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THE NEXUS BETWEEN FDI, PER CAPITA INCOME, ENERGY CONSUMPTION, TRADE OPENNESS, AND CARBON DIOXIDE EMISSIONS: PANEL DATA ANALYSIS OF ASEAN PLUS SIX

HUBUNGAN ANTARA PENANAMAN MODAL ASING, PENDAPATAN PER KAPITA, KONSUMSI ENERGI, TRADE OPENNESS, DAN EMISI KARBON DIOKSIDA: ANALISIS DATA PANEL ASEAN PLUS SIX

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ABSTRAK

Komitmen negara ASEAN dan negara ASEAN Plus dalam mengikuti Persetujuan Paris mengharuskan mereka memanfaatkan perdagangan dan investasi untuk menyeimbangkan pertumbuhan ekonomi dan peningkatan kualitas lingkungan. Data observasi dari sebelas negara ASEAN Plus dari 1979–2018 digunakan dalam penelitian ini bertujuan untuk menilai bagaimana pendapatan, konsumsi energi, Penanaman Modal Asing (PMA), dan trade opennes secara bersama-sama menyebabkan emisi CO_2 di negara-negara ASEAN Plus dengan menggunakan estimasi data panel. Penelitian ini membuktikan bahwa adanya fenomena Inverted-U Environmental Kuznets Curve di negara-negara ASEAN Plus. Selain itu, peningkatan konsumsi energi yang signifikan menjelaskan peningkatan tingkat emisi CO_2 di wilayah ini. Aliran masuk PMA telah ditemukan memiliki hubungan negatif dengan tingkat emisi CO_2. Sementara itu, keterbukaan perdagangan terbukti berpengaruh positif terhadap tingkat emisi CO_2. Hubungan PMA dan perdagangan dengan emisi CO_2 ini menunjukkan perlunya harmonisasi baru dari sistem produksi terintegrasi yang lebih ramah lingkungan di kawasan ini.

Kata kunci: *Emisi CO_2, Konsumsi Energi, Pendapatan Domestik Bruto, Penanaman Modal Asing, Trade JEL Classification: F18, F21, O44, Q52, Q56*

ABSTRACT

ASEAN and ASEAN Plus countries' commitment in following the Paris Agreement requires them to utilize trade

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and investment to balance economic growth and improve environment quality. Using observational data from eleven ASEAN Plus countries from 1979–2018, this study aims to assess how income, energy consumption, FDI, and trade openness jointly cause CO_2 emissions in ASEAN Plus countries using panel data estimates. This research proves the existence of the Inverted-U Environmental Kuznets Curve phenomenon in ASEAN Plus countries. In addition, a significant increase in energy consumption explains the increase in CO_2 emissions levels in this region. FDI inflows have been found to have a negative relationship with the level of CO_2 emissions. Meanwhile, trade openness has been found to positively influence the level of CO_2 emissions. This FDI and trade relationship with CO_2 emissions shows the need for a new harmonization of a more environmental-friendly integrated production system in the region.

Keyword: CO_2 Emissions, energy consumption, GDP, FDI, trade JEL Classification: F18, F21, O44, Q52, Q56

INTRODUCTION

The Association of Southeast Asian Nations (ASEAN) is a multidimensional cooperation for ten countries in Southeast Asia. ASEAN aims to support trade and investment among countries in the region so that it can boost the region's contribution to the global economy. ASEAN's contribution of gross domestic product (GDP) has reached US$2.4 trillion in 2017, which can be said to be the third largest economy in Asia and the fifth largest in the world (Chin, 2017). The economy in the region is expected to have a positive growth in the future, mainly supported by the prediction that five ASEAN countries, namely Indonesia, Malaysia, Thailand, the Philippines, and Vietnam, will enter the top 25 countries with the largest economies in 2050 (PWC, 2017).

This huge contribution of the ASEAN economy makes the region an attractive trading and investment partner for non-ASEAN countries. Cooperation with non-ASEAN parties is realized through the cooperation of ASEAN Plus Three and ASEAN Plus Six. ASEAN Plus Three consists of 10 ASEAN countries, China, Japan, and South Korea, while ASEAN Plus Six consists of 13 countries in ASEAN Plus Three, plus India, Australia, and New Zealand. Both cooperations are expected to accelerate economic integration in the East Asian region.

In 2015, total trade between ASEAN and the Plus Three countries reached US$708.6 billion, equivalent to 31.1% of total ASEAN trade (ASEAN, 2017). In the same year, total foreign direct investment (FDI) coming from the Plus Three countries to ASEAN reached US$31 billion, equivalent to 26% of the total FDI inflows of ASEAN. China and Japan are the main trade destinations for ASEAN countries and they have managed to control more than 25% of ASEAN trade in the past five years (Figure 1). The high contribution of ASEAN Plus to the ASEAN economy makes it important to consider ASEAN Plus in the regional studies of ASEAN.

Amidst the high level of trade and investment, a trend shows that countries in ASEAN Plus have been experiencing high levels of carbon dioxide (CO_2) emissions in the recent years. China, India, and Japan occupied the top five positions as

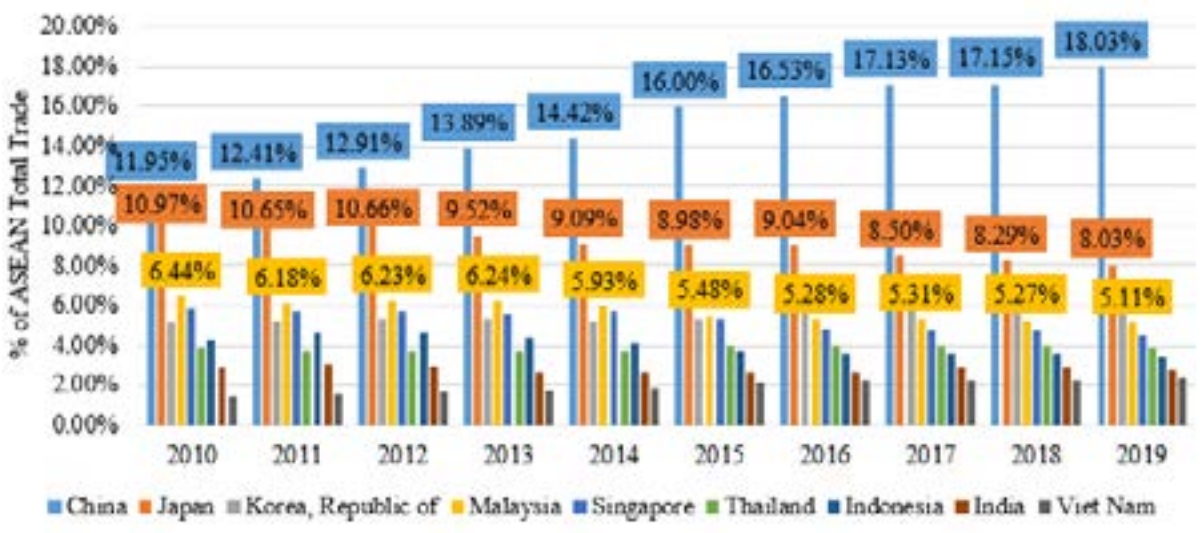

Figure 1 ASEAN Plus Countries in Top 15 ASEAN Trading Partners
Source: Trademap (2020, constructed by author)

the highest emitters of CO_2 in 2018 (UCS USA, 2020). South Korea, Indonesia, and Australia were also among the twenty countries with the highest levels of CO_2 emissions in the same year. At the same time, China and South Korea were included in the top 10 exporters in the world in 2018 (Global Economy, 2020). China, India, and Australia occupied the top 10 positions as countries with the highest levels of FDI in 2018. From these trends, we want to argue that promoting trade and investment will lead to environmental degradation among ASEAN Plus countries, especially in the midst of the emerging economic growth.

Previous studies have proved that FDI inflows and trade openness are the causes of the high level of CO_2 emissions, especially in the emerging economies (Antweiler et al., 2001; Cole & Elliott, 2003; Kasman & Duman, 2015; Baek, 2016; Dogan & Seker, 2016). The negative influence of FDI on environmental quality is in line with the pollution haven hypothesis, where weak environmental regulations in the host country will attract FDI from profit-driven foreign companies where these companies find it difficult to comply with environmental regulations in their home countries. Promoting trade will also increase the level of pollution as it causes an increase in overall consumption and output—as the output increases, the emission level will also increase as a result of less environmental-friendly production processes. Studies proving the impact of FDI inflows and trade on CO_2 emissions are usually conducted within the framework of nexus FDI-Income-Energy consumption-CO_2 emissions in order to reduce the bias from not including the omitted variables into the model (Pao & Tsai, 2011; Kasman & Duman, 2015; Baek, 2016; Dogan & Seker, 2016).

Controlling CO_2 emission levels amidst high efforts to support economic

growth has received considerable global attention lately. Through the UNFCCC's 21st Conference of Parties in Paris in 2015, countries have expressed their commitment to fighting climate change and accelerating the actions and investments needed to achieve a low-carbon future. The agreement, known as the Paris Agreement, aims to strengthen the global response to the threat of climate change by keeping annual global temperature increases below two degrees Celsius. Through this agreement, each country involved is required to prioritize its mitigation through a Nationally Determined Contribution (NDC), where each country must prepare, communicate, and pursue national contribution targets in reducing the threat of climate change. Through the NDC, each country is expected to be able to formulate the best policies in dealing with the problems of balancing economic growth and its impact on environmental conditions. In formulating policies related to mitigation and adoption of NDC, especially for ASEAN Plus, so far, the latest research to our best knowledge was carried out by Baek (2016) which attempted to assess the relationship between FDI inflows, income, and energy consumption on CO_2 emission levels in the five ASEAN countries, namely Indonesia, Malaysia, Singapore, Thailand, and the Philippines. The study used data from the 1981–2010 observation period. We consider that this study is not sufficiently relevant to describe the current economic and environmental conditions in the ASEAN region. The high global and ASEAN commitments embodied in the 2015 Paris Agreement and the establishment of the ASEAN Socio-Cultural Community Blueprint 2025 in 2015 have indicated structural changes for each country in mitigating environmental problems. For this reason, by adding the observation period from 1980–2019, this study is expected to be able to create a more relevant analysis regarding the effect of the nexus FDI inflows, income, and energy consumption on CO_2 emission levels in ASEAN.

Apart from adding to the observation period, the high interdependence between ASEAN and the Plus countries is a concern of this study. The observations in this study were extended to analyze the level of CO_2 emissions for the ASEAN Plus Six region. To our best knowledge, this study will be the first study to analyze environmental damage problems for the ASEAN Plus region. In addition, the additional variable of the trade openness in ASEAN Plus countries will also be a concern of this study so that this study will be able to contribute to the future direction of ASEAN Plus cooperation in overcoming environmental problems.

By estimating panel data on 11 countries in ASEAN Plus, including Indonesia, Malaysia, Singapore, Thailand, the Philippines, and the Plus countries, for the period 1980–2019, this study is aimed at detecting correlations of Income, FDI Inflows, Energy Consumption, and Trade Openness on CO_2 emission levels in the ASEAN Plus region. We expect the inverted U-curve EKC phenomenon to occur in ASEAN Plus, as well as a positive relationship between energy consumption

and CO_2 emissions, and between FDI inflows and CO_2 emissions. Since most Plus countries are ranked among the highest CO_2 emitters, we also expect a positive relationship between trade openness and the level of CO_2 emissions in ASEAN Plus.

LITERATURE REVIEW

Effect of Economic Growth on CO_2 Emissions

So far there are two types of literature that study the relationship between economic growth and the level of CO_2 emissions in a country. The first type of literature studies this relationship in the framework of the Environmental Kuznets Curve (EKC). The EKC framework was first developed by Grossman and Krueger (1991) which developed from the basic concept of the Kuznets Curve that describes the relationship between per capita income and the level of inequality (Kuznets, 1955). The EKC hypothesis illustrates that along with an increase in income, carbon emissions will continue to increase up to a certain point, then it will be followed by a decrease in carbon emissions as income increases (the EKC curve is an inverted U-curve). In this framework, per capita income is assumed to have a unidirectional relationship with carbon emissions. This EKC hypothesis has also been proven in various other studies, where these studies found the inverted U-curve EKC phenomenon in some of the highest emitting countries and newly industrial countries (Dinda & Condoo, 2007; Managi & Jena, 2009; Zhang et al., 2017).

The second type of literature shows how the relationship between income and CO_2 emissions is through the relationship between income and energy consumption, where energy consumption becomes a proxy for the level of emissions in the environment. This framework originated from a study conducted by Kraft and Kraft (1978) which tried to prove that there was an effect between income and energy consumption, but the findings indicated that there was no causal relationship between the two variables. The relationship between income and energy consumption has been reviewed by Al-Iriani (2006) and still gives the result that there is no causal relationship between the two variables. Therefore, the relationship between income and energy consumption is developed into a nexus income-energy consumption-emission which is then confirmed by a long-term relationship between the three variables by Apergis and Payne (2009).

The nexus income-energy consumption-emission still proves the existence of the EKC hypothesis, where output growth requires an increase in energy consumption which in turn will create additional emissions by Apergis and Payne (2009). Kasman and Duman (2015) argued that CO_2 emissions will not decrease in the near future as long as output continues to increase. This study also states that the government must be able to implement policies that are capable of controlling air emission levels, one of which is by creating an energy efficiency program in production. The same argument is also expressed by

a study conducted by Pao and Tsai (2011) which states that the government must be able to encourage industries to immediately adopt new technologies that can minimize pollution levels.

Effect of FDI Inflows on CO_2 Emissions

In the study of economic and environmental development, FDI inflows have become a topic that has received considerable attention in many studies. Many studies have studied the possible determinants of environmental performance that depend, for one, on financial development. Frankel and Romer (1999) prove that financial liberalization and development will attract FDI and create an increase in investment in R&D so that economic growth will accelerate and will affect environmental performance. Birdsall and Wheeler (1993) and Frankel and Rose (2002) indicate that financial development will provide options for developing countries to use new technologies that will create more environmental-friendly production thereby creating better environmental performance. Apart from proving the phenomenon of increasing environmental performance along with financial developments, other studies also prove that there is a negative effect of inflows of FDI on the environment. Jensen (1996) states that financial development will create economic growth, which in turn will have an impact on pollution and decreasing environmental quality. Tamazian et al. (2009) also prove that the high level of economic and financial development will create a decrease in environmental quality (in this study, financial development is measured through FDI inflows). Studies that prove the negative influence of FDI on environmental quality are in line with the pollution haven hypothesis, where weak environmental regulations in the host country will attract FDI from profit-driven foreign companies where these companies find it difficult to comply with environmental regulations in their home countries (Dean et al., 2009; Hoffmann et al., 2005; Jensen, 1996).

In addition to the pollution haven hypothesis, the effect of FDI on environmental quality can also be detected through two other hypotheses. The pollution halo hypothesis states that multinational companies engaging in FDI will contribute to transferring more environmental-friendly technology in their production activities in the host country (Birdsall & Wheeler, 1993; Sandbroke, 2002). In addition, known as the scale effect, this hypothesis states that multinational companies engaging in FDI will significantly contribute to the overall industrial output in the host country and the level of pollution in that country (Jiang & Rencheng, 2007; Zarsky, 1999). Kim and Baek (2011) state that in order to avoid a decline in environmental quality while experiencing high FDI inflows, the focus on FDI absorption should be directed at the service sector rather than the manufacturing sector. In addition, countries that receive FDI are expected to be able to tighten regulations and qualifications for incoming FDI so as to avoid a decline in environmental quality (Pao & Tsai, 2011).

Effect of Trade Openness on CO_2 Emissions

The influence of international trade on the environment has also received attention in several studies (Antweiler et al., 2001; Cole & Elliott, 2003). The existence of international trade will create a movement of goods, both final and intermediate goods, from one country to another, which are designated as consumption and as input for production. The increase in overall consumption and output caused by the development of international trade can be a source of pollution. Halicioglu (2009), Jayanthakumaran et al. (2012), and Farhani et al. (2014) suggest the importance of investigating the effect of international trade through adding international trade indicators to the emission-income-energy nexus framework.

The relationship between trade and environmental degradation in several studies has resulted in different directions of the relationship. Dogan and Seker (2016) illustrate the negative relationship of increased trade on CO_2 emissions. In countries with high trade openness, most exporters are required to create outputs that are environmental-friendly and limit production activities that have high levels of pollution in order to meet demand from importing countries. In addition, countries with high trade openness also accept environmental-friendly imports of goods and services and trade interactions between countries can lead to a transfer of knowledge and technology in creating environmental-friendly economic activities. On the other hand, Kasman and Duman (2015) have found an increase in environmental degradation along with an increase in trading activities. Cole and Elliott (2003) state that the different direction of the relationship occurs due to differences in industry characteristics in each country.

DATA AND METHODOLOGY

Data

The main focus of this study is to investigate the relationship between FDI, real GDP, energy consumption, trade openness, and CO_2 emissions in ASEAN Plus Six countries. ASEAN consists of ten Southeast Asian countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. However, given the availability of the data for all variables, only five countries from ASEAN (Indonesia, Malaysia, the Philippines, Singapore, Thailand) are analyzed for the empirical work. Therefore, plus six countries (China, Japan, South Korea, India, Australia, and New Zealand), in total there are 11 countries included in this study.

In this study, we use the data of 11 countries from ASEAN Plus Six for 40-year observations during the period 1979–2018—we only use 11 countries since the rest of the countries have limitations on the data. As this study aims to assess the relationship between FDI, real GDP, energy consumption, trade, and CO_2 emissions in ASEAN Plus Six countries, we use annual data on CO_2 emissions, real GDP, FDI, trade openness, and population

from those 11 countries with the balanced observation of 40-year samples for each country. Annual data for CO_2 emissions are obtained from the Global Carbon Project which are compiled and converted from tonnes of carbon to tonnes of CO_2 by Our World in Data using a conversion factor of 3.664. Annual data for real GDP, FDI, trade openness, and population are obtained from World Bank Open Data from 1979 to 2018. This study uses data for trade as a proxy for trade openness. Annual data for trade is obtained by adding exports and imports of each ASEAN Plus Six country. Annual data for energy consumption is obtained from the BP Statistical Review of World Energy released in 2020.

Variabel

In this study, our variables of interest are FDI inflows and trade openness. We use real GDP per capita and energy consumption per capita as control variables in order to follow the nexus framework between CO_2 emissions and Income-FDI-Energy consumption-Trade openness. The variables used in the model are explained through Table 1.

Table 1 Variables of Our Model

Variable	Label	Description	Measurement	Expected Sign
CO_2 emissions per capita	co	As the proxy for environmental degradation	Tonnes	
Real GDP per capita	y	As the proxy for income levels	Constant 2010 US$	*Forming an Inverted U-Curve*
FDI net inflows	fdi	As the proxy for financial development	Billion US$	+
Energy consumption per capita	encons	As the proxy for energy consumption	Gigajoules	+
Trade openness	trade	As the proxy for trade intensity and is measured by adding export and import values*	Billion US$	+

*We prefer to use the summation of export and import values as the proxy for trade openness rather than trade openness index since we follow the study of Dogan and Seker (2016) and we find no significant impact on CO2 emissions when using trade openness index as the proxy.

Estimation Strategy

In this study, the analysis will be estimated through a static panel analysis from 11 countries (from ASEAN Plus Six countries) for 40 years during the period 1979–2018. Panel data comes from cross-sectional dimensions and time series dimensions, so it gives more total observations and more degrees of freedom and thereby it will lead us to collinearity among variables and a more efficient model (more reliable parameter results). Using static panel data analysis, the model will be estimated using three panel estimation methods, namely

Pooled Least Squares (PLS), Fixed Effect (FE), and Random Effect (RE). From those three estimations, this study tests the best estimation that can be further used by doing the Hausman test, Chow test, and Breusch-Pagan LM test. Based on the test results done, it indicates that the most suitable estimation that can be used is the Fixed Effect (FE) model.

In seeking the relationship between FDI, real GDP, energy consumption, trade, and CO_2 emissions in ASEAN Plus Six countries, this study combines the empirical frameworks built by Pao and Tsai (2011), Baek (2016), and Dogan and Seker (2016). Pao and Tsai (2011) study the impact of both economic growth and financial development in BRIC (Brazil, Russian Federation, India, and China) countries; and the results support the EKC hypothesis and find the relationship between emissions, energy consumption, GDP, and FDI. Meanwhile, Baek (2016) also tries to estimate the effects of energy consumption, income, and FDI on CO_2 emissions; and the results find that FDI has a unidirectional relationship with CO_2 emissions, and that income and energy consumption have a negative impact on reducing CO_2 emissions. Further, Dogan and Seker (2016) find that increases in trade openness and FDI decrease emissions and the results support the EKC hypothesis.

In this study, the developed model is specified as follows:

$$co_{it}=a_0+a_1 y_{it}+a_2 y_{it}^2+a_3 fdi_{it}+a_4 encons_{it}+a_5 trade_{it}+u_{it} \quad (1)$$

where co_{it} is the logarithm of CO_2 emissions per capita for country i in period t; y_{it} is the logarithm of real GDP per capita for country i in period t; fdi_{it} is the logarithm of the amount of foreign direct investment net inflows for country i in period t; $encons_{it}$ is the logarithm of energy consumption per capita for country i in period t; $trade_{it}$ is the total trade for country i in period t; and u_{it} is the error term. The coefficients of interest to us are a_4 and a_5, which show the direction of the effect of FDI and trade on CO_2 emissions. The FDI inflows will result in increasing CO_2 emissions if FDI increases the production of dirty products in each country, it could be expected that the $a_3>0$. Otherwise, the value of $a_3<0$. Finally, if the trade results in increasing CO_2 emissions through an increase in trade for goods and services for dirty industrial raw materials, then it is expected that $a_5>0$.

Considering the role of income on environment outcomes, this study tries to include the hypothesis of Environmental Kuznets Curve (EKC) stating the relationship between per capita income and environmental damage levels can be represented by an inverted U-shaped curve. The EKC is predicted to hold if the Equation (1) has $a_1>0$ and $a_2<0$, which shows that CO_2 emissions per capita will at some point decrease as the economy grows after a turning point. Moreover, greater income will likely bring greater energy consumption which will likely bring more CO_2 emissions into the environment.

RESULTS AND DISCUSSION

Descriptive Statistics

Singapore and Australia are in the top two highest means for CO_2 emissions per capita and energy consumption per capita [Table 2]. Australia has the highest mean for CO_2 emissions per capita (17.08), meanwhile Singapore has the highest mean for energy consumption per capita (396.43). The highest mean for real GDP per capita is also found in Australia (42584.8). For FDI, the highest mean value is found in China (85.04). The country with the highest degree of trade openness is absolutely China because of its highest mean for total trade (1436.84). The Philippines has the lowest means for CO_2 emissions per capita (0.83), FDI (2.01), energy consumption (12.55), and total trade (90.52). Meanwhile, the lowest mean for real GDP per capita is found in India (931.8).

In addition, South Korea has the highest variation in CO_2 emissions per capita as shown by the highest standard deviation (2.92). Singapore has the greatest variation in real GDP per capita (13873.9) and also in energy consumption per capita (145.30); while the greatest variation in FDI (94.67) and total trade (1407.64) is found in China. Overall, among the ASEAN Plus Six countries, the Philippines has the lowest mean and standard deviation for CO_2 emissions per capita, FDI, and energy consumption. The highest mean and standard deviation for energy consumption per capita are found in Singapore. Meanwhile, the greatest mean and standard deviation for both FDI and total trade are found in China.

Figure 2–6 show how each data series for the ASEAN Plus Six countries has changed over time. Figure 2 shows that ASEAN countries, except Singapore, have shown a positive trend in CO_2 emissions per capita. Although Singapore has a negative trend data in its CO_2 emissions per capita, it has a considerably high fluctuation in its value. Still taking about Singapore, Figure 5 shows that Singapore has the most significant increase in energy consumption per capita. However, this significant increase in energy consumption per capita is accompanied by a negative trend in CO_2 emissions per capita. Figure 2–5 show that China series has shown a significant increase since the period 2000, except for its FDI that has risen significantly since the period 1991.

Table 2 Desciptive statistics of data (before taking logarithm), 1979—2018.

Country	CO_2 emissions per capita		GDP per capita		FDI		Energy consumption per capita		Total trade	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Indonesia	1.29	0.49	2353.3	884.7	5.56	8.09	18.33	7.57	221.39	133.30
Malaysia	5.19	0.18	6818.3	2635.9	4.83	3.99	85.17	35.98	236.50	158.91
The Philippines	0.83	0.18	1904.4	463.4	2.01	2.54	12.55	2.24	90.52	63.87
Singapore	11.97	2.74	33082.6	13873.9	23.87	27.28	396.43	145.30	474.09	382.82
Thailand	2.56	1.20	3582.2	1499.8	4.61	4.28	42.43	23.00	245.41	179.24
China	3.64	2.02	2501.1	2226.9	85.04	94.67	45.47	26.64	1436.84	1407.64
Japan	9.15	0.94	39637.9	6730.9	6.52	9.27	153.45	16.21	1152.56	515.15
South Korea	8.16	2.92	14799.4	7794.4	5.72	5.05	148.48	69.18	551.81	478.43
India	0.97	0.44	931.8	479.2	12.30	16.02	13.09	5.41	386.26	396.09
Australia	17.08	1.38	42584.8	9077.4	19.80	22.18	233.83	18.38	289.40	179.82
New Zealand	7.62	1.03	30046.4	6515.2	2.73	9.35	188.45	19.38	59.86	28.93

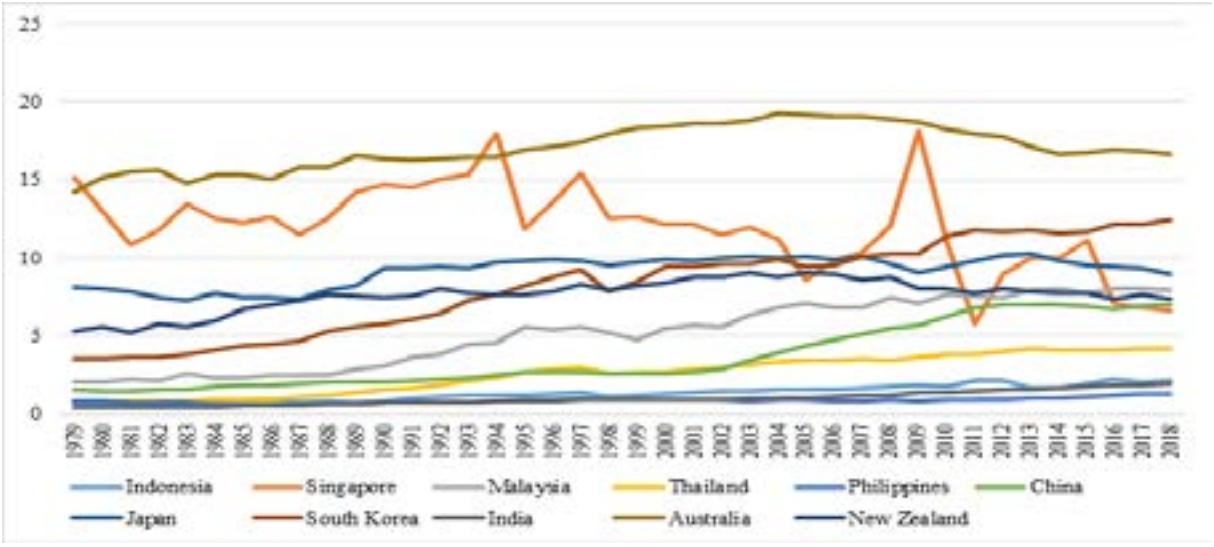

Figure 2 CO_2 emissions per capita (before taking logarithm)
(in tonnes of CO_2 emission per capita)
Source: Global Carbon Project (2020, constructed by author)

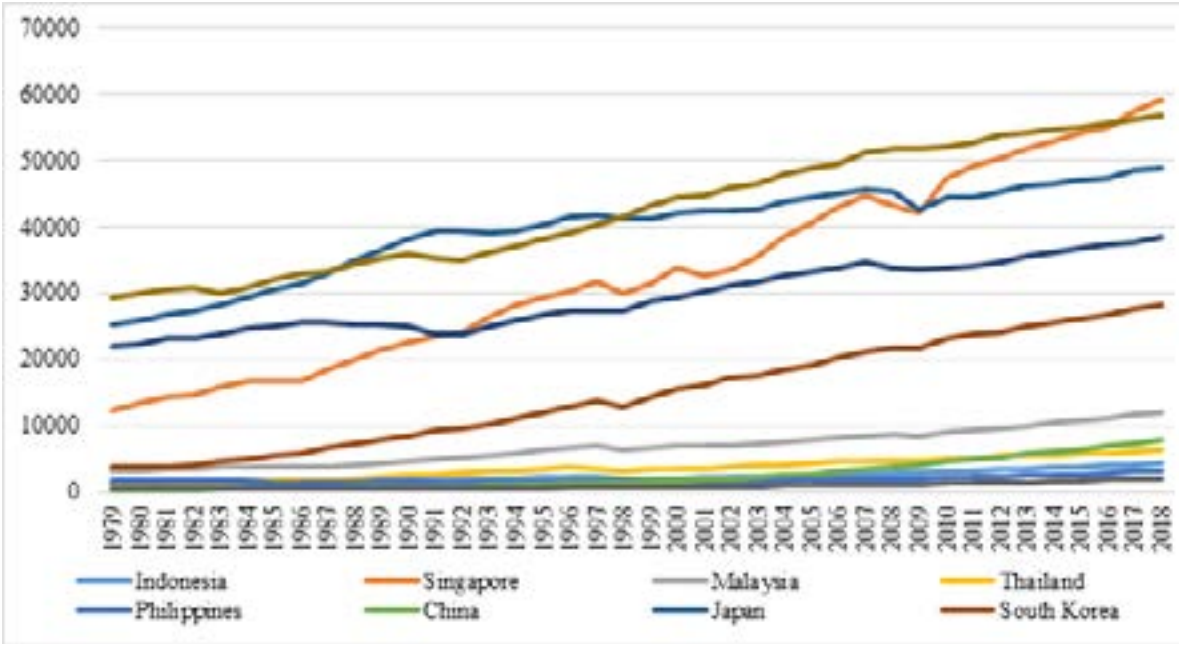

Figure 3 Real GDP per capita (before taking logarithm) (in constant 2010 US$)
Source: Global Carbon Project (2020, constructed by author)

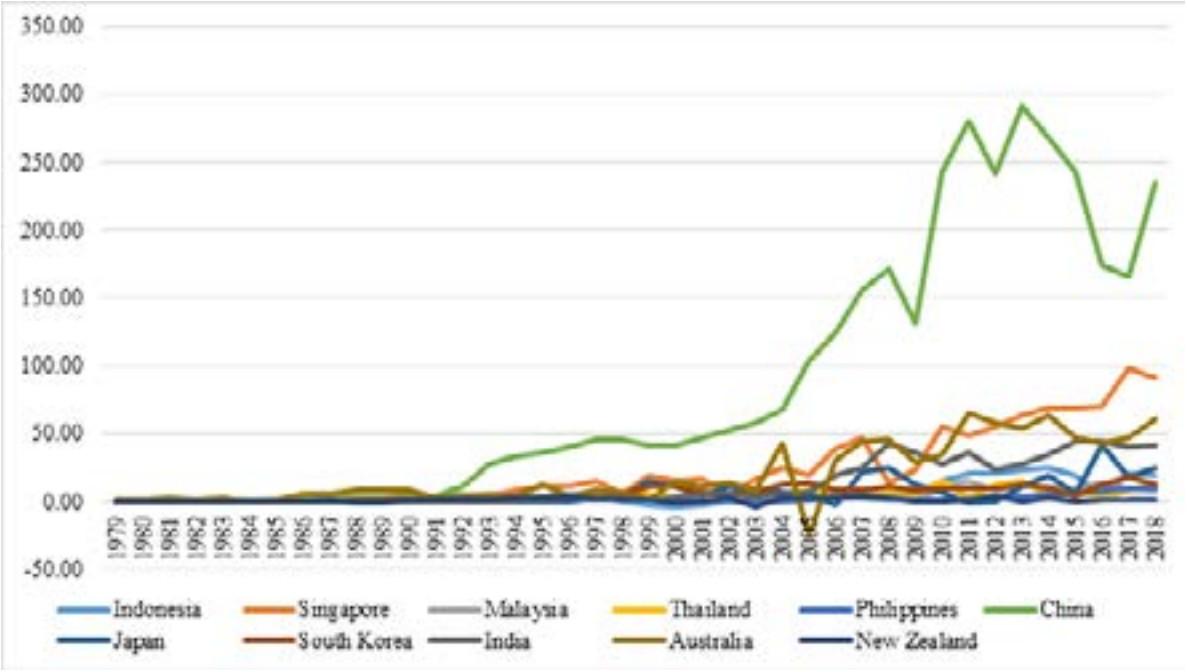

Figure 4 Foreign Direct Investment net inflows (before taking logarithm) (in current billion US$)

Source: World Bank (2020, constructed by author)

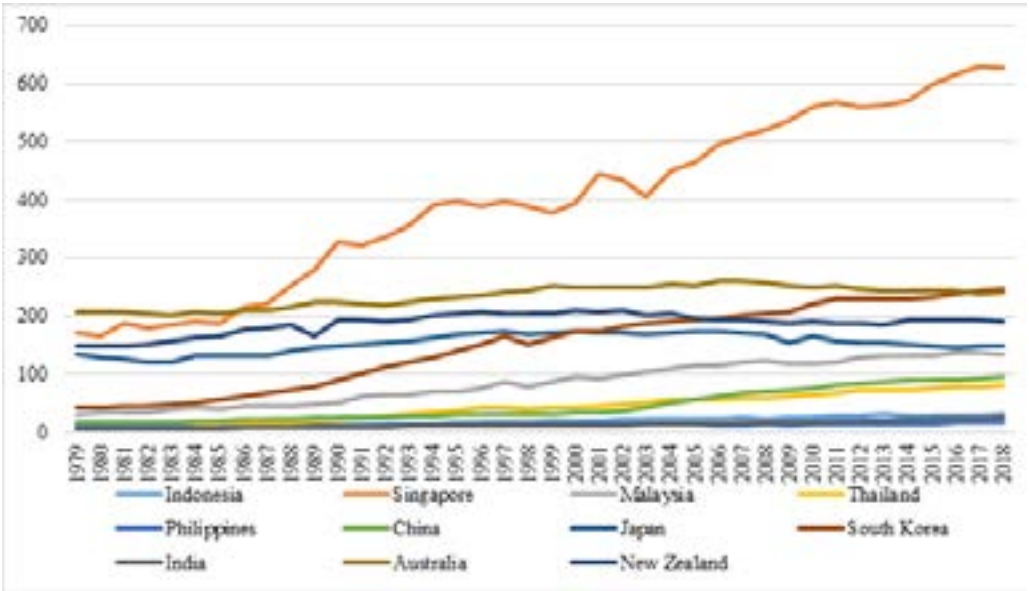

Figure 5 Energy consumption per capita (before taking logarithm) (in gigajoules)

Source: World Bank (2020, constructed by author)

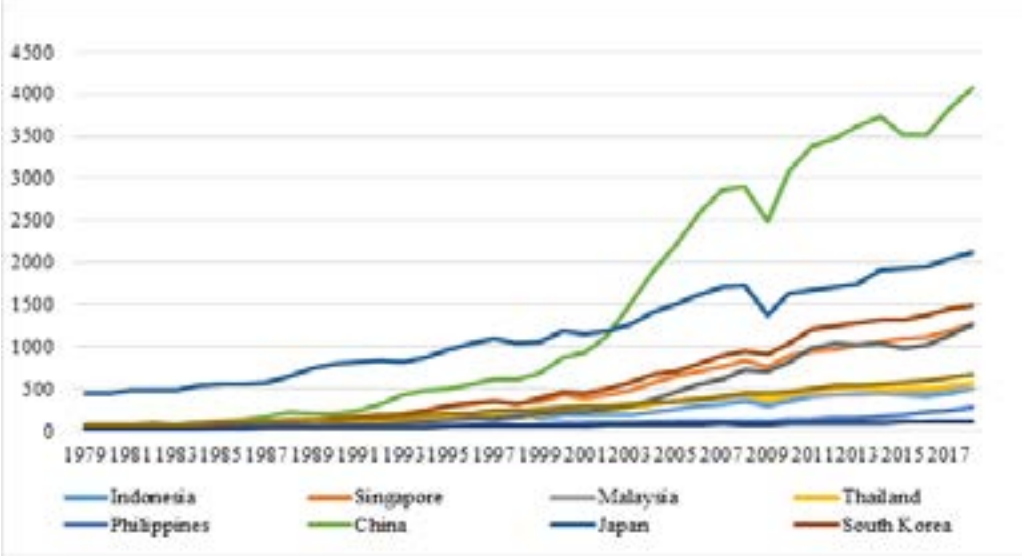

Figure 6 Total trade (total exports and imports) in current billion US$
Source: World Bank (2020, constructed by author)

Empirical Results and Discussion

Now we move to the discussion of our empirical results. Table 3 shows the key estimation results in this study, where CO_2 emissions are the dependent variable, using a three-panel data estimation method. The results of the test show that the most appropriate panel data method to be used in this study is the Fixed model. The following are the results of all three panel estimates.

The main empirical results of the FE model above show a statistically significant coefficient at the 1% significance level of all variables of CO_2 emissions in ASEAN Plus Six countries except for the coefficient for FDI. The results also answer the main interest of this study about the relationship between income and CO_2

Table 3 The results from the research estimation using panel data models

Regressors	Model 1 (Pooled Least Square Model)			Model 2 (Fixed Effect Model)			Model 3 (Random Effect Model)		
	Coefficient		p-value	Coefficient		p-value	Coefficient		p-value
y	0.3423	***	0.009	1.4400	***	0.000	1.4158	***	0.000
y^2	-0.0178	**	0.015	-0.0991	***	0.000	-0.0895	***	0.000
fdi	-0.0073		0.496	-0.0159	*	0.056	-0.0101		0.221
encons	0.7959	***	0.000	0.8303	***	0.000	0.8548	***	0.000
trade	0.0522	***	0.002	0.1010	***	0.002	0.0182		0.463
constant	-4.757	***	0.000	-9.1798	***	0.000	-7.7919	***	0.000
R^2	0.9415			0.8454			0.9118		

Note: The dependent variable is CO_2 emissions per capita
* denotes statistical significance at the 10% level
** denotes statistical significance at the 5% level
*** denotes statistical significance at the 1% level

emissions. Table 2 shows us the positive coefficient of income and the negative coefficient on its quadratic term. Our results hence support the existence of the EKC hypothesis in ASEAN Plus Six countries, in which emissions increase with real output, stabilize, and then decline at some point. These are in line with the results studied by Shahbaz et al. (2014), Baek (2015), Balaguer and Cantavella (2016), Li et al. (2016), Al-Mulali and Ozturk (2016), and Jebli et al. (2016). Although the coefficient of per capita real income is positive, the existence of the EKC hypothesis has been validated and hence indicates the potential of ASEAN Plus Six countries to reach a condition where increasing real income will lead to lower emissions in the future as the real income of each country grows.

The effect of FDI inflows on CO_2 emissions in ASEAN Plus Six countries can also be seen through the direction and magnitude of the coefficient of the FDI inflows. Although it is only statistically significant at the 10% level, we can still say that an increase in FDI inflows will lead to lower CO_2 emissions. The results of this study regarding the effect of FDI inflows are different from the results of previous study done by Pao and Tsai (2011) and Baek (2016). However, as discussed in the previous section, this phenomenon is not impossible to happen since the FDI inflows can increase the production of green products in ASEAN Plus Six countries. The results from a study done by Dogan and Seker (2016) are in the same direction as the results found in this study regarding the negative relationship between FDI inflows and CO_2 emissions. Increasing FDI leading to lower CO_2 emissions is possible because nowadays many developed countries have made a progressive pathway in new environmental-friendly technological inventions and the countries in the ASEAN Plus Six countries which are now being analyzed seem to have taken benefit from both technology and knowledge spillover through the FDI network.

One of the interests of this study is to examine the effect of energy consumption on CO_2 emissions. The sign is positive and statistically significant at the 1% significance level. The result suggests that CO_2 emissions will increase as energy consumption increases. With the coefficients shown in Table 2, an increase in energy consumption by 1%, holding other conditions remain the same, will increase CO_2 emissions by 0.83%. The insights taken from the results provide an evidence that higher energy consumption will lead to higher CO_2 emissions, and hence this should be controlled in order to control the amount of CO_2 emissions borne in the environment.

The other interest that this study wants to figure out is the impact of trade on CO_2 emissions across the ASEAN Plus Six countries, hence we can also figure out what these countries should do with their trade in order to contribute to limiting global warming by reducing CO_2 emissions. The coefficient of trade is positive, which indicates that an increase in trade will increase the amount of CO_2 emissions. The findings related to trade in this study

are different from what Dogan and Seker (2016) found in their study. However, this is possible since a high proportion of goods and services are traded for dirty industrial raw materials. It is because most producers of dirty products do not have green or clean certification and produce in a way that reduces the quality of the environment.

The results reported in this study are strong and reliable since we have already done the Chow Test, LM Test, and Hausman Test to seek for the best and most appropriate model to be used. However, our study does not include the explanation of short-term movement patterns and long-term convergence so that future studies can try to explain them. Further studies can also potentially get more robust results if longer data sets become available.

Future ASEAN Plus Action on Mitigating Environmental Degradation

As an association of countries involved in the 2015 Paris Agreement, ASEAN encourages its members to immediately implement environmental impact mitigation and adaptation in accordance with the measurements and targets to be achieved by each country which is in line with the NDC framework. One of ASEAN's commitments is reflected in the implementation of the ASEAN Action Plan on Joint Response to Climate Change (ASEAN, 2015). In this action, ASEAN seeks to strengthen its regional cooperation in providing capacity building, technical assistance, technology development and transfer, and financing related to mitigation and adaptation of environmental impacts. In addition, ASEAN also encourages the exchange of scientific and technical expertise in partnership with regional and global experts, and enhances cooperation towards joint research and development of appropriate measures to minimize the impact of environmental problems.

As a concrete step in realizing this commitment, ASEAN is expected to be able to control the direction of trade and investment to create an environmental-friendly regional economic ecosystem. Labeling and certification are crucial for highlighting the environmental attributes of products being traded for this region (Anbumozhi & Kojima, 2019). Harmonization of labeling and product certification will lead to a common standard on energy efficiency in the production process so as to trigger trade in environmentally friendly products. This action needs to be supported from the governments of member countries to help increase the volume of trade for these products by increasing government spending on these products.

Apart from trade, FDI that enters ASEAN countries is expected to be directed into environmental-friendly production systems in order to reduce the environmental degradation. To realize this, ASEAN still faces high perceived risks in green financing and the conditions in which market-based mechanisms to finance green initiatives are in the early stage of development (Anbumozhi & Kojima, 2019). Obstacles in developing green financing in ASEAN are also caused by the method of risk

assessment of green financing from banking and regulatory authorities which still use the old risk assessment method (Hongo & Anbumozhi, 2019). These obstacles make it difficult for investors to increase their green investment so that it is necessary to get support for a green funding ecosystem from various stakeholders.

CONCLUSION

The seriousness of ASEAN Plus countries in following the Paris Agreement requires them to direct trade and investment to balance economic growth and improve environmental quality. Using observational data from eleven ASEAN Plus countries from 1980–2018, this study aims to assess how income, energy consumption, FDI, and trade openness jointly cause CO_2 emissions in the region using panel data estimates. The high level of interdependence between countries in the ASEAN Plus makes this study the first research to conduct economic and environmental studies for the ASEAN Plus region. In addition, the expansion of the observation sample until 2018 also makes this research more relevant for assessing environmental mitigation and adaptation in ASEAN Plus, especially after the Paris Agreement in 2015.

This research proves the existence of the Inverted-U Environmental Kuznets Curve phenomenon in ASEAN Plus countries, where in the near future, an increase in income will be accompanied by an increase in CO_2 emission levels to a certain point which will then be followed by a decrease in CO_2 emissions levels as income increases. In addition, a significant increase in energy consumption explains the increase in CO_2 emissions levels in this region. FDI Inflows and Trade Openness are also found to be able to explain the reasons for the increase in CO_2 emissions in this region.

Having a significance level of 10%, the increase in FDI inflows is found to reduce the level of CO_2 emissions in ASEAN Plus. This is in contrast to Baek (2016) who found a positive relationship between FDI and CO_2 emissions in ASEAN. The findings in our study illustrate the pollution halo hypothesis conditions in the ASEAN Plus region, where an increase in FDI will increase the transfer of environmental-friendly technology to the host country. The difference between findings and previous research is likely due to the addition of Plus Countries to this study, where most of these countries are categorized as high-income countries so that the use of FDI is directed towards production that is more environmental-friendly.

The high trade intensity in ASEAN Plus is found to have a positive relationship with levels of CO_2 emissions. This finding is likely to be explained by the low volume of trade in environmental-friendly goods in ASEAN countries. Harmonization of labeling and certification for environmental-friendly goods is important to be implemented immediately in order to support the trading volume of these goods. In addition, the public sector also plays an important role in boosting the volume of

trade in these goods by increasing public consumption for these goods.

In summary, the creation of an environmental-friendly economic ecosystem in ASEAN Plus is important to be implemented immediately, especially in the midst of high levels of trade and investment in the region. The combination of developing an environmental-friendly real sector and creating incentives for funding channels for this sector is expected to be able to realize ASEAN's commitment to support the implementation of the Paris Agreement. However, the combination of these policies will not run smoothly amid high perceptions of institutional risk in the region. Weak enforcement of regulations is still a big threat in handling environmental problems in the region. For this reason, it is expected that in the future there will be further studies that are able to include institutional components in explaining the phenomenon of environmental degradation in ASEAN and ASEAN Plus.

APPENDIX

	Coefficient		Difference	S.E.
	FEM6	REM6		
lngdpcap	1.440024	1.415755	0.024269	
lngdpcapsq	-0.0990833	-0.0894826	-0.0096007	0.0013609
lnfdi	-0.0158987	-0.0101232	-0.0057755	0.0004321
lneconscap	0.8303506	0.8548458	-0.0244952	0.0088352
lntrade	0.1010796	0.0181675	0.0829121	0.0210788
chi2(5) = 13.43				
Prob>chi2 = 0.0197				

Appendix 1 Hausman Test

	Var	sd
lnco2ecap	1.191274	1.091455
e	0.0203174	0.1425392
u	0.0499405	0.2234737
chibar2 (01) = 2359.96		
Prob > chibar2 = 0.0000		

Appendix 2 Breush Pagan Test

(1)	2.id	=	0
(2)	3.id	=	0
(3)	4.id	=	0
(4)	5.id	=	0
(5)	6.id	=	0
(6)	7.id	=	0
(7)	8.id	=	0
(8)	9.id	=	0
(9)	10.id	=	0
(10)	11.id	=	0
F (10, 406) = 103.81			
Prob > F = 0.0000			

Appendix 3 Chow Test

REFERENCE

Al-Iriani, M. A. (2006). Energy-GDP relationship revisited: An example from GCC countries using panel causality. Energy Policy, 34(17), 3342–3350. doi:10.1016/j.enpol.2005.07.005

Al-Mulali, U., & Ozturk, I. (2016). The investigation of environmental Kuznets curve hypothesis in the advanced economies: The role of energy prices. Renewable and Sustainable Energy Reviews, 54, 1622–1631. doi:10.1016/j.rser.2015.10.131

Anbumozhi, V., & Kojima, M. (2019). Resilience and Environmental Sustainability. In F. Kimura, V. Anbumozhi, & H. Nishimura (Eds.), Transforming and Deepening the ASEAN Community (pp. 72–104). Jakarta: ERIA.

Antweiler, B. W., Copeland, B. R., & Taylor, M. S. (2001). Is free trade good for the environment? The American Economic Review, 91(4), 877–908. Retrieved from www.jstor:stable/2677817

Apergis, N., & Payne, J. E. (2009). CO2 emissions, energy usage, and output in Central America. Energy Policy, 37(8), 3282–3286. doi:10.1016/j.enpol.2009.03.048

ASEAN. (2015). Declaration on ASEAN post-2015 environmental sustainability and climate change agenda. Retrieved from http://environment.asean:wp-content/uploads/2018/11/Declaration-on-ASEAN-Post-2015-Env-Sustainability-and-CC-Agenda.pdf

ASEAN. (2017). Overview of ASEAN Plus Three cooperation. ASEAN Secretariat Information Paper, 1–7. Retrieved from https://asean.org/storage/2017/06/Overview-of-APT-Cooperation-Jun-2017.pdf

Baek, J. (2015). Environmental Kuznets curve for CO2 emissions: The case of Arctic countries. Energy Economics, 50, 13–17. doi:10.1016/j.eneco.2015.04.010

Baek, J. (2016). A new look at the FDI-income-energy-environment nexus: Dynamic panel data analysis of ASEAN. Energy Policy, 91, 22–27. doi:10.1016/j.enpol.2015.12.045

Balaguer, J., & Cantavella, M. (2016). Estimating the environmental Kuznets curve for Spain by considering fuel oil prices (1874–2011). Ecological Indicators, 60, 853–859. doi:10.1016/j.ecolind.2015.08.006

Birdsall, N., & Wheeler, D. (1993). Trade policy and industrial pollution in Latin America: Where are the pollution havens? The Journal of Environment & Development, 2(1), 137–149. :doi:10.1177/107049659300200107

Chin, C. (2017). What are the opportunities for ASEAN? Retrieved from https://insights.som.yale.edu/insights/what-are-the-opportunities-for-asean#gref

Cole, M. A., & Elliott, R. J. R. (2003). Determining the trade-environment composition effect: The role of capital, labor and environmental regulations. Journal of Environmental Economics and Management, 46(3), 363–383. doi:10.1016/S0095-0696(03)00021-4

Dean, J. M., Lovely, M. E., & Wang, H. (2009). Are foreign investors attracted to weak environmental regulations? Evaluating the evidence from China. Journal of Development Economics, 90(1), 1–13. doi:10.1016/j.jdeveco.2008.11.007

Dinda, S., & Coondoo, D. (2006). Income and emission: A panel data-based cointegration analysis. Ecological Economics, 57(2), 167–181. doi:10.1016/j.ecolecon.2005.03.028

Dogan, E., & Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. Renewable and Sustainable Energy Reviews, 60, 1074–1085. doi:10.1016/j.rser.2016.02.006

Farhani, S., Mrizak, S., Chaibi, A., & Rault, C. (2014). The environmental Kuznets curve and sustainability: A panel data analysis. Energy Policy, 71, 189–198. doi:10.1016/j.enpol.2014.04.030

Frankel, J. A., & Romer, D. (1999). Does trade cause growth. American Economic Review, 89(3), 379–399.

Frankel, J., & Rose, A. (2002). An estimate of the effect of common currencies on trade and income. Quarterly Journal of Economics, 117(2), 437–466. doi:10.1162/003355302753650292

GlobalEconomy. (2020). Exports, billion dollars - country angkings. https://www.theglobaleconomy.com/rankings/fdi_dollars/

GlobalEconomy. (2020). Foreign direct investment, billion dollars - country rangkings. https://www.theglobaleconomy.com/rankings/fdi_dollars/

Grossman, G., & Krueger, A. (1991). Environmental impacts of a North American free trade agreement. National Bureau of Economic Research, 3914. doi:10.3386/w3914

Halicioglu, F. (2009). An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, 37(3), 1156–1164. doi:10.1016/j.enpol.2008.11.012

Hoffmann, R., Lee, C.-G., Ramasamy, B., & Yeung, M. (2005). FDI and pollution: A granger causality test using panel data. Journal of International Development, 17(3), 311–317. doi:10.1002/jid.1196

Hongo, T., & Anbumozhi, V. (2019). Building the banking sector's capacity for green infrastructure investments for a low-carbon economy. ERIA Discussion Paper Series No. 312, 312. Retrieved from www.eria:uploads/media/discussion-papers/Building-the-Banking-Sectors-Capacity-for-Green-Infrastructure-Investments-for-a-Low-Carbon-Economy.pdf

Jayanthakumaran, K., Verma, R., & Liu, Y. (2012). CO2 emissions, energy consumption, trade and income: A comparative analysis of China and India. Energy Policy, 42, 450–460. doi:10.1016/j.enpol.2011.12.010

Jebli, M. Ben, Youssef, S. Ben, & Ozturk, I. (2016). Testing environmental Kuznets curve hypothesis: The role of renewable and non-renewable energy consumption and trade in OECD countries. Ecological Indicators, 60(2016), 824–831. doi:10.1016/j.ecolind.2015.08.031

Jensen, V. (1996). The pollution haven hypothesis and the industrial flight hypothesis: Some perspectives on theory and empirics (Working Paper 1996.5). Center for Development and the Environment, University of Oslo.

Jian, W., & Rencheng, T. (2007). Environmental effect of foreign direct investment in China. Retrieved from https://www.iioa.org/conferences/16th/files/Papers/Xu%20Environmental%20Effect%20of%20Foreign%20Direct%20Investment%20in%20China.doc

Kasman, A., & Duman, Y. S. (2015). CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. Economic Modelling, 44, 97–103. doi:10.1016/j.econmod.2014.10.022

Kim, H. S., & Baek, J. (2011). The environmental consequences of economic growth revisited. Economics Bulletin, 31(2), 1198–1211.

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. The Journal of Energy and Development, 3(2), 401–403.

Kuznets, S. (1955). Economic growth and income inequality. The American Economic Review, 45(1), 1–28.

Li, T., Wang, Y., & Zhao, D. (2016). Environmental Kuznets curve in China: New evidence from dynamic panel analysis. Energy Policy, 91, 138–147. doi:10.1016/j.enpol.2016.01.002

Managi, S., & Jena, P. R. (2008). Environmental productivity and Kuznets curve in India. Ecological Economics, 65(2), 432–440. doi:10.1016/j.ecolecon.2007.07.011

Pao, H.-T., & Tsai, C.-M. (2011). Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. Energy, 36(1), 685–693. doi:10.1016/j.energy.2010.09.041

PWC. (2017). The world in 2050. Retrieved from www.pwc.com/gx/en/research-insights/economy/the-world-in-2050.html

Sandbroke, R. (2002). FDI and environment – lessons from the mining sector. Retrieved from https://www.oecd.org/austria/2089022.pdf

Shahbaz, M., Khraief, N., Uddin, G. S., & Ozturk, I. (2014). Environmental Kuznets curve in an open economy: A bounds testing and causality analysis for Tunisia. Renewable and Sustainable Energy Reviews, 34, 325–336. doi:10.1016/j.rser.2014.03.022

Tamazian, A., Chousa, J. P., & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. Energy Policy, 37(1), 246–253. doi:10.1016/j.enpol.2008.08.025

UCS USA. (2020). Each country's share of CO2 emissions. Retrieved from www.ucsusa:resources/each-countrys-share-co2-emissions

Zarsky, L. (1999). Havens, halos and spaghetti: Untangling the evidence about the relationship between foreign investment and the environment. Retrieved from https://nautilus.org/napsnet/napsnet-special-reports/havens-halos-and-spaghetti-untangling-the-evidence-about-the-relationship-between-foreign-investment-and-the-environment/

Zhang, S., Liu, X., & Bae, J. (2017). Does trade openness affect CO2 emissions: Evidence from ten newly industrial-

ized countries? Environmental Science and Pollution Research, 24(21), 17616–17625. doi:10.1007/s11356-017-9392-8