten states above. Within the span of ten years, most of the developing countries have been able to lower the rate of those living below the $1 poverty rate to 18.8% (World Bank, 2003–2012). On the other hand, as the EKC hypothesis dictates, economic development in SEA is expected to have an adverse impact on the environment, especially in air quality, reflected in total greenhouse gas emissions (hereafter GHG).

The earliest studies concerning the US, Canada, and Mexico analyzed the impact of trade liberalization in the EKC of three countries (Grossman & Krueger, 1991, 1995). Grossman and Krueger's attempt sparked for specific country mentioned above to see the broad implication of economic development in a larger region. Up to this day, there have been few studies specifying the EKC of SEA, either current or past (Bo, 2011). The challenge in arriving at estimates for a region as big as Asia, despite being the oldest and historically noted area within history, is that there is no reliable data set on which to base the EKC analysis (Sinha & Bhatt, 2017).

The purpose of this study is to investigate if there exists the inverted U-shaped phenomenon as per the EKC hypothesis for SEA within a period from 2003 to 2012. The primary pollutants used to measure environmental degradation are carbon dioxide (CO_2) and sulfur dioxide (SO_2). These two are the most commonly used environmental degradation indicators due to their availability and importance in SEA. Particularly because most of the pollutants generated in the countries within SEA consist of these two pollutants (Napoli, 2013), testing the EKC hypothesis for these two pollutants in SEA is significant. The pooled data used to test for the existence of the EKC for CO_2 and SO_2 in SEA consist of 10 countries, Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Singapore, the Philippines, Thailand, and Vietnam, in the period 2003–2012. Moreover, income elasticity of CO_2 and SO_2 emissions is calculated respectively for each country to observe the sensitivity of environmental degradation through the emissions of CO_2 and SO_2 brought by economic development.

This study is important for several reasons. One of the reasons is because all ten countries in SEA have contributed heavily to the development of global emissions, and it is important to pinpoint their economic and environmental position within the 21st century. The EKC hypothesis will be able to confirm and lay out the current situation in SEA so that future economic policies can reference this information. Another reason is to lay the foundation which future EKC study can use as a reference relating to Asia and the SEA region. Because there has been little information concerning the EKC hypothesis for SEA, it would be a useful addition to the literature in the investigation of the EKC hypothesis. As a result, this study can further deepen the EKC analysis of the past literature for countries in SEA.

1. Economic development and environmental situation of SEA

1.1. SEA historical and general background. SEA is prominently one of the largest economies leading the changes within the 21st century. With over 4,506,597 square kilometers, compared to the entire Asia region of 44,580,000 square kilometers, it has ten countries that are diverse and play an integral yet distinct role within the economies of SEA. The earliest history within the SEA is that it was dominated by Proto-Asiatic inhabitants over 63,000 years ago (Wayman, 2012). Fig. 1 shows the map of SEA geography that displays the 10 countries of the SEA region. The overall geography within the SEA region is surrounded with open waters, providing easy access to ports. Due to the ease of establishing ports around the coasts of SEA, the arrival of much more developed countries such as the Netherlands, Portugal, France, Spain, and the United Kingdom have provided links to the outside world.

Moreover, SEA has long been a central region for trade involving diverse peoples and sources of income and knowledge from around the world. The Europeans brought financing and investment opportunities that SEA never had. Currently, the ten countries that occupy SEA are as follows: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Singapore, the Philippines, Thailand, and Vietnam. Each country has become a major economic player in the global market. Table 1 describes the descriptive statistics for various indicators for the overall picture of the SEA within the 21st century. The largest country in the area within the SEA is Indonesia, while the smallest is Singapore. Countries in SEA are also home to numerous manufacturing factories that host many international brands outside SEA. This, coupled with overflowing resources of labor that are unmatched outside SEA, has provided the perfect stage for stable economic development.

The most interesting part of this data set is how developing countries have begun to emerge within SEA in the 21st century. As shown in Table 1, countries that have the highest growth rate regarding economic development are Laos and Myanmar, while that with the lowest economic growth rate is Singapore. Similar performance occurs for GDP per capita. The highlight of this income difference is that countries within SEA have a high level of disparity. The 21st century has been quite kind to Laos and Myanmar. Laos for example has been able to restructure its economic infrastructure by enhancing the energy sector, which in turn has provided power for most of its significant economic development. Myanmar has also withdrawn its military from sensitive, important industries, thus allowing the economy to flourish. Furthermore, it is important to note that every country in SEA has positive economic development except Brunei.

Fig. 1. The map of SEA region

Source: Free World Maps (2005).

Table 1. General economic indicators of each country in SEA

Country	Area (km^2)	Total population	GDP per capita total (US$)	GDP growth (%)	Population density ($person/km^2$)	Unemployment rate (%)
Brunei	5,765.00	428,539	31,007	-2.40	74.34	1.90
Cambodia	181,035.00	15,677,059	1,161	7.00	86.60	0.30
Indonesia	1,472,639.00	255,708,785	3,371	5.20	132.26	6.20
Laos	236,800.00	7,019,652	1,760	7.40	29.64	1.50
Malaysia	330,803.00	30,651,176	9,766	4.30	92.93	3.10
Myanmar	676,578.00	54,164,262	1,148	7.30	80.06	5.00
Philippines	300,000.00	101,802,706	2,864	6.50	339.34	6.30
Singapore	716.00	5,618,866	53,626	2.30	8,226.74	1.90
Thailand	513,000	67,960,000	5,816	2.80	133.02	0.56
Vietnam	331,212.00	93,386,630	2,034	6.30	281.55	3.40

Source: Bouzanis (2017).

1.2. Change in environment within SEA. Within the 21st century, SEA economies have indeed been growing positively, and it is necessary to emphasize how these economic developments impact on environmental degradation, which includes emissions of GHG. The GHG emitted due to the economic development from countries in SEA have created various negative consequences for the planet (Ranveer & Latake, 2015). Among these, agriculture and the energy sector are two main culprits of the emissions of GHG in SEA. Rainforests in SEA account for 20% of the world rainforests, which is significant enough to be one of the first filters in global warming (Chakravarty et al., 2012). The way that a rainforest works is to act as a respiratory system for the Earth as it recycles heavy materials such as SO_2 and CO_2, and turns them into oxygen. Every year an estimated 15 million hectares of tropical forests are cut down for the sake of timber, rubber, and palm oil, rainforests within SEA will certainly disappear along with their ability to clean the polluted environment (Food and Agricultural Organizations of the United Nations, 2010).

Energy has always been essential for building an economy in SEA; without energy the economy could not function since there is no power to support all kinds of activities. Electricity generation within SEA has always utilized coal due to the fact that the supply of coal within SEA is abundant. It turns out that almost 75% of the world coal supplies come from Indonesia's and Malaysia's coal mines (International Energy Agency, 2015). Coal power plants are primary facilities to generate electricity in SEA. The energy pathway of coal combustion releases heavy chemicals such as CO_2, SO_2, NO_2, and mercury into the environment. Coupled with the fact that 7 out of 10 countries in SEA are still developing countries and have difficulties in applying sustainable energy to generate energy, the coal power plants have been increasingly popular within SEA. Most of the countries have an upward trend of the production of electricity using coal (World Bank, 2003–2012).

2. Conceptual framework

Many studies have strived to re-create the EKC, in most cases using GDP per capita as the key indicator to measure the changes in economic development for a specific country or for a particular area. Azam and Khan (2016) attempted to test the EKC hypothesis for four countries, which are Tanzania, Guatemala, China, and the USA under the circumstance that each of these four countries has different incomes, with dominant pollution types of their own. A similar study by Jalil and Mahmud (2009) attempted to figure out how to apply the EKC hypothesis with CO_2 for China in the 21st century. Some studies also conclude that no matter whether countries are rich or poor, the hypothesis of EKC is not sustained (Dasgupta et al., 2002).

Another critical development that has been quite new within the context of EKC is to doubt the original hypothesis of the EKC. The original EKC hypothesis suggests that when countries are experiencing economic development, almost everybody tends to disregard environmental integrity and strictly focus on gain within economic development. In addition, when the economy has developed to a certain point, the majority within the economy demand more environmental protection and start a change in environmental protection status from a luxury good to a normal good (Stern, 2004b). In the literature on EKC, there has been an increase in the incorporation of trade-associated variables within the EKC regression. Many countries in SEA have a big chunk of their economies generated by cross-country operations, which affects the place of trade in the analysis between environment degradation and economic development in SEA. Because there is much more available data that can be used to explore more factors that might influence environmental degradation without affecting economic progress, recent EKC studies have been incorporating other factors that might also influence the EKC hypothesis. These topics include income inequality, long-run and/or short-run human health, and potential renewable energy (Utari & Cristina, 2015; Saboori et al., 2012; Sugiawan & Managi, 2016). Abella and Bayacag (2013) attempted to define the Philippines' EKC in terms of health and not just economic development. They discovered that a 10 percent increase in revenue would increase a disease rate by 5.42%, which leads to the fact that an increase in income would no doubt lead to worse health conditions in the Philippines.

Within the last decade, economists have speculated that there is situation where the economy of a country could deviate from the original conventional hypothesis portrayed in Fig. 2. The first variation in the hypothesis, highlighted as new toxins in Fig. 2, suggests that within the distant future there will be various types of pollutants that are either impossible to resolve or which the current technology level is just incapable of containing. The aftermath of this would be a much grimmer result within the EKC, because as economic development continues, the new kinds of pollutants will keep rising.

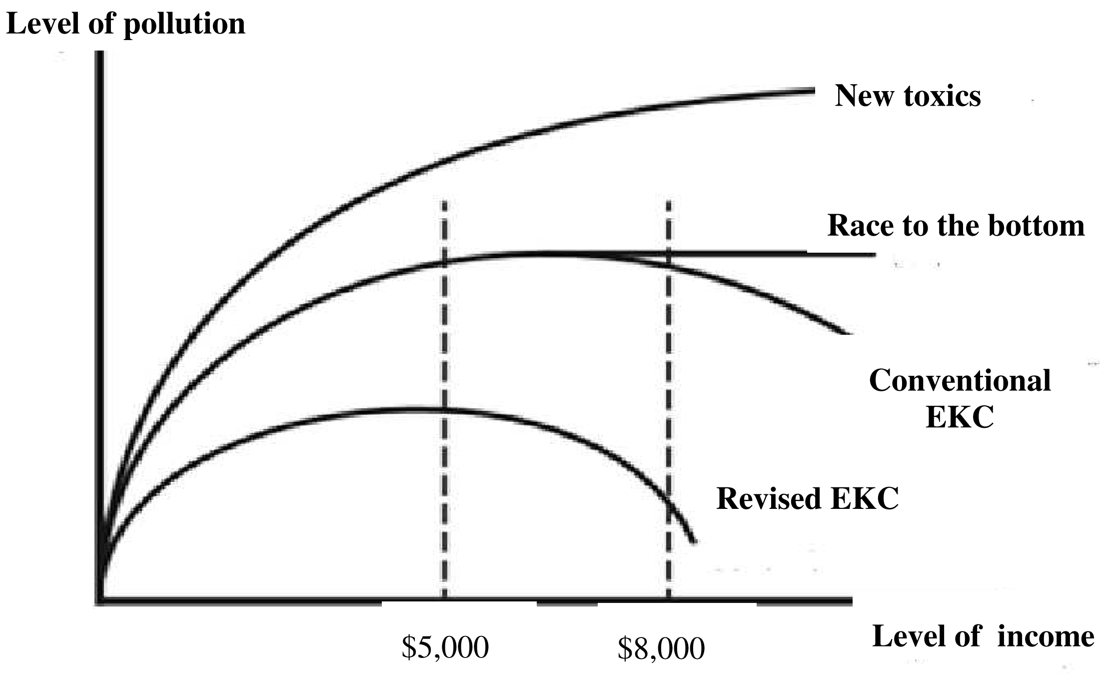

Fig. 2. Different scenarios of environmental Kuznets curve

Source: Taguchi (2012).

The second variation of the EKC hypothesis comes from Dasgupta et al. (2002), in which he and other economists described the first pessimistic outcome as "Race to the bottom". The idea of race to the bottom describes a scenario where pollution levels remain constant at their highest contamination levels even after passing the turning point in the EKC. This newly developed hypothesis is born from the idea that governments in higher-income countries have already enforced rigid environmental policies and regulation. The domestic producers then outsource their production to less stringently regulated countries. As a result, pollution as a whole is scattered but not reduced as a whole (World Health Organization, 2004). The last alternative to the EKC hypothesis ends with a more positive note called the revised EKC. It predicts that even more aggressive development in community pursuit of environmental protection would invigorate humanity to protect the environment even more aggressively, i.e. an upward spiral of environmental protection. What we learn from this is that these likely can happen in the future, and it is wise to pay attention to what the current economy does to prevent environmental degradation today.

3. Data description and empirical specifications

3.1. Sources of data and summary statistics for all variables. The summary statistics within the pooling time series and cross-sectional data are listed in Table 2. The data are gathered from the World Bank database due to its completeness and reliability. Due to the lack of data for other variables and difficulty in controlling a considerably extended period within the estimation, and because the purpose is to figure out the actual position for a country in SEA during its latest stage of development, it was decided to use only the latest ten years, from 2003 to 2012. There are 100 observations composed of ten years and ten countries.

Since this study explores the relationship between environmental degradation and economic development, the most crucial kind of data is the economic development indicator defined by the variable of real GDP per capita. That is, 2010 is used as the base year to deflate GDP per capita as real magnitudes. Environmental degradation is operationalized as the emissions of CO_2 and SO_2 gauged by kilograms per capita. The definition of CO_2 and SO_2 is, for every person in a country, how much pollution on average a person produces in kilograms annually. The original data for CO_2 and SO_2 emissions provided by the World Bank are in kilotons and are converted to kilograms to create a more comprehensible measurement. The reason for using per capita is that it is easier to compare among countries. The other explanatory variable for the estimation is trade, which is crucial because trade has contributed substantially to economic development in the SEA. The measurement used for the trade variable for EKC estimation here is the amount of imports and exports over the amount of GDP in a certain period. Trade is expected to have a positive relation with economic development, and might harm the environment to a certain degree (Zhang, 2011).

Another explanatory variable is technological progress. The idea behind this variable is denoted by energy intensity. The definition of energy intensity is the ratio between energy produced in a year over the GDP produced over that year. This means that when there is any technological improvement within the economy (i.e. technical change), overall energy usage to produce one unit of output is reduced (Nourdhaus, 2007). With less energy used to produce an output, a country or region should be producing less pollution due to the fact that fewer resources are used to produce energy (Stern, 2004a).

Table 2. Definition and descriptive statistics of the variable for estimation

Variable	Definition (unit)	Mean	Standard deviation	Minimum	Maximum
CO_2	Carbon dioxide emissions (kg per capita)	2.1648	5.3719	0.1465	19.9128
SO_2	Nitro dioxide emissions (kg per capita)	14.9536	16.5674	0.2040	76.2000
GDP	Real GDP per capita (US dollars in thousand)	0.8574	1.4470	0.0165	5.2948
Trade	Trade in services is sum of service exports and imports divided by value of GDP US dollars	129.4424	101.9500	0.1674	439.6567
Tech	Energy intensity level of primary energy (MJ/$2011PPP GDP)	4.8000	1.1937	2.5709	8.2380

Source: The World Bank (2003–2012).

3.2. Model specifications for estimation of CO_2 and SO_2 emissions and GDP. The regressions (1) and (2) both focus on the impact which real GDP per capita has on environmental degradation in SEA. By using quadratic and cubic forms, regression equations (1) and (2) are designed to produce a representation of the EKC hypothesis of SEA in hopes of finding the inverted U-shape that the EKC hypothesis has proposed. An equation suggested by Stern (2004b) is adopted for our purpose:

$$E_{it} = \alpha_t + \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_3 trade_{it} + \beta_4 tech_{it} + \beta_5 year_t + \varepsilon_{it} \qquad i = 1,...,10; \quad t = 1,...,10 \tag{1}$$

$$E_{it} = \alpha_t^{'} + \beta_0^{'} + \beta_1^{'} GDP_{it} + \beta_2^{'} GDP_{it}^2 + \beta_3^{'} GDP_{it}^3 + \beta_4^{'} trade_{it} + \beta_5^{'} tech_{it} + \beta_6^{'} year_{it} + \delta_{it} \qquad i = 1,...,10; \quad t = 1,...,10 \tag{2}$$

Here i = 1, …, 10 correspond to the country used in the SEA and t = 1, …, 10 is the year designated in 2003–2012. E_{it} represents environmental degradation, using kilograms per capita of CO_2 or SO_2. There are two parts of the error terms in equations (1) and (2). The symbols α_t and $\alpha_t^{'}$ account for the non-time different errors within countries, it is necessary to recognize α_t and $\alpha_t^{'}$ within the regression since we are dealing with panel data that include endogeneity. ε_{it} and δ_{it} are the second part of the error terms, representing the idiosyncratic error indicating the error changes over time. β_0 and $\beta_0^{'}$ are the constant terms for each regression.

GDP is the variable that represents real GDP per capita. The incorporation of the polynomials form of the economic indicator is derived from Stern's model, which is designed to portray the inverted U-shape or N-shape of the EKC hypothesis (Stern, 2004b). The variable of *Trade* is the sum of service exports and imports divided by the value of GDP, all in U.S. dollars. The interpretation of this value is that it is the ratio of contribution from exports and imports in relation to the growth of GDP. Thus, trade is hypothesized to be correlated with environmental degradation. Another explanatory variable is *Tech*, indicating the energy intensity level of primary energy in the CO_2 regression. The calculation of energy intensity is the ratio between energy used and GDP measured at purchasing power parity (World Bank, 2003–2012). This rationale is used to measure the technological efficiency in economic development in SEA because it tracks how much energy is used to produce one unit of output. The corresponding energy usage from consuming combustible materials reflects the efficiency usage of current technology (Roy & Sardar, 2015). Finally, the variable *year* represents the year dummy variable coefficient. It is necessary to represent every single year within the 10 years because each year might have significantly different contribution in the development of EKC within SEA.

3.3. The relationship between CO_2 and SO_2 emissions and GDP for countries in SEA. The EKC analysis has always revolved around the use of a random effect (RE) and a fixed effect (FE) to control the subject time-invariant factors (Wooldridge, 2009). In this case, it is important to acknowledge that each country within SEA is different in many aspects despite being constant annually, such as geography, culture, education level, and natural resources. The decision to use the fixed or random effect is determined by the utilization of the Hausman test. In some sense, if the null hypothesis is favored, then the random-effect is model favored over the fixed-effect model (Hsiao, 1986).

The foundation of the EKC hypothesis is that the environmental degradation level is expected to increase at the same time as real GDP per capita increases, until a certain point, at which environmental degradation is expected to decrease as income enters a different level. The calculation of the turning point for a quadratic situation is taken from Egli (2001) as follows:

$$\mu_2 = \frac{-\beta_1}{2\beta_2}. \quad (3)$$

Another interesting estimation is through the cubic term that is displayed under equation (4). The discussion of use of quadratic and cubic terms has been popular in the determination of the EKC curve to achieve a much more realistic representation of the relationship between the economy and environment (Sulemana et al., 2017; Gupta et al., 2016; Katircioglu et al., 2014). When $\beta_3 > 0$, then the cubic form also produces a similar N-shaped parabola, but instead of having just one turning point, there are two turning points within the economy. The turning point derived by Disli et al. (2016) for the cubic form of the EKC regression is as shown in equation (4):

$$\mu_3 = \frac{-\beta_2 \pm \sqrt{\beta_2^2 - 3\beta_1\beta_3}}{3\beta_3}. \quad (4)$$

3.4. Testing CO_2 and SO_2 emissions with income differences in SEA. Due to the diverse economic conditions among the ten different SEA countries, it is necessary to measure each country's contribution individually within the development of SEA. Because the ten countries differ in economic wealth, it is determined that income differentiation is used to see how much impact each economy brings into the EKC for SEA. The analysis of income differences uses dummy variable to represent whether a country is high or low within the context of SEA. A low-income country ranges from 0 to 1,000 US$, while high-income countries are those above 1,000 US$.

Under this classification, high-income countries consist of Singapore, Brunei, and Malaysia, while low-income countries include Indonesia, Thailand, Vietnam, Laos, Myanmar, the Philippines, and Cambodia. Equation (5), derived from Torras and Boyce (1998), represents the aspect of income differences within the estimation:

$$E_{it} = \alpha_{it} + \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_3 GDP_{it}^3 + \beta_4 Income_{it} + \varepsilon_{it}$$
$$i = 1,...,10; \quad t = 1,...,10 \quad (5)$$

Here i = 1, …, 10 correspond to the country used in the EKC estimation, and t = 1, …, 10 is the year of time-series. After obtaining the regressions that separate high- and low-income countries' EKC, both fixed and random effects are used to control the time-invariant factors. Afterward, the regressions from the fixed- and random-effect model are used to generate a separate regression that could represent the 10 high- and low-income countries in SEA. The way to do this is to create an average of all ten years for each variable besides real GDP per capita so that the factors that contributed to the EKC regression are absorbed within the constant term. This method creates a regression for every year, since utilizing a yearly average of the variable of interest would only isolate the power of that variable within that year. Further analysis is to compare the two line graphs and to see the impact of being a low- or high-income country within the realm of the EKC.

3.5. Income elasticity of environmental degradation in SEA. The last analysis is to compute income per capita elasticity to the average emissions of CO_2 and SO_2. The sole purpose of this estimation is to calculate the percentage change in CO_2 or SO_2 emissions for every one percent change in income. The equations for CO_2 and SO_2 elasticity are represented as (6) and (7) respectively:

$$\frac{\partial CO_2}{\partial GDP} * \frac{\overline{GDP}}{\overline{CO_2}}, \quad (6)$$

$$\frac{\partial SO_2}{\partial GDP} * \frac{\overline{GDP}}{\overline{SO_2}}, \quad (7)$$

where $\overline{CO_2}$ and $\overline{SO_2}$ is the average emissions for all the countries in a certain period. The significance of income elasticity in respect to CO_2 or SO_2 emissions is that it will clarify the relationship each country of SEA between its real GDP per capita and environmental degradation. In addition, the income elasticity of emissions can show the magnitude of change brought by economic development toward the environmental degradation rate of each country.

4. Results and analyses

4.1. Results of the relationship between CO_2 or SO_2 emissions and GDP in SEA.

4.1.1. Discussion of CO_2 estimation and GDP in SEA. Table 3 describes the result for CO_2 as the dependent variable for the EKC of SEA. It can be seen that not all models are statistically significant. The cubic model is not as effective as the quadratic model. Moreover, the Hausman test for the quadratic in the estimation of CO_2 emissions is in favor of using the fixed-effect model. The coefficient for real GDP per capita will then determine whether there is an inverted U-shape. The estimation result shows that the variable of *Tech* has positive impact towards environmental improvement within SEA. In addition, all across the model the *Tech* variable shows statistical significance, which proves that technological efficiency plays a major role in controlling CO_2 emissions in SEA. As with the *Trade* variable, the trade coefficients across all models do not display full statistical significance. This shows that trade is not a prevalent variable in determining the importance of trade within the analysis of EKC within SEA.

Table 3. Comparison of fixed- and random-effect models for CO_2 emissions and GDP

Variables	Quadratic form		Cubic form	
	FE	RE	FE	RE
GDP	2.492**	5.099***	1.367	9.147***
	(3.18)	(7.18)	(0.75)	(7.89)
GDP^2	-0.303** (-3.29)	-0.621*** (-6.50)	0.103 (0.14)	-2.016** (-3.59)
GDP^3	-----	-----	-0.045	0.145*
			(-0.55)	(2.04)
Tech	-0.454**	-0.368**	-0.454**	-0.490**
	(-3.15)	(-3.39)	(-2.99)	(-3.40)
Trade	0.002	-0.006	0.001	-0.014***
	(0.53)	(-1.59)	(0.15)	(-4.73)
year1	-0.505**	0.103	-0.667*	0.363
	(-2.78)	(0.28)	(-1.97)	(0.71)
year2	-0.518	-0.034	-0.671**	0.231
	(-3.57)	(-0.10)	(-2.25)	(0.46)
year3	-0.492***	-0.131	-0.639**	0.167
	(-4.75)	(-0.40)	(-2.64)	(0.34)
year4	0.096	0.351	-0.044	0.652
	(1.27)	(1.11)	(-0.20)	(1.32)
year5	0.036	0.197	-0.090	0.489
	(0.71)	(0.64)	(-0.49)	(1.00)
year6	0.046	0.136	-0.061	0.380
	(1.41)	(0.45)	(-0.38)	(0.79)
year7	0.063	0.220	-0.043	0.448
	(1.17)	(0.71)	(-0.29)	(0.93)
year8	-0.036	0.001	-0.113*	0.166
	(-1.68)	(0.00)	(-0.98)	(0.35)
year9	-0.009	-0.028	-0.010	0.069
	(0.75)	(-0.10)	(-0.27)	(0.15)
Const	0.646	-0.499	1.11**	-2.475
	(0.68)	(-0.57)	(1.81)	(-2.92)
Adj R^2	0.392	0	0.397	0
corr(u_i, Xb)	0.712	0	0.542	0
Hausman χ^2	0		0.014	

Notes: Numbers in parentheses are t statistics for each variable. Numbers with one asterisk "*" indicate variables significant at the 10% significance level, those with two asterisks "**" mean variables significant at the 5% significance level, and those with three "***" asterisks indicate variables are significant at the 1% significance level.

4.1.2. Discussion of SO_2 estimation and GDP in SEA. The results in Table 4 show there are less significant variables in the estimation of SO_2 than the results from CO_2. Nevertheless, the cubic fixed-effect model displays its significance in the estimation of SO_2 and is able to portray a robust representation of the SO_2 EKC in SEA. Accordingly, the analysis focuses on the cubic model. The Hausman test also suggests it is in favor of using the fixed-effect model. The estimation in Table 4 also yields the shape and curve of the EKC, which produce a clear representation of SO_2 in SEA in 2003–2012. The results indicate that when it has reached a certain growth point, SO_2 level will plateau while economic developments will still grow positively. The significance of this estimation suggests that at the beginning of 2003, SEA began reducing its SO_2 volume and moved toward much better environmental integrity. Table 4 shows that there is no statistical significance for the *Tech* variable. This leads to the idea that the technological energy reduction factor is not a significant factor for the estimation of SO_2, while the negative coefficient for the *Tech* variable provides an SO_2 emissions reduction in SEA.

4.2. Results of CO_2 and SO_2 EKC under income differentiation. Another issue is to see the possible EKC of CO_2 and SO_2 separated into different income groups within SEA. The low-income countries include Indonesia, Thailand, Vietnam, Laos, Myanmar, Cambodia, and the Philippines. The high-income countries are Brunei, Malaysia, and Singapore. The purpose of providing this flexibility within the regression is to see how the environmental degradation of countries in SEA changes when the income variable is directly incorporated in the regression. Table 5 describes the CO_2 estimation for SEA under income differences. Based on the Hausman test, it is determined to use the fixed quadratic model for interpretation. Fig. 3 describes the aforementioned estimation from Table 5.

Table 4. Comparison of fixed- and random-effect models for SO_2 emissions and GDP

Variables	Quadratic form		Cubic form	
	FE	RE	FE	RE
GDP	-4.80E-04	-1.971	-1.06E-03**	-2.414
	(-1.70)	(-0.40)	(-2.49)	(-0.21)
GDP^2	4.47E-05	1.269	2.40E-04**	1.837
	(1.39)	(1.37)	(2.62)	(0.32)
GDP^3	-----	-----	-2.10E-05**	-0.994
			(-2.83)	(-0.13)
Tech	-2.55E-05	-1.249	-2.27E-05	-1.082
	(-0.66)	(-0.84)	(-0.57)	(-0.74)
Trade	6.42E-07	0.071**	1.39E-06	0.067**
	(-0.46)	(2.72)	(-0.88)	(2.76)
year1	-2.39E-04**	8.008	-3.21E-04**	7.512
	(-2.32)	(1.38)	(-2.70)	(1.25)
year2	-1.01E-04	5.690	-1.71E-04*	5.222
	(-1.31)	(1.00)	(-1.90)	(0.87)
year3	-5.04E-05	5.439	-1.13E-04*	5.018
	(-0.96)	(0.98)	(-1.77)	(0.85)
year4	-1.15E-04**	11.964**	-1.72E-04***	11.550*
	(-3.11)	(2.18)	(-3.61)	(1.96)
year5	-8.72E-05**	4.405	-1.40E-04***	4.022
	(-3.67)	(0.81)	(-3.94)	(0.69)
year6	-1.40E-04***	3.260	1.81E-04***	2.911
	(9.73)	(0.60)	(-8.07)	(0.51)
year7	-1.757E-04***	5.869	-2.32E-04***	5.452
	(-4.64)	(1.08)	(-4.43)	(0.95)
year8	2.5E-05	3.556	-6.40E-05*	3.220
	(1.34)	(0.66)	(-2.12)	(0.57)
year9	-9.64E-07	1.363	-1.12E-05	1.293
	(-0.14)	(0.26)	(-1.10)	(0.24)
Const	1.16E-03***	4.979	1.47E-03***	4.835
	(5.20)	(0.59)	(5.31)	(0.58)
Adj R^2	0.149	0	0.158	0
corr(u_i, Xb)	-0.713	0	0.652	0
Hausman χ^2	0.027		0	

Notes: Definitions are the same as those in Table 3. Variables of CO_2, SO_2, *GDP*, GDP deflator, population of each country, *Trade*, and *Tech* represented by energy intensity are collected from the World Bank (2003–2012a; 2003–2012b; 2003–2012c; 2003–2012d; 2003–2012e; 2003–2012f; 2003–2012g).

Table 5. Comparison of income differentiation for CO_2 in SEA

Variables	Quadratic form		Cubic form	
	FE	RE	FE	RE
GDP	3.322***	5.089***	1.717*	10.866***
	(4.34)	(6.94)	(2.10)	(4.67)
GDP^2	-0.394***	-0.623***	0.233	-2.761**
	(-4.32)	(-6.03)	(0.53)	(-2.85)
GDP^3	–	–	-0.070	0.212*
			(-1.25)	(1.82)
Income	-0.039	-0.133	-0.326	0.319
	(-0.23)	(-0.22)	(2.94)	(0.23)
Constant	2.229***	1.331*	2.554***	-0.046
	(6.33)	(2.06)	(13.27)	(-0.13)
Sample size	100	100	100	100
Adj R^2	0.406	0.110	0.225	0.150
corr(u_i, Xb)	0.571	0	0.801	0
Hausman χ^2	0.020		0	

Note: Definitions are the same as those in Table 3.

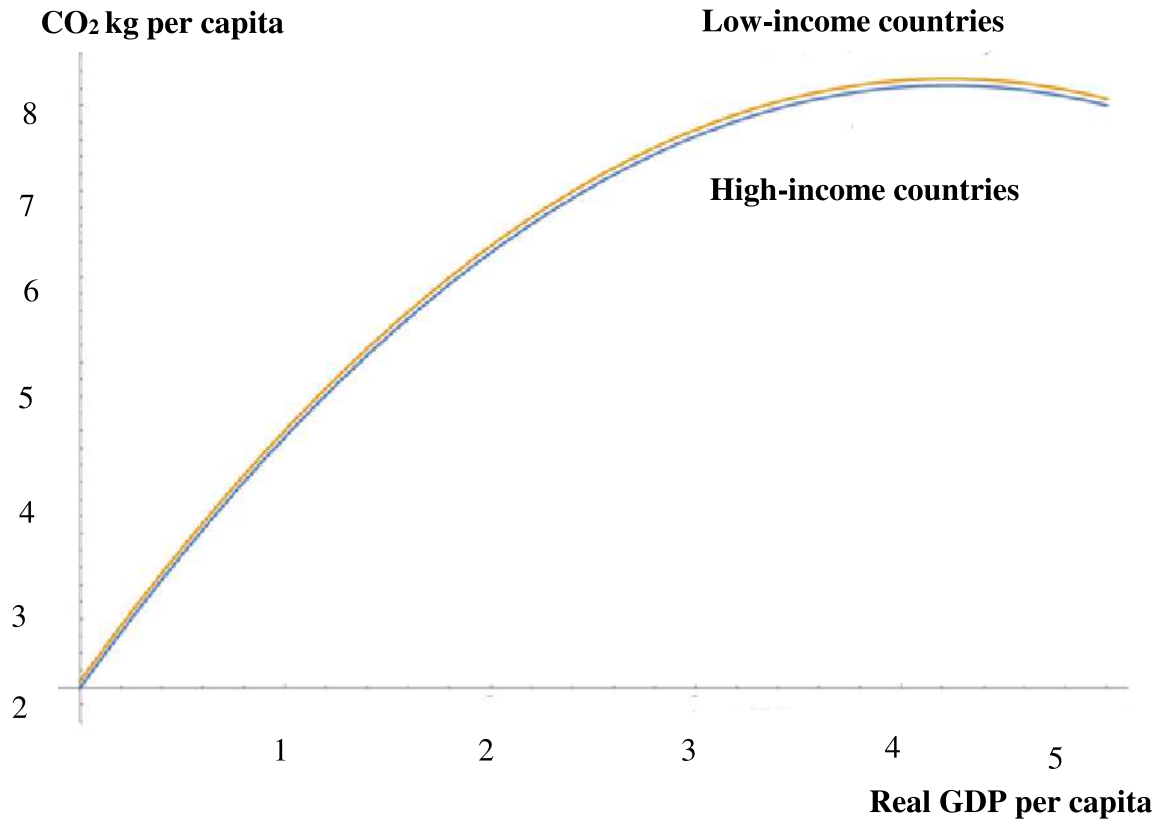

Fig. 3. Comparison of CO_2 emissions for high- and low-income countries in SEA

For low-income countries, the shape of the EKC for low-income countries is similar to that for high-income ones, which is downward sloping. This suggests that as low-income countries economically grow into the future, the growth of CO_2 within low-income countries will decline eventually. The comparison between low-income and high-income countries is that the EKC for high-income countries is at a much lower position than that of low-income countries. Even though the gap between the high- and low-income EKC is fairly minimal, the meaning of this estimation is that richer countries will have their CO_2 decline much more than low-income SEA countries. Nevertheless, the important conclusion obtained here is that no matter the level of income within SEA, CO_2 growth in general will decline as economic development continues to grow. The suggested interpretation of income differentiation variables *(Income)* within this estimation is that higher-income countries will have a lower amount of CO_2 kilograms per capita by 0.039 in comparison with lower-income countries.

Similar results for SO_2 are displayed in Table 6. Based on the Hausman test, it is suggested that the fixed effect of cubic form is best to describe the SO_2 emissions for high-income and low-income countries. Another interesting point here is that countries at both income levels follow the same curvature between SO_2 and real GDP per capita. The statistical interpretation within Table 6 for the fixed-effect cubic form for a high-income country in SEA is that it will reduce SO_2 emissions by –2.64E-05 kilograms per capita for a particular country, while for a low-income country it will induce a –2.64E-05 kilogram per capita increase in SO_2 kilograms per capita.

Fig. 4 shows how results for a high- or low-income country within SEA when using SO_2 as the dependent variable. The clear pattern here is that high-income countries have a lower position than low-income countries. The interpretation of this graph is that low-income countries are experiencing the same thing as high-income countries are undergoing, but with a higher level of environmental degradation as economic development progresses. Fig. 4 suggests that for future economic development for SEA, countries that start developing into higher-income countries will be able to more greatly reduce environmental degradation due to the increase in income.

The turning point according to the EKC hypothesis dictates that income will be able to change the preferences for consumers to adopt a much more environmentally friendly consumption pattern. The advantage of this discovery is that Fig. 4 represents a fundamental understanding that income greatly affects the relationship between economic development and environmental integrity. From the current trend of economic development within SEA, SO_2 will most likely be declining in the future, but this is accompanied by the cautionary tale that it will eventually change track to be increasing in the future when it has reached its second turning point.

Table 6. Comparison of income differentiation for SO_2 emissions in SEA

Variables	Quadratic form		Cubic form	
	FE	RE	FE	RE
GDP	-1.324E-04	6.06E-05	1.626E-04*	2.828E-04
	(-1.15)	(0.33)	(2.22)	(0.81)
GDP^2	6.81E-06	-1.78E-05	-1.084E-04**	-1.108E-04
	(0.45)	(-0.66)	(-3.33)	(-0.81)
GDP^3	–	–	1.29E-05**	1.08E-05
			(3.67)	(0.67)
Income	-2.64E-05	-2.78E-05	-2.64E-05	-1.97E-05
	(-0.82)	(-0.15)	(-0.90)	(-0.10)
Const	6.608E-04***	5.641E-04***	6.012E-04***	5.269E-04
	(11.16)	(4.29)	(9.15)	(4.45)
Sample Size	100	100	100	100
Adj R^2	0.430	0.110	0.324	0.150
corr(u_i, Xb)	0.571	0	0.644	0
Hausman χ^2	0.010		0	

Note: Definitions are the same as those in Table 3.

4.3. Results of income elasticity of CO_2 and SO_2 emissions in SEA. The last part of the result is the income elasticity of CO_2 and SO_2 emissions in SEA. This is important in clarifying the sensitivity of the relationship between economic development and emissions of CO_2 and SO_2 kilograms per capita within individual countries in SEA. Table 7 describes the income elasticity of CO_2 emissions for every single country in SEA. The computed CO_2 emissions average between 0.19 to 17.37 kilograms per capita, and the real GDP per capita ranges between 37.8 to 3,754.1 US$ annual for every country in the 10-year period 2003–2012.

Table 7 shows that among the ten countries, Singapore has the most sensitive change in economic development in respect to its CO_2 changes of 0.64%. Thailand is the least elastic country within this analysis, with only 0.12%, and Malaysia with 0.15% is ranked as the second least elastic. Both Malaysia and Singapore, however, are categorized among the three high-income countries. This shows that there is no indication that wealthy countries have a significant impact on CO_2 emissions through economic development. The income elasticity of CO_2 emissions also indicates that CO_2 for every individual country in SEA is in fact a normal good.

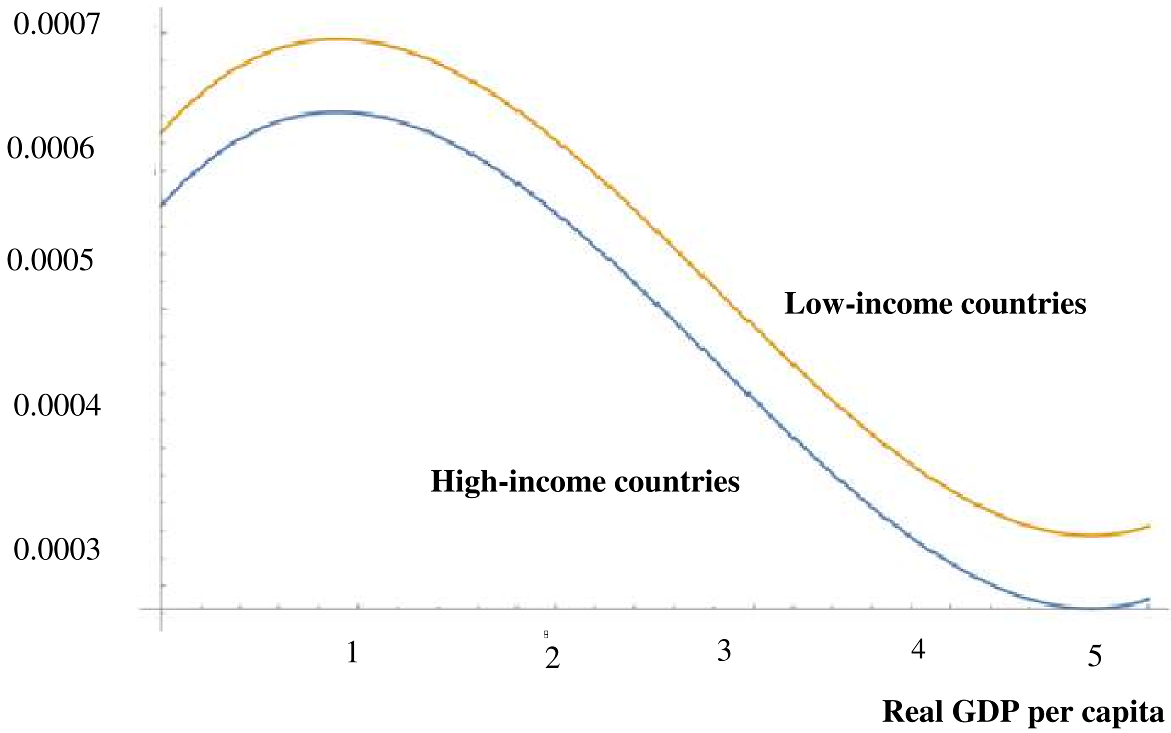

Fig. 4. Comparison of high- and low-income countries for SO_2 emissions in SEA

Table 7. Income elasticity of CO_2 emissions for individual countries in SEA

Country	Average real GDP per capita (US$ in thousands)	Average CO_2 (kg per capita)	Income elasticity of CO_2
Brunei	3,397.5	17.3663	0.0029
Cambodia	38.0	0.2773	0.0021
Indonesia	169.8	1.6066	0.0016
Laos	37.8	0.2317	0.0024
Malaysia	684.1	6.7663	0.0015
Myanmar	46.2	0.1933	0.0036
Philippines	98.4	0.8932	0.0016
Singapore	3,754.1	8.7573	0.0064
Thailand	282.5	3.4224	0.0012
Vietnam	65.6	0.3155	0.0031

Similarly, Table 8 shows the calculated income elasticity of SO_2 emissions for each country in SEA. Average SO_2 income elasticities for each country in the period 2003–2012 are all negative. This suggests that SO_2 is an inferior good in comparison with CO_2. The conclusion obtained here is that as the economy of SEA develops further, the emissions of SO_2 will eventually decline. Furthermore, it can be observed that the country that has the most sensitivity relationship between economic development and change in SO_2 emissions is Brunei, with an 8.41% change in SO_2 when there is a 1% change in its economic development. The least sensitive country is Myanmar, with only 0.58% change in its kilograms per capita SO_2 emissions. From this, we can conclude that a country's wealth does not justify the sensitivity towards change in its economic development.

As a final note, SO_2 emissions for countries in SEA are inferior goods. However, the elasticity of SO_2 emissions is very different from the impact of CO_2. In general, CO_2 has relatively low income elasticity, whereas the SO_2 has much more income elasticity. This explanation leads to the notion that the amount of SO_2 and the influence of economic development will provide a larger swing in emissions or reduction in atmospheric pollutants in comparison with CO_2..

The advantage of this is that there will be an exponential reduction in SO_2 emissions when economic development continues.

Conclusion

This study aims to investigate the hypothesis that there is a relationship between economic development and environmental degradation in Southeast Asia within the years 2003 to 2012. The results estimated by fixed- and random-effect models indicate that CO_2 and SO_2 in Southeast Asia behave differently in relation to economic development. CO_2 in Southeast Asia has indeed behaved like the conventional EKC hypothesis, where it has displayed an inverted U-shape. On the other hand, the SO_2 in Southeast Asia has displayed a pattern of starting to decrease at an increasing rate since 2003. It is expected that in the near future, Southeast Asia's SO_2 will increase as the SEA economies further develop. The turning points for both CO_2 and SO_2 indicate that the current Southeast Asian economies have not reached the level of income of the turning point. Thus, the importance of this discovery suggests that the general populace of Southeast Asia will continue to pollute the environment until the day comes when the overall economic development level reaches the turning point.

By differentiating countries by high- and low-income levels in SEA, we observe the impact of economic level in correspondence to the EKC hypothesis. The results show that when separating SEA countries into those of low income, operationalized as less than US$1,000 real GDP per capita, and higher income, defined as above US$1,000 real GDP per capita annually, the EKC for low-income countries is positioned above that of the high-income countries. This suggests that high-income countries, as they grow richer across time, have a bigger reduction in environmental degradation compared to low-income countries. The results suggest that countries with different levels of income will have different levels of progression in tackling CO_2 and SO_2 emissions.

Lastly, the income elasticities of CO_2 and SO_2 emissions for every country in Southeast Asia perform differently. The estimation shows that the income elasticity of CO_2 emissions increases with positive growth of CO_2 emissions. On the other hand, SO_2 displays a different relationship with Southeast Asia's economic development. As Southeast Asia's economies develop, there will be a decreasing level of SO_2 emissions. The lessons from this study are applicable to Southeast Asia's future economic development. Because Southeast Asia's economies have been proven to comply with the EKC hypothesis, each country in Southeast Asia needs to heed the fact that an obsession with progressive economic development always damages the environment.

References

1. Abella, J. A., & Bayacag, P. (2013). Environment, health, and economic growth in the Philippines. Philippines Agricultural Economics and Developmental Association. University of Southeastern Philippines, Bo. Obrero, Davao City. Retrieved from https://paedacon.files.wordpress.com/2013/10/fullpaper_abella_junecell.pdf (accessed on 5 December, 2017).
2. Anand, N. (2014). An overview of Indian economy (1991-2013). *Journal of Economics and Finance, 3*(3), 19-24.
3. Azam, M., & Khan, A. Q. (2016). Testing the environmental Kuznets curve hypothesis: A comparative empirical study for small, lower, middle, upper middle and high-income countries. *Renewable and Sustainable Energy Reviews, 63*(1), 556-567.
4. Bo, S. (2011). A literature survey on environmental Kuznets curve. *Energy Procedia, 5*(1), 1322-1325.
5. Bouzanis, A. (2017). Economic snapshot for ASEAN. *Focus Economics*. Retrieved from http://www.focus-economics.com/regions/asean (accessed on 25 June, 2017).
6. Carson, R.T. (2009). The environmental Kuznets curve: Seeking empirical regularity and theoretical structure. *Review of Environmental Economics and Policy, 4*(1), 3-23.
7. Chakravarty, S.K., Ghosh, C.P., Suresh, A.N, Dey and Gopa Shukla, okia, C. A. (2012). *Deforestation: causes, effects, and control strategies, global perspectives on sustainable forest management*. Retrieved from http://www.intechopen.com/books/globalperspectives-on-sustainable-forest-management/deforestation-causes-effects-and-control-strategies (accessed on 30 June, 2017).
8. Dasgupta, S., Laplante, B., & Wheeler, D. (2002). Confronting the environmental Kuznets curve. *The Journal of Economic Perspective, 16*(1), 147-168.
9. Disli, M., Ng, A., & Askari, H. (2016). Culture, income, and CO_2 emission. *Renewable and Sustainable Energy Review, 62*(1), 418-428.
10. Food and Agricultural Organizations of the United Nations (2010). Global forest resources assessment. Rep. No. 163. Rome: Food and Agriculture Organization of the United Nations.
11. Frankel, J., & Orszag, P. (2001). *Retrospective on American economic policy in the 1990s*. Cambridge, Massachusetts: MIT Press.
12. Free World Maps (2005). South East Asia political map. Retrieved from http://www.freeworldmaps.net/asia/southeastasia/southeastasia_political.gif. (accessed on 13 April, 2017).

13. Egli, H. (2001). *Are cross-country studies of the environmental Kuznets curve misleading? New evidence from time series data for Germany*. Ernst-Moritz-Arndt University of Greifswald. Discussion Paper 10/2001. University of Greifswald, Greifswald, Germany. Retrieved from https://ideas.repec.org/p/zbw/grewdp/102001.html (accessed on 25 May, 2017).
14. International Energy Agency (2015). Southeast Asia Energy Outlook of Southeast Asia 2015: World energy outlook special report. France: International Energy Agency. Retrieved from https://www.iea.org/publications/freepublications/publication/WEO2015_SouthEastAsia.pdf (accessed on 30 May, 2017).
15. Grossman, G., & Krueger, A. (1991). *Environmental impacts of a North American free trade agreement. National Bureau of Economic Research* (Working Paper No. 3914). Cambridge, Massachusetts: MIT Press. Retrieved from http://www.nber.org/papers/w3914 (accessed on 07 April, 2017).
16. Grossman, G., & Kruger, A. (1995). Economic growth and environment. *The Quarterly Journals of Economics, 110*(2), 353-377.
17. Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve for CO_2 emissions: A cointegration analysis for China. *Energy Policy, 37*(12), 5167-5172.
18. Katircioglu, S. T., Feridun, M., & Kilinc, C. (2014). Estimating tourism-induced energy consumption and CO_2 emissions: The case of Cyprus. *Renewable and Sustainable Energy Reviews, 29*(1), 634-640.
19. Millimet, D. L., List, J. A., & Stengos, T. (2003). The environmental Kuznets curve: Real progress or misspecified models? *Review of Economics and Statistics, 85*(4), 1038-1047.
20. Napoli, C. (2013). *Growing green: A comparison across Southeast Asia*. (Working Paper Prepared for the Nottingham GEP). University of Nottingham, Kuala Lumpur, Malaysia. Retrieved from https://www.nottingham.ac.uk/gep/documents/conferences/2013/malaysia-conference/christopher-napoli.pdf (accessed on 16 May, 2017).
21. Nourdhaus, W. D. (2007). Economic theory of technological change theory of innovation. *The American Economic Review, 59*(2), 18-28.
22. Ranveer, A. C., & Latake, P. T. (2015). The greenhouse effect and its impacts on environment. *International Journal of Innovative Research and Creative Technology, 1*(3), 333-337.
23. Saboori, B., Sulaiman, J., & Mohd, S. (2012). Economic growth and CO_2 emissions in Malaysia: A cointegration analysis of the evironmental Kuznets curve. *Energy Policy, 51*(1), 184-191.
24. Sulemana, I., Harvey, S., & Rikoon, S. (2017). Environmental Kuznets curves for air pollution in African and developed countries: Exploring turning point incomes and the role of democracy. *Journal of Environmental Economics and Policy, 6*(2), 134-152.
25. Sugiawan, Y., & Managi, S. (2016). The environmental Kuznets curve in Indonesia: Exploring the potential of renewable energy. *Energy Policy, 98*(1), 187-198.
26. Sinha, A., & Bhatt, M. (2017). Environmental Kuznets curve for CO_2 and NO_2 emissions: A case study of India. *European Journal of Sustainable Development, 6*(1), 267-276.
27. Stern, D .I. (2004a). Economic growth and energy. *Encyclopedia of Energy, 2*(1), 35-51.
28. Stern, D. I. (2004b). The rise and fall of the environmental Kuznets curve. *World Development, 32*(8), 1419-1439.
29. Taguchi, H. (2012). The environmental Kuznets curve in Asia: The case of sulphur and carbon emissions. *Asia-Pacific Development Journal, 19*(2), 77-92.
30. Torras, M., & Boyce, J. K. (1998). Income, inequality, and pollution: A reassessment of the environmental Kuznets curve. *Ecological Economics, 25*(1), 147-160.
31. The World Bank, World Development Indicators (2003–2012a). CO_2 emissions (metric tons per capita). Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam. The World Bank Development Data Group.
32. The World Bank, World Development Indicators (2003–2012b). SO_2 emissions (metric tons per capita). Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam. The World Bank Development Data Group.
33. The World Bank, World Development Indicators (2003–2012c). GDP per capita (US$ current Thousand). Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam. The World Bank Development Data Group.
34. The World Bank, World Development Indicators (2003–2012d). GDP deflator (base year varies by country). Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam. The World Bank Development Data Group.
35. The World Bank, World Development Indicators (2003–2012e). Population, total. Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam. The World Bank Development Data Group.
36. The World Bank, World Development Indicators (2003–2012f). Trade (% of GDP). Brunei, Cambodia,

Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam. The World Bank Development Data Group.
37. The World Bank, World Development Indicators (2003–2012g). Energy intensity level of primary energy (MJ/$2011 PPP GDP). Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam. The World Bank Development Data Group.
38. Wayman, E. (2012). The oldest human fossils in Southeast Asia. *Smithsonian Magazine*. Retrieved from http://www.smithsonianmag.com/science-nature/the-oldest-human-fossils-in-southeast-asia-16207900/ (accessed on 12 April, 2017).
39. World Health Organization (2004). *The World Health Report 2004*. Switzerland: World Health Organization.
40. Wooldridge, J. M. (2009). *Introductory Econometrics*: *A modern approach* (5th International Edition). Ohio, US: South-Western, Cengage Learning.
41. Utari, G. A, & Cristina, R. (2015). Growth and inequality in Indonesia: Does Kuznets curve hold? *Journal of Modern Accounting and Auditing, 11*(2), 93-111.
42. Zhang, Y. (2011). Scale, technique, and composition effects in trade-related carbon emissions in China. *Environtal Resource Economics, 51*(1), 371-389.