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Testing the Existence of Environmental Kuznets Curve (EKC) Hypothesis in ASEAN 5

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Abstract. This study aims to test the existence of the Environmental Kuznets Curve (EKC) hypothesis in cases of economic growth and environmental degradation caused by carbon dioxide (CO2) emissions in 5 ASEAN countries (Indonesia, Malaysia, Thailand, the Philippines and Singapore). To see the existence of the EKC hypothesis in each country in ASEAN 5, it is done by combining the economic growth and CO2 emission data graphs to see the EKC turning point. The results of the analysis show that the turning points are different in each country. Indonesia is a country with the largest amount of CO2 emissions with an EKC pattern, namely M-shape. Thailand has the same EKC pattern as Indonesia but with slightly lower CO2 emissions due to a lower economic growth rate. Malaysia, Philippines and Singapore have EKC patterns with more turning points. Singapore has the lowest CO2 emissions with the highest economic growth rate.

Keywords. Environmental Kuznets Curve, economic growth, environmental degradation

1. Introduction

The increasingly massive flow of globalization followed by increasingly complex economic dynamics has important implications for changes in development patterns. The acceleration of increasingly large technological progress also requires every country to be more responsive and adaptive to respond to changes. This will give rise to externalities resulting from these developmental change activities. These externalities can be either positive or negative externalities. Positive externalities can have a beneficial impact on development such as technological advances that can help streamline socio-economic activities. Meanwhile, negative externalities are reflected in the impact of activities such as increasingly intense industrialization, urbanization, mobility with transportation that uses a lot of fossil fuels that are not environmentally friendly and exploitation of natural resources on a large scale that is not balanced with policies that support sustainability. This action can have implications for increasing environmental degradation resulting in many more complex environmental problems.

The form of environmental degradation due to natural exploitation and socio-economic activities that do not consider the environmental impact will result in an increase in carbon dioxide emissions or called *Greenhouse Gas Emissions* (GHG). GHG emissions result in solar radiation that penetrates directly into the atmosphere in the form of ultraviolet (UV) light,

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infrared and various other radiations that have an impact on extreme climate change. This condition is caused by an increase in carbon dioxide (CO2) from burning fossil fuels such as for transportation, coal, oil and gas and forest exploitation. Based on the World Meteorological Organization (2016), GHG emissions trigger a significant impact on the sustainability of the earth, especially in the Southeast Asian region which is predicted to have a significant impact in 30-50 years due to global warming. This condition will ultimately have an impact on the sustainable development activities of a country and affect economic performance from various aspects. It was recorded that in 2014, the amount of carbon dioxide (CO2) reached 397.7 ppm1, methane (CH4) was 1883 ppb2 and nitrous was 325.9 ppb in the atmosphere. Various studies on environmental degradation have been carried out in various countries as a solution in formulating appropriate policies in dealing with environmental problems. In the early 1990s have been many empirical studies that examine the validity of the inverted U curve hypothesis (i*nverted U*) with indicators of environmental quality and revenue. Kuznets (1995) in his study estimates the change in the relationship between per capita income and environmental quality that moves following an inverted U-curve. The pattern of the relationship between per capita income as a reflection of economic growth and environmental quality that reflects environmental degradation is known as the EKC (*Environmental Kuznets Curve*) which is then widely used as a reference in environmental and economic analysis. The EKC explains that a country's economic growth encourages an increase in the concentration of gas pollution emissions and will experience a turning point after the optimal point where increased development will reduce environmental degradation.

Various phenomena of correlation between environmental degradation and economic development such as the EKC curve occur in several countries including countries in ASEAN and become an important urgency in the context of sustainable economic development. Figure 1 shows the correlation of economic growth (GDP) and the intensity of CO2 emissions in several ASEAN countries, namely Indonesia, Singapore, Malaysia, the Philippines and Thailand. Indonesia is a country with a correlation between GDP growth and CO2 emissions which tends to fluctuate. During the period 2007-2016, a significant increase occurred in 2010 before declining in 2013 and then slowing down in 2014-2016 due to various external and internal factors. Meanwhile CO2 emissions tend to grow faster and increase until 2016 reaching 563324.54 kt. In Malaysia, GDP growth experienced a very extreme downward trend in 2009 to a negative number of -1.51%. In addition, Thailand experienced a negative GDP growth in 2009 which reached -0.69%. The Philippines and Singapore only showed a downward trend but still positive numbers, namely 1.44% and 0.11% respectively in 2009. This condition was motivated by the global economic crisis which had a major impact on the growth of a country's domestic output due to low purchasing power and public demand.

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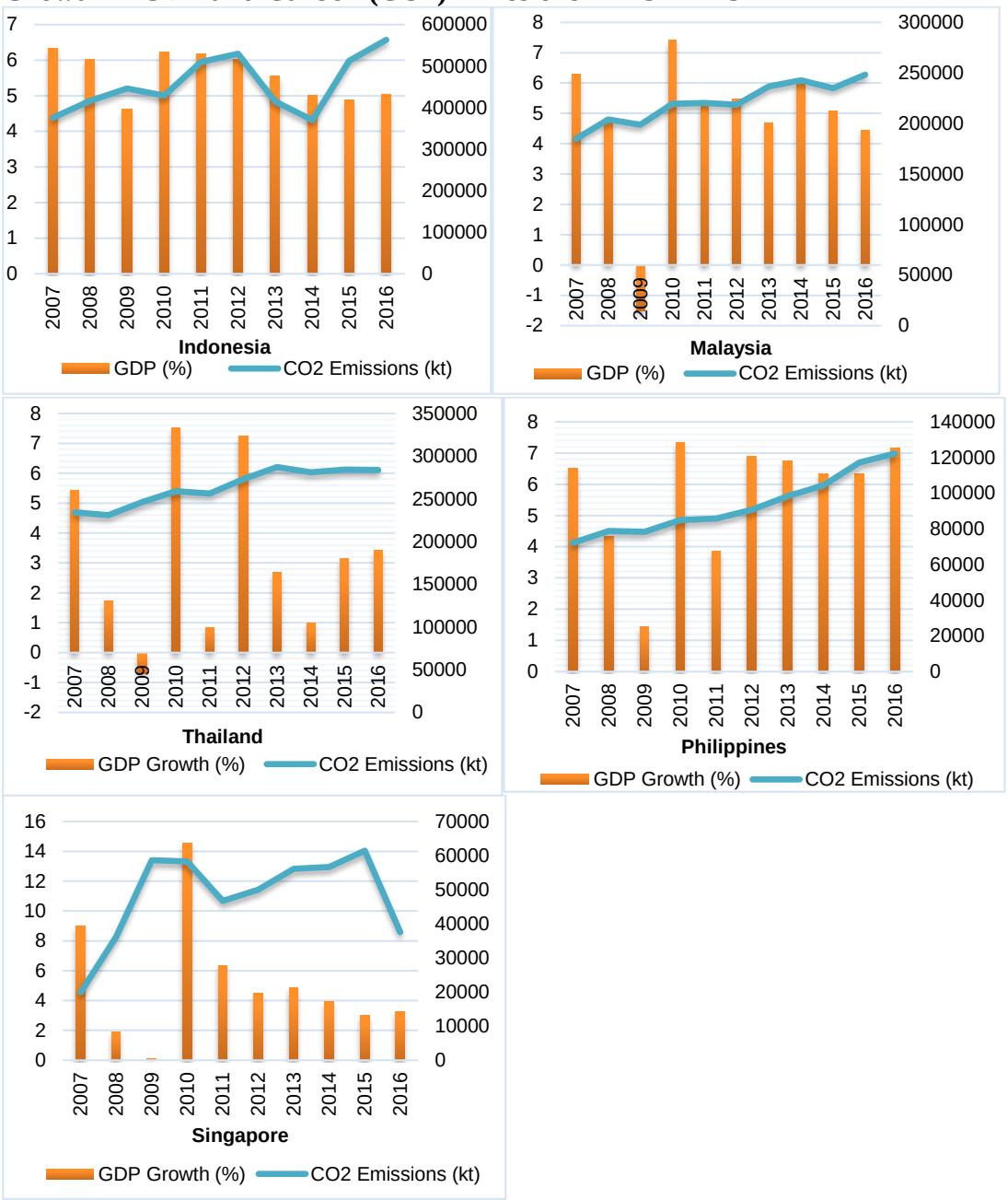
Figure 1
Growth in GDP and Carbon (CO2) Emissions in ASEAN 5



Source: World bank, 2020

Meanwhile, in terms of CO2 emissions, Indonesia, Malaysia, Thailand and the Philippines show an increasing trend. Based on the latest World bank publications related to CO2 emissions that have been released. In Malaysia, CO2 emissions experienced a significant increase, reaching 248288,903 kt in 2016. Thailand also showed a tendency to increase from 2007 to 234027.94 kt which continued to increase until 2016 reached 283763,461 kt. Similar to Indonesia, Malaysia and Thailand, the Philippines is also experiencing an increase in environmental degradation as indicated by an increase in the number of CO2 emissions from year to year. In 2007, CO2 emissions reached 72170,227 kt and continued to show an increase until 2016 reaching 122287,116 kt.

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In contrast to the other four countries in ASEAN, Singapore tends to be more able to suppress the increase in environmental degradation even though it is at a level that tends to be higher than other countries. However, the Singapore government has shown good performance in reducing the level of CO2 emissions. This condition was shown in 2007 with CO2 emission levels of 19926,478 kt and increased until 2015 with the highest number reaching 61451,586 kt, but could decrease in 2016 to reach 37535,412kt. This problem is very important to pay attention to, because this environmental degradation will threaten human existence and human activities in meeting needs, especially for future generations.

Kumar's study (2011) shows that the existence of the EKC hypothesis is invalid in the case of energy consumption, capital and population on economic growth. Meanwhile, the Lawson et al., (2020) study collaborated on the empirical literature on *Environmental Convergence* (EC) with EKC. The results of the analysis do not support the EKC hypothesis between CO2 emissions and GDP per capita. While the study of Benavides et al., (2017) integrates the variable of trade openness which shows that in the long term, the EKC pattern is inverted U-shaped and there is an indirect relationship between methane emissions and other variables. These results confirm the importance of policies in development planning to mitigate climate change and global warming. Energy consumption and CO2 emissions also have a lot of influence on the economy of countries in the world, both developed and developing countries. Archeampong (2018) with panel data found that in the Sub-Saharan Africa region, carbon emissions have a positive effect on economic growth and a negative effect on global levels such as Middle East and North Africa (MENA), Asia Pacific and Caribbean-Latin America. These results confirm that the EKC hypothesis is proven in the Sub-Saharan Africa region. Luzati et al., (2018) investigated the EKC hypothesis from two different aspects as a form of response to find a middle ground in the EKC hypothesis testing debate that has been going on. The results of the study show that globalization has an impact on changes that occur in the EKC hypothesis testing and there is a decrease in elasticity in high-income countries. In addition, the Great Recession also had a significant impact on the structural decline in CO2 in the countries affected by the recession. In Germany, active energy policies can reduce energy consumption and CO2 without harming the economy.

Environmental problems that are increasingly complex as development progresses and accelerated technological development have forced various countries to formulate effective policy strategies to synergize economic growth but also maintain sustainable development. In the EKC hypothesis, it is emphasized that at a certain point when economic growth increases in the early stages, it will reduce environmental quality due to environmental degradation, one of which is caused by an increase in CO2 emissions. However, at a later stage, increasing economic growth that reflects a country's income can actually reduce environmental degradation and at this stage there is a turning point where the country is ready with a policy package that can synergize economic improvement accompanied by environmental quality improvements. This study wants to test the existence of this EKC hypothesis in ASEAN 5 countries (Indonesia, Malaysia, the Philippines, Thailand and Singapore) because these countries have high economic activity and mobility in the ASEAN region. In addition, ASEAN 5 is also a country that has quite stable economic growth progress in the ASEAN region in the last decade.

2. Literature Review

Environmental Kuznets Curve (EKC)

The beginning of the emergence of the EKC hypothesis began with various debates between income and environmental gradation. The EKC hypothesis states that higher income

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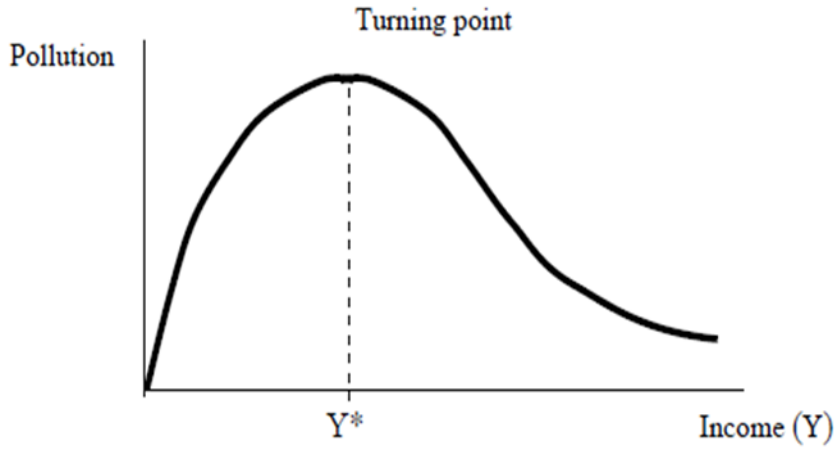
levels will have an impact on increasing environmental degradation. Empirically, high income levels can reduce environmental degradation, thus economic growth can be a prerequisite for environmental improvement (Beckerman, 1992; Bhagawati, 1993). So in this case, growth can be one of the solution steps in improving the quality of the environment, especially in developing countries that have the impact of environmental degradation due to various cases of environmental pollution (Panayotou, 1993). Environmental quality has been the object of debate for many years. Prior to the 1970s, some views believed that the consumption of raw materials, energy and natural resources went hand in hand with the movement of economic growth. The model to show the relationship between environmental quality and economic growth was first carried out by Grossman and Krueger (1991). The findings show that at higher income levels there is a decrease in environmental degradation which is statistically evidence of a relationship with the EKC hypothesis. Various empirical studies have also shown that economic openness accompanied by contributive policies that lead to environmental quality will also reduce environmental degradation that occurs along with the increase in a country's income (Borhan et al., 2012).

In the early 1990s, empirical data on various pollutants available through the *Global Environmental Monitoring System* (GEMS), environmental data from the OECD and various other related sources prompted various researchers to test the validation of the inverted U hypothesis curve with indicators of environmental quality and income. The results of empirical studies by Grossman and Kruger (1991) and later Kuznets (1995) predict that the change in the relationship between per capita income and income inequality is an inverted U-curve. Increasing per capita income will also increase income inequality at the beginning and then decrease after the turning point (TP). So that the distribution of income becomes more unequal in the early days and then increases and becomes equal as economic growth continues to increase (Kuznets, 1995). Then the Kuznets curve shows a new existence as evidenced by environmental degradation (environmental quality) and per capita income which moves following an inverted U-curve. The relationship of economic growth as reflected by per capita income with environmental quality indicators is known as the *Environmental Kuznets Curve* (EKC).

Figure 2.1
***Environmental Kuznets Curve* (EKC)**



Source: Jula, et al, (2017)

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Figure 2.1 describes the relationship between income and pollution as an indicator of environmental quality measurement. When pollution conditions increase at the peak (Y*) income will also increase. Furthermore, when a turning point occurs after the *turning point* , income will also increase and pollution will increase. Environmental degradation will increase along with income growth until it reaches a peak point then the quality of the environment will decrease with an increase in the number of higher per capita incomes (Jula et al, 2015). The Kuznets curve predicts that income inequality increases initially as per capita income increases but then begins to decline after a turning point (Yurttagüler & Kutlu, 2017).

The EKC hypothesis is to show the long-term relationship between environmental impacts and economic growth. Along with the increasingly rapid and rapid economic development with the intensification of several sectors that are at the take-off stage such as the agricultural sector and other resource extraction, this has resulted in the depletion of the availability of resources. This results in the availability of greater resources exceeding the regeneration resources which in turn will cause the quantity of waste to increase. At this point, there will be a structural change towards industry so that there will be an increase in environmental awareness accompanied by technological developments and environmental enforcement regulations. In addition, some researchers argue that economic growth will open up opportunities for improving environmental quality. A higher level of income will cause a demand to improve the quality of the environment so that it forces to provide facilities for environmental protection efforts (Panayotou, 2003), In this condition will result in a step in the reduction of environmental degradation (Dinda, 2004). initial impact on improving environmental quality. In conclusion, this EKC hypothesis shows a dynamic process of change between economic growth indicated by income that grows over time along with the development of environmental quality.

Various countries with developed economic conditions, the majority have gone through the history of the journey of the inverted U curve in the EKC hypothesis. One of the countries that currently has shown economic performance skyrocketing at a fast pace is China. China's very rapid economic growth rate is accompanied by the mitigation of environmental degradation which is interesting for attention (Jiang et al., 2008). The empirical study of Groot et al., (2004) estimates the EKC hypothesis for emissions, wastewater and industrial effluents in China with provincial panel data. The results of the analysis found that emissions and revenues depend on the type of environmental pollution. In the case of gas emissions, a pattern following an inverted U-curve was found. The study of Liu et al., (2007) found that the existence of the EKC hypothesis applies to emissions caused by the production process, but does not apply to emissions caused by consumption activities in China.

The openness of the economic system that is not well controlled can also trigger increased pollution. The context of trade liberalization in large countries must be accompanied by appropriate regulations. This is because weak regulations can have an impact on imbalances and uncontrollable damage between production processes in industrialization. This results in environmental quality will decrease. Economic activities related to production accompanied by strict policy management can have a positive impact on state revenues as well as on environmental quality (Ginevicius et al., 2017). Meanwhile, in terms of consumption, environmental risks and environmental quality uncertainty in the future will increase and disrupt. Environmental quality is an important component in sustainable development to maintain future wealth for the next generation. The risk of environmental damage resulting in a decrease in environmental quality will interfere with development which will ultimately have an impact on welfare.

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Uncertainty of increasing consumption in the future will result in increased environmental risks, among which risks include unclear climate change due to the greenhouse effect caused by gases emitted in the atmosphere. These gases are often produced such as carbon dioxide (CO2) produced from burning fossil oil and pollution from factories. The accumulation of CO2 and other gases in the atmosphere will have an impact on increasing solar radiation emitted to the earth which ultimately results in the phenomenon of global warming. In the long term, this condition will affect global sectors such as agriculture and the trading system (WCED, 1987) which will eventually trigger a crisis of natural resources, food, the world economy and the future of the earth (Ginevičius et al., 2017). Responding to this condition, it is important to apply the EKC hypothesis to minimize environmental degradation that threatens Earth's life. According to Stern (2004), as in the condition of the EKC hypothesis, environmental degradation indicators initially increase and then decrease along with the increase in per capita income.

The Kuznets curve shows that the initial stages of environmental degradation and pollution will be responded to by increasing economic growth in this case called income. Then when the declining environmental quality is reflected by increasing pollution conditions due to high production that is not accompanied by pro-environmental policies to the peak, then it will be responded by pro-environmental policies to minimize environmental degradation (Janssens-Maenhout et al., 2017). Until the turning point U, the two variables between income and pollution will go hand in hand and show an increase in environmental quality accompanied by an increase in economic growth (Islam et al., 2013). Various research results also indicate recommendations that economic growth becomes a very important macroeconomic instrument to increase environmental awareness. The scale of production and technological improvements can influence the EKC hypothesis.

3. Method

The method used to test the existence of this EKC is to calculate the turning point that occurs by calculating the data on economic growth and environmental degradation. Two data components are needed which consist of *Gross Domestic Product* (GDP) data as a reflection of economic growth, and CO2 emission data to proxy environmental degradation. The data is in the form of annual data sourced from the World Bank with a time series of 2010-2016. The combination of data is then formed in a graph so that turning points can be seen at several points on the graph throughout the period of the data used. From this turning point, it can be seen that the movement of economic growth which initially increases will also result in higher environmental degradation, but there is a turning point when economic growth increases by itself environmental degradation can decrease. This can be motivated by several reasons, for example, the more advanced and increasing the economic growth of a country, the more mature policy makers apply the right policies to reduce environmental impacts.

4. Results and Discussion

The Environmental Kuznets Curve (EKC) hypothesis explains the relationship between environmental degradation and economic growth. The initial stage of the curve is indicated by increasing CO2 emissions and decreasing environmental quality and at a time when economic growth is increasing and at a maximum point leading to environmental improvement. The pattern of this relationship is described by an inverted U shape (*inverted-U*). The pattern of the relationship between environmental degradation and economic growth as in the EKC shows a different pattern in each country. EKC pattern viewable from the turning point *(turning* point) in the EKC pattern. The number of *turning points* and deviations in the quantity of emissions

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as well as changes in economic growth indicate how much and quickly a country through its various policies is able to reduce emissions. Based on the results of the analysis, *turning point* it can also be concluded that in the long term, increased economic growth will provide a turning point for CO2 emissions in ASEAN 5 countries with different patterns and magnitudes.

Figure 2.
***Turning Point Environmental Kuznets Curve* (EKC) di ASEAN 5**

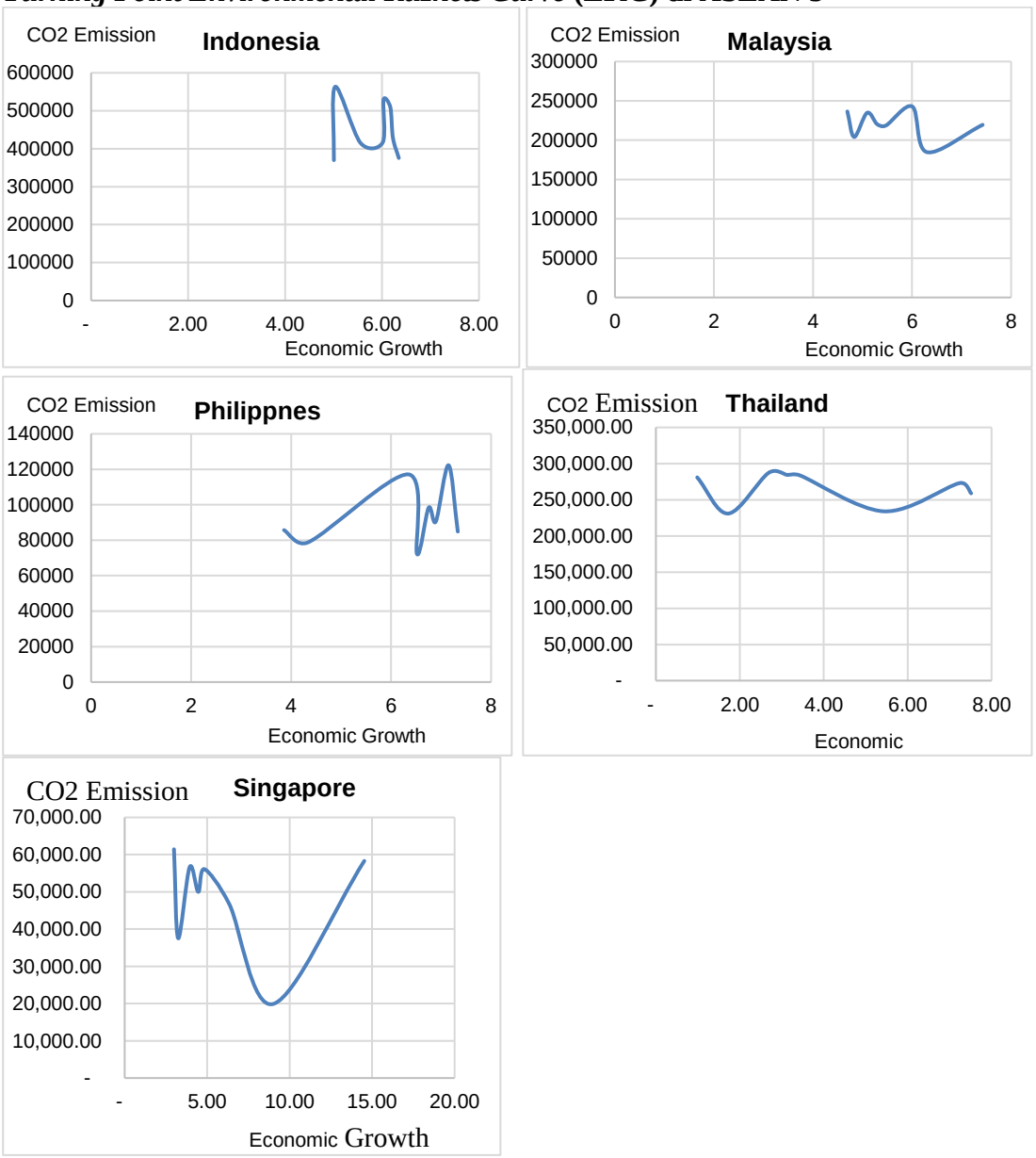

Figure 2 shows the pattern of the relationship between CO2 emissions and economic growth in ASEAN 5 countries. Indonesia is a country with a fairly high level of economic growth with industrialization dynamics that is developing quite rapidly. However, the impact of accelerated development is followed by an increase in the amount of CO2 emissions which is the highest among the five other ASEAN member countries. Based on the plot of the relationship pattern of CO2 emissions and economic growth, it can be seen that the *turning point of* the EKC curve occurs four times with emission deviations of up to 100,000 kt with

changes in growth in the range of 5% to 6%. EKC in Indonesia follows the pattern *M-shape*. The Indonesian government's commitment to a *green development economy is* shown by the optimism of energy conservation in achieving the energy efficiency target of 17% from *Business as Usual* (BAU) in 2025. The energy sector has a target in the *Nationally Determined Contribution* (NDC) to reduce emissions by 314 million tons by 2030 The focus of emission reduction in Indonesia in the NDC is on five sectors, namely the energy, industry, forestry, agriculture and waste sectors.

Thailand has the characteristics *turning point* same as Indonesia, which is four times with emission deviations reaching 50,000 kt, slightly lower than Indonesia. However, different things are indicated by changes in economic growth which are slightly slower than Indonesia, namely from 1% to 7%, followed by a slowdown in the increase or decrease in CO2 emissions. EKC in Indonesia follows the pattern *M-shape*. Thailand has emission reduction targets through the Paris Agreement with a focus on energy efficiency policies and a clean energy transition. Policies implemented through carbon pricing. Carbon pricing is considered part of the core policy mix in the climate energy policy package, as a way of setting costs for carbon emissions. This step is in an effort to support low carbon and allow for cost-effective ways to reduce emissions across sectors. The two main types of carbon pricing are through emissions trading systems, such as programs *cap-and-trade*, and carbon taxes.

Meanwhile, Malaysia, the Philippines and Singapore have EKC patterns with more *turning points*, namely six times. The lowest carbon deviation is Malaysia at around 50,000 kt with a change in economic growth of 4% to 7%. Malaysia has a commitment to reduce its carbon emission intensity by 40% (compared to 2005 levels) by 2020 and a reduction of 45% (compared to 2005 levels) by 2030. Malaysia's challenges in its decarbonization program are population growth pressures and substantial poverty rates. Some of the decarbonization policies are behavioral transformation, institutional shift, and institutional network. The Philippines' CO2 emission deviation is up to 40,000 kt with changes in economic growth of 4% to 7%. The Philippines is committed to reducing its carbon emissions by 70 percent by 2030 from the energy, transportation, waste, forestry and industrial sectors. Reducing emissions requires adequate financial resources, technology development and transfer.

Singapore is a country with the highest economic growth compared to the other four ASEAN countries. Likewise, the proportion and deviation of the lowest CO2 emissions. As an industrial country, the policy of accelerating economic development is followed by good management of emission externalities even though Singapore contributes around 0.11 percent of global emissions. The increase in energy demand is in line with the increase in economic growth and urban population. It is estimated that power generation will increase by around 30% from 2010 to 2025. Despite increasing demand, Singaporean authorities have announced a commitment to reduce carbon emissions by 7-11% below business as usual levels by 2020, with half of the reduction coming from the power sector. While its strategic position along the East-West trade route makes Singapore a natural location for oil storage and refining facilities serving the region. Although the refining and petrochemical sector is a large source of carbon emissions, Singapore continues to strive and continuously to improve the level of energy efficiency.

In 2018, total emissions growth reached 51.8 gigatons (Oliver & Peters, 2020) with a lower average annual growth of 1.3% and compared to a much higher average annual growth rate of 2.5% in the first decade of this century. This increase occurred while 3.4% global economic growth in 2018 continued at an average annual growth rate of 3.4% since 2012. CO2 emissions, excluding land pollution, were 57% higher than the 1990 period and 43% higher than the 2000 period. The increase in emissions every decade reflects that policies related to

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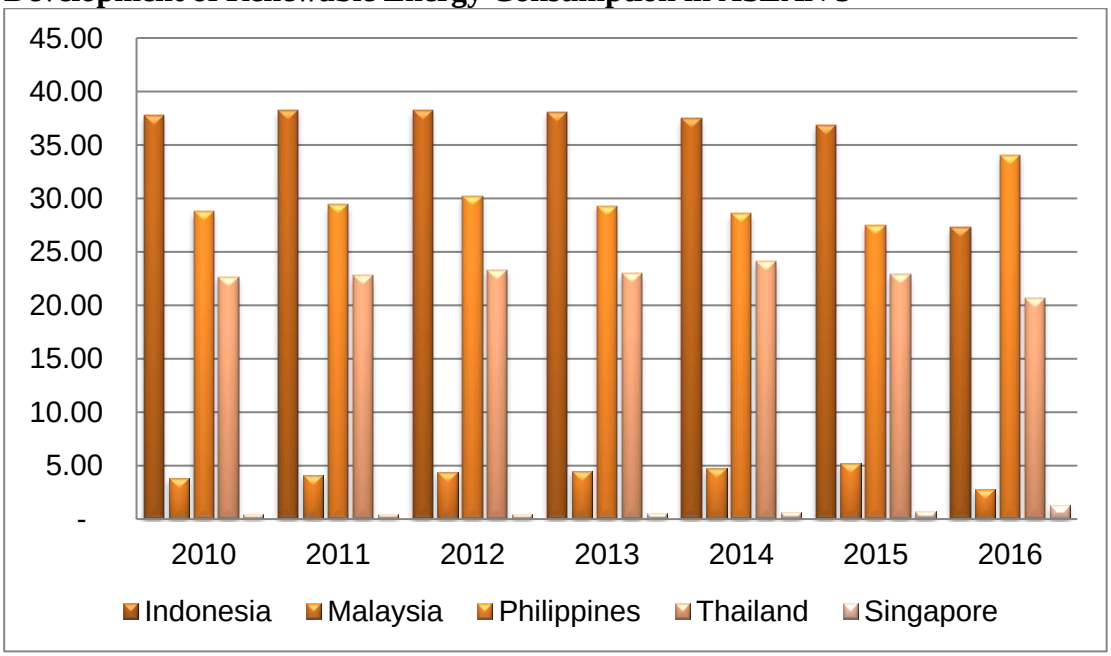
mitigating the increase in CO2 emissions have not run optimally. In 2018, CO2 emissions and land use pollution, if accumulated, reached 55.6 gigatons. In 2018, temperatures across much of the world were much warmer than average. Record warm temperatures were measured across much of Europe, the Middle East, New Zealand and parts of Asia. A heat wave of unprecedented intensity and duration swept through Europe, from April 18-22. France, Germany and Switzerland had their hottest years since national records began. The Netherlands experienced the second-warmest year on record (with 2014 being the year of record-high heat). The deviation from the mean global temperature level was 0.97 oC above the 1880–1900 average, slightly below the 2015–2017 years (NOAA, 2019).

The annual growth rate of 2.0% in 2018 was twice the average growth since 2012, when the average growth in greenhouse gas emissions was also 1.0% per year. In 2003, growth in global greenhouse gas emissions increased to 3.9% and remained high during 2007, due to China's rapid industrialization, since the country became a member of the World Trade Organization (WTO). The increase in temperature as a result of the increase in CO2 emissions has a big connection with the higher industrialization occurring at the same time from the trade side.

Alternative forms of effort in mitigating environmental problems can be done by creating renewable energy. The existence of renewable energy aims to minimize the exploitation of resources used as non-renewable energy materials. In addition, the existence of resources for renewable energy can also minimize the creation of increased air pollution and various environmental degradation problems. Basically, this renewable energy is sourced from natural processes that can be carried out and maintained in a sustainable manner such as solar energy, air energy, wind energy which can be an alternative solution in reducing the use of fossil fuels as fuels that tend to be dangerous in environmental pollution and pollution. One form of efforts to reduce environmental degradation due to increasing CO2 emissions can be reflected in the progress of the development of renewable energy creation in ASEAN countries 5.

Figure 3.
Development of Renewable Energy Consumption in ASEAN 5



Source: Worldbank, 2020

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The development of renewable energy in Figure 3 shows that the Philippines is a country with stable development and tends to increase until 2016 to 34.06%. Similar conditions are shown by Singapore, which is experiencing the development of renewable energy, although the numbers are relatively very small when compared to other ASEAN countries. However, its development tends to increase from year to year for renewable energy until 2016 reaching 1.26%. Meanwhile, Indonesia, Malaysia and the Philippines tend to experience a decline in the development of renewable energy. It was recorded that until 2016, Indonesia had 27.26% of renewable energy, lower than the previous year in 2015 which was 36.88%. Malaysia also experienced a decrease in renewable energy from 2015 of 5.19%, a significant decrease to 2.78% in 2016. The same thing happened in Thailand where renewable energy experienced a significant decline from 2015 of 22.86%, down to 20 ,71%. This indicates that efforts to create renewable energy as a solution in reducing CO2 emissions have not been realized in a stable and optimal manner.

In various countries, many efforts have been made to create renewable energy as an alternative in the use of fossil energy and so on, one of which is in the ASEAN region which is known to be one of the ports of world economic activity. Figure 4.2 shows efforts to use renewable energy in ASEAN 5 countries. Similar to the CO2 emission component in Indonesia, efforts to use renewable energy in Indonesia are also high compared to the other 4 countries. Renewable energy in Indonesia also fluctuates as indicated by an up and down trend. From 2007 to 2008 showed an increase in renewable energy consumption from 39.97% to 40.16%. However, due to the limited supply of renewable energy compared to the demand for meeting the needs of the community, there was a decline from 2009-2010 to 38.97% in 2009 and decreased again in 2010 to 37.75%. In 2011 it showed an increase to 38.23% and was stagnant in 2012 with the same number. Then in 2013-2016 showed a decrease of 38.11% in 2011 which continued to show a decline until in 2016 it reached 27.26%.

The same condition is also shown in Malaysia, Thailand and the Philippines in the use of renewable energy. In 2007, the consumption of renewable energy in Malaysia reached 4.56% and increased in 2008 to reach 4.73%. In 2009-2010 showed a significant decline in the use of renewable energy in Malaysia, respectively 4.23% in 2009 and decreased again in 2010 at 3.82%. In 2011-2015, there was another increase in renewable energy consumption in Malaysia to 4.11% and continued to increase until in 2012 it reached 4.41% and in 2013 it reached 4.49%. Then in 2014-2015 showed a significant increase in renewable energy consumption reaching 4.77% in 2014 and 5.19% in 2015. However, in 2016, renewable energy consumption experienced a very significant downward trend until it reached figure of 2.78%. This condition confirms that the stability in the use of renewable energy still cannot be balanced with the available renewable energy supply.

Thailand also shows fluctuations in the up and down trend in the use of renewable energy. In 2007-2012 there was an increase in the use of renewable energy in Thailand. From 2007 it reached 21.61% then increased in 2008 by 22.49% and increased every year until 2012 it reached 23.29%. This increase indicates that the supply of renewable energy in Thailand is able to offset the need for energy as a substitute for fuel and so on which can trigger an increase in environmental degradation. Meanwhile, in 2013 there was a decline in the use of renewable energy which decreased to 22.94%. In 2014 showed an increase again in Thailand's use of renewable energy reaching 24.10%. However, in 2015-2016, the use of renewable energy actually decreased at 22.86% respectively in 2015 and decreased quite drastically in 2016 reaching 20.71%.

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In the Philippines also showed fluctuations in the use of renewable energy in 2007-2008, which increased to 31.20% and 31.73% in 2008 respectively. However, in 2009-2010 there was a decline at 31.22% in 2009 and 28 ,81% in 2010. In 2011-2012 it turned around to show an increase reaching 29.40% in 2011 and 30.22% in 2012. However, in the following years until 2015 it continued to show a decline in renewable energy consumption in the Philippines until it reached 27.45%.

In contrast to Indonesia, Malaysia and Thailand which tend to experience fluctuations in the use of renewable energy, Singapore actually shows a positive performance. This is shown in Figure 4.2 with an increasing movement every year in Singapore's renewable energy use. In 2007 it reached 0.50% use of renewable energy and continued to show an increase until 2016 it reached 1.26%. This condition confirms that Singapore has a good performance in creating renewable energy that is used to meet energy needs from fossil fuels and so on which can trigger an increase in environmental degradation and CO2 emissions.

In 2018, the renewable energy market was relatively stable, in addition to 181 gigawatts (GW) of renewable energy, the speed was added and consistent compared to 2017. In addition, efforts to mitigate increased emissions and environmental degradation are also supported by the efforts of various countries to integrate renewable energy in over the increasing energy consumption. This progress is concentrated in the electric power sector, because renewable energy is identical in the use of electrical energy which is mostly used by humans in carrying out their activities. Renewable energy provides approximately more than 26% of global electricity which is supported and driven by stable policies.

According to Finance and Development (2018), most of Southeast Asia is dominated by coastal areas, so it has the longest coastline as well as lowlands with high population density. This condition causes the region in this region to be very vulnerable to extreme weather. In addition, other rising water levels related to global warming are also the main trigger for the emergence of various environmental problems and natural disasters. In addition, the average temperature in Southeast Asia has increased every decade since 1960. Based on the Global Climate Risk Index compiled by German Watch, environmental groups of several countries including Vietnam, Myanmar, the Philippines and Thailand are among the top 10 countries in the world. most affected by climate change in the last 20 years. Meanwhile, according to the World Bank based on its calculations, Vietnam is a country that has the potential to be affected by global warming in the future. The economic impact can be devastating. According to the Asian Development Bank (ADB), Southeast Asia is the region that will mostly suffer losses. Efforts to control climate also require budgetary spending and are expected to cut 11% of the region's GDP. However, this can be a substitute in the long term to increase the role and contribution of basic sectors such as agriculture, tourism, and fisheries. It is also an effort to maintain the health, productivity and welfare of the community.

The success of EKC implementation cannot be separated from the comparative advantage of resources owned by each country. Each country is expected to be able to specialize in resource-intensive production supported by environmentally friendly regulations. However, the phenomenon that occurs is the tendency of developed countries to transfer the impact of environmental pollution to developing countries (Stern et al., 1996). Strengthening international cooperation in the field of energy and environmental sustainability is very crucial. So that each country is committed to maintaining environmental sustainability with various innovations such as technology transfer that is beneficial for sustainable development throughout the country.

5. Conclusion

Furthermore, the relationship between GDP growth which reflects economic growth and environmental degradation indicated by CO2 emissions is stated in the EKC hypothesis as in the second problem formulation. In the EKC hypothesis, it emphasizes the relationship between the existence of the hypothesis *Environmental Kuznets Curve* (EKC)in Indonesia, Thailand and the Philippines, Malaysia, and Singapore showing indications of an EKC pattern *Inverted-U* with *turning points* different. Indonesia is a country with the largest amount of CO2 emissions with an EKC pattern, namely *M-shape*. Thailand has the same EKC pattern as Indonesia but with slightly lower CO2 emissions due to a lower economic growth rate. Malaysia, Philippines and Singapore have EKC patterns with more turning points. Singapore has the lowest CO2 emissions with the highest economic growth rate.

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