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Causal study of macroeconomic indicators on carbon dioxide emission in ASEAN 5

Adhitya Wardhono[*], *Panji Tirta Nirwana Putra*[**] and *M. Abd. Nasir*[***]

Abstract

Carbon dioxide Emission is one of the environment degradation resulted from economic activities. The study aims at revealing the relation of macroeconomic indicators with carbon dioxide emission in ASEAN 5 countries. Carbon dioxide emission is a dependent variable explained by macroeconomic indicator variables such as GDP, trades, energy consumption and exchange rates as an independent variable. The data employed are time series data, the annual data in ASEAN 5 countries (Indonesia, Malaysia, Thailand, the Philippine and Singapore) from the period of 1975 to 2011. The research employs two methods of analysis; narrative descriptive qualitative and VAR (Vector Auto Regressive) method. The estimated research findings indicate different results concerning macroeconomic indicators affecting the carbon dioxide emission in ASEAN 5. AR results reveal that GDP in Indonesia has significant negative effect while the energy consumption shows a significant positive effect. Meanwhile, the variables such as GDP, trades and exchange rate have a significant positive affect in Malaysia. In Singapore, energy consumption has a significant effect and the exchange rate has positive significant one. Lastly, the Philippine shows that exchange rate variable indicates a significant effect towards carbon dioxide emission.

Keywords: ASEAN 5, Carbon dioxide emission, Macroeconomic Indicator, VAR

JEL classification: Q50, Q51, Q53, Q54

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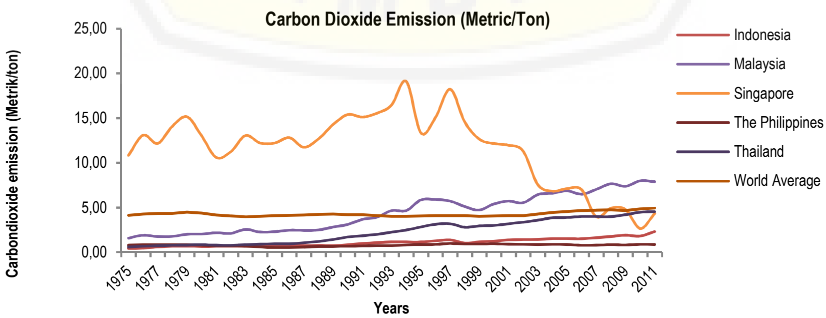
1. Background

Globalisation is an international integration process which occurs as a result of an increase in global exchange of goods and services and it is also influenced by other aspects related to cultural and social environment (Surugiu and Surugiu, 2015; Shahbaz *et al.*, 2016). Globalisation refers to an economic integration through trades, investments, cultures and other forms of interaction that the limit of countries' level of openness becomes narrower (Shangquan, 2000; Akram Ch. *et al.*, 2011; Chilosi and Federico, 2015). Globalization process in the economy provides direct investment opportunities and the transfer of technology from developed countries to developing ones and further resulting in the development of the country's economy (Velde, 2005; Marginean, 2015). One of significant alternation due to globalization is the robust increase on trade integration in the economy (Carp, 2014; Pekarskiene and Susniene, 2014). Globalisation can have a positive and negative impact to the economy in terms of economy globalisation is an industrialization which greatly contributes to a country's economy. Industrialisation began in 18 centuries starting from England and since then it was also widely dispersed in Asia Regions (IMF, 2008; Shahbaz *et al.*, 2016). The excessive use of fossil energy in industrialisation process has been affecting the carbon dioxide concentration in the atmosphere causing global warming (Halicioglu, 2009; Van Hoa and Limskul, 2013; Kasman and Duman, 2015).

Global warming is a phenomena caused by concentrated emission of carbon dioxide in the atmosphere. Figure 1 portrays the fluctuated level of carbon dioxide emission in ASEAN 5. The highest level of carbon dioxide emission occurs in Singapore with 11.60 metric per tonne annually, which is closely correlated with its high level of economic growth in its industrial sectors and advanced trade. The second highest level of carbon dioxide emission is Malaysia, in which it is dominated by industrial sectors, trade and agriculture. Unlike Singapore, which decreases its emission, Malaysia tends to increase emission as consequences of its industrial activities using fossil fuel, transportation and trading. Indonesia is considered as having relatively low carbon dioxide emission with approximately increase of 1.08 metric per tonne annually caused by industrial sectors, trade and agriculture. Indonesian forests are believed to contribute a significant decrease of emission. The vast range of forests supply oxygen and sequester carbon dioxide in the atmosphere (Schwarze *et al.*, 2005; Olivier *et al.*, 2014).

Figure 1 – The Movement of Carbon Dioxide Emission in ASEAN 5



Climate change is a tangible problem for life as a consequence of the rise in earth surface's temperature (Goodman, 2016; Zhu *et al.*, 2016). IPCC reports that the earth surface's temperature approximately increases 0.6 to 0.7 degree Celsius each year. Consequently, it affects natural ecosystem and results in the rise of sea level, threatening 50% of world population living in coastal areas (Speers *et al.*, 2016; Bosello and Cian, 2013; Lau *et al.*, 2009). The impact of climate change and global warming urged the countries to sign treaties and set policies. The ASEAN formed ASEAN Socio-Cultural Community (ASCC) Blueprint 2009-2015 dan ASEAN Cooperation on Climate Change. Furthermore, the United Nation founded an institution called United Nation Framework Convention on Climate Change (UNFCCC) on Desember 12, 1997 in Jepang. The agreement of UNFCCC came into force on 16 februari 2005 and was recognized as Kyoto Protocol.The economic growth is undoubtedly becoming every country's objectives. However, reaching high economic growth would obviously forfeit the environment, which means the environment degradation is an impact of country's economic growth (Halicioglu, 2009; Tol, 2009; Lau *et al*., 2014). Therefore, it can be inferred that economic growth affects the level of environment degradation (Huang *et al*., 2008).

The study discuses correlation of interaction between environment and economy is Kuznet's Growth Theory (1995). Kuznet reveals that the change in the relation between per capita income and imbalance in environment degradation forms an inverted U curve known as *EnviromentalKuznetsCurve* (EKC) (Halicioglu, 2009; Lau, Choong and Eng, 2014; Kasman and Duman, 2015; Zhu *et al.*, 2016). Several previous literature shows different results. Kasman and Duman, 2015 focuses their research on newly joined member of European Union. Further researches are Abbasi and Riaz, 2016 focusing on emerging market countries, Arvin *et al*., 2015 focusing on G-20 countries, and Meng *et al*., 2012 researching on carbon dioxide emission and the economy development in China. Research by Jalil and Mahmud, 2009 reveals that there is a reciprocal relation between real per capita GDP and carbon dioxide. In line with these facts, Halicioglu, 2009 states that income is the most significant affecting variable to explain the carbon dioxide emission in Turkey. This is supported by their search done by Omri dan Bassem, 2013 which demonstrates a causality relation between energy consumption, FDI and economy growth in countries with low or high income.

This study focuses on ASEAN 5 countries consisting of Indonesia, Malaysia, Singapore, the Philippines and Thailand. Those countries are selected based on their similarity in the economy structure and the intensity to use fossil fuel in their industrial process. Carbon dioxide (CO_2) is used to investigate emission pattern occurs in ASEAN 5 countries. Moreover, macroeconomic indicator such as GDP, trades, energy consumption, and exchange rate are also employed to examine the determination of carbon dioxide emission in each ASEAN 5 countries.

2. Previous Researches

Several researches have been done concerning the relation between carbon dioxide emission and economy in various ranges of countries as study case to investigate and to estimate the relation. Examples of studies were carried out in Malaysia as one of the countries in South East Asia (Chandran and Tang, 2013; Begum *et al.*, 2015; Ang and Goh, 2016). Research findings are diverse in every country studied due to strengths and weaknesses in the research's method or approaches applied. Phenomena and different period of research taken are also considered to yield different results.

Research by Omri dan Kahouli, 2014 was conducted using simultaneous equation panel analysis with data from 54 countries as a mixed of time series and cross section data. The research aimed at revealing causality of the relation between carbon dioxide emission, Foreign Direct Investment (FDI) and the economy growth in the period of time 1990-2011. Findings indicated that causal relation occurred in all sub panels first, in the form of reciprocal relation of economy growth and FDI inflow and carbon dioxide emission for all panels, reciprocal causality of FDI inflow and carbon dioxide emission for all panels except in Europe and North Asia, and moving non-complementary relation of FDI inflow and carbon dioxide emission for the economy growth with exception condition in Middle East, North Africa and sub-Sahara, as well as reciprocal relation of carbon dioxide emission and economy growth. Secondly, the correlation of causal feedback of FDI inflow and carbon dioxide emission for all panes, except for Europe and North Asia, inferred that environmental pollution and FDI inflow were accordingly determined and influenced at the same time.

Further research using panel method in analysing the impact of carbon dioxide emission to economy is the one carried out by Apergis, 2016. The research aimed at examining the validity of Environmental Kuznets Curve (EKC) by applying panel data analysis and co-integrated analysis Common Correlation Effect (CCE), OLS Fully Modified (FMOLS) and Quantil estimation procedure. The data were collected from 15 countries in the period of 1960 to 2013. Implication of findings demonstrated that the countries had increased their effectiveness to manage their environment issues particularly carbon dioxide emission. In other words, they succeeded to reform numbers of policies concerning environmental regulations enabling them to create efficient efforts related to environment degradation, energy power plant, whilst energy necessity remained increasing.

Other methods applied to analyse relation of carbon dioxide emission using panel data is research by Kasman dan Duman (2014) with its aim to investigate causal relation of energy consumption, carbon dioxide emission, economy growth and the trade openness and urbanisation in newly joined members of European Union. Their research applied dynamic data panel and simultaneous equation by collecting data in the period of 1992-2010. The results showed a long term co-integrated relation amongst five variables. Furthermore, results using estimated FMOLS suggested that inverted U existed in the real GDP and carbon emission, at the time when carbon emission increased accompanied by the increase of income, and it eventually declined. It means that the results indeed prove the Environmental Kuznets Curve (EKC) Hypotheses.

3. Method of Research

To analyse the correlation of macroeconomic indicators and carbon dioxide emission in ASEAN 5, data CO2 per capita in the period of 1975-2011 are used. VAR is employed to see the effect of macroeconomic indicator which are (GDP in US$), traded (% GDP), energy consumption and exchange rate (US$) (kg oil/capita)to the amount of carbon dioxide emission in ASEAN 5

VAR equation is adapted by Kasman dan Duman (2014), in which:

$$CO_2 = f(GDP, T, Enrg, Exc) \quad (1)$$

note that:
CO_2 = carbon dioxide per capita
Lgdp = Log real GDP
T = trade
Enrg EX = energy consumption (CO_2 per capita/metric tonne)
Exc = exchange rates

And then deriving into the econometric model equals to

$$CO_2 = \alpha_0 + \alpha_1 \beta lgdp_t + \alpha_2 \beta T_t + \alpha_3 \beta Enrg_t + \alpha_4 \beta Exc_t + \varepsilon_t \quad (2)$$

Next, deriving into VAR model yielding

$$CO_{2t} = \alpha_{10} + \alpha_{11} CO_{2t-1} + \alpha_{12} lgdp_{t-1} + \alpha_{13} T_{t-1} + \alpha_{14} Enrg_{t-1} + \alpha_{15} Exc_{t-1} + \varepsilon_t \quad (3)$$

$$gdp_t = \alpha_{20} + \alpha_{21} CO_{2t-1} + \alpha_{21} lgdp_{t-1} + \alpha_{23} T_{t-1} + \alpha_{24} Enrg_{t-1} + \alpha_{25} Exc_{t-1} + \varepsilon_t \quad (4)$$

$$T_t = \alpha_{30} + \alpha_{31} CO_{2t-1} + \alpha_{32} lgdp_{t-1} + \alpha_{33} T_{t-1} + \alpha_{34} Enrg_{t-1} + \alpha_{35} Exc_{t-1} + \varepsilon_t \quad (5)$$

$$Enrg_t = \alpha_{40} + \alpha_{41} CO_{2t-1} + \alpha_{42} lgdp_{t-1} + \alpha_{43} T_{t-1} + \alpha_{44} Enrg_{t-1} + \alpha_{45} Exc_{t-1} + \varepsilon_t \quad (6)$$

$$Exc_t = \alpha_{50} + \alpha_{51} CO_{2t-1} + \alpha_{52} lgdp_{t-1} + \alpha_{53} T_{t-1} + \alpha_{54} Enrg_{t-1} + \alpha_{55} Exc_{t-1} + \varepsilon_t \quad (7)$$

4. Results and Discussion

VAR analysis shows behaviour of each macroeconomic variable in affecting carbon dioxide emission in ASEAN5 both in short and long term. There are several important tests in VAR analysis including: stationary test, cointegration test, optimal lag option, VAR model estimation, Impulse Response function (IRF) and Variance Decomposition (VD). Such analysis tests are applied for causal analysis method using Vector Auto Regression (VAR).

Data stationarity test was applied for this study using unit root test Augmented Dicky-Fuller (ADF). If the probability value is ADF<α, then data is stationary. The estimation result reveals that all variables in ASEAN 5 are stationary in the first difference level as indicated by the probability value of ADF<α.

Table 1 – Results of Data Stationarity Test

Indonesia	*Prob. Co2*	*Prob. Log GDP*	*Prob. Trade*	*Prob. Energy Consumption*	*Prob. Exchange Rate*
Level	0.9953	0.9389	0.0521	0.9627	0.7651
1st *Difference*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
Malaysia	*Prob. Co2*	*Prob. Log GDP*	*Prob. Trade*	*Prob. Energy Consumption*	*Prob. Exchange Rate*
Level	0.9493	0.7476	0.5625	0.9184	0.6310
1st *Difference*	0.0000*	0.0003*	0.0009*	0.0000*	0.0002*
Singapura	*Prob. Co2*	*Prob. Log GDP*	*Prob. Trade*	*Prob. Energy Consumption*	*Prob. Exchange Rate*
Level	0.7820	0.7766	0.0892	0.4610	0.5107
1st *Difference*	0.0000*	0.0133*	0.0001*	0.0000*	0.0080*
The Philippines	*Prob. Co2*	*Prob. Log GDP*	*Prob. Trade*	*Prob. Energy Consumption*	*Prob. Exchange Rate*
Level	0.7153	0.9322	0.3759	0.3153	0.7425
1st*Difference*	0.0004*	0.0028*	0.2289	0.0040*	0.0008*
Thailand	*Prob. Co2*	*Prob. Log GDP*	*Prob. Trade*	*Prob. Energy Consumption*	*Prob. Exchange Rate*
Level	0.9919	0.7096	0.9144	0.9984	0.6092
1st*Difference*	0.0031*	0.0042*	0.0000*	0.0004*	0.0004*

*Significancy 5%

Optimum lag test is accomplished to determine optimum lag value to obtain the best Vector Autoregressive model for this research. An exact lag determination is important to release model from autocorrelation problem (Gujarati and Porter, 2009). Meanwhile, lag optimum test is used to identify the length period of variable interference towards past variables as well as other endogen variables. The determination lag used is Akaike Information Criteria (AIC) since it provides additional variable intervals to reduce the degree of freedom. The optimum value chosen is the smallest one. Optimum lag estimation result using AIC indicates that Indonesia has VAR equation on optimum lag value 4. Meanwhile, Malaysia, Singapura, the Philippines and Thailand are all on lag value 3.

Table 2 – Optimum Lag Test

Lag	*AIC (Indonesia)*	*AIC (Malaysia)*	*AIC (Singapore)*	*AIC (The Philippines)*	*AIC (Thailand)*
1	33.878	22.661	29.943	19.899	23.934
2	26.654	14.721	21.938	97.558	13.739
3	26.500	14.559*	22.437*	97.356*	13.394*
4	26.295*	14.861	21.882	92.487	13.531

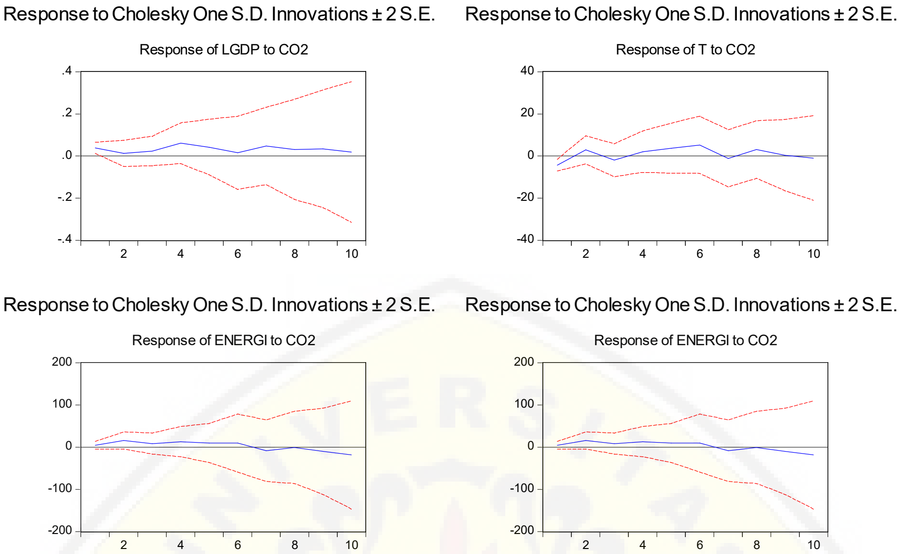
**Value of AIC is small*

Based on the estimated result of VAR, it can be acknowledged that the variables such as GDP, trade and exchange rates do not significantly affect carbon emission in Indonesia. However, energy consumption variable has a significant positive affect to carbon emission. Meanwhile, estimated result on VAR for Malaysia reveals a variable GDP, trade, and energy consumption has a significant positive effect for carbon dioxide emission. For Singapore, energy consumption variable and its exchange rates significantly affected the emission. VAR results for the Philippines show that only its exchange rate that has significant effect to carbon emission. VAR also reveals that energy consumption and exchange rate affect carbon emission in Thailand respectively.

Table 3 – Empirical Model of VAR

	Indonesia	*Malaysia*	*Singapura*	*The Philippiness*	*Thailand*
C	-7.066.829 [0.0571]	1.510.132 [0.9064]	7.264.066 [0.8965]	-0.349269 [0.7498]	-6.974353 [0.0033]
$CO2_{t-1}$	0.301168 [0.3333]	0.590652 [0.0163]	0.519927 [0.1987]	1.075938 [0.8857]	0.907478 [0.0840]
$CO2_{t-2}$	-0.270015 [0.7411]	0.032027 [0.0201]	-276861 [0.4615]	-0.005007 [0.2563]	-0.513362 [0.0251]
$CO2_{t-3}$	0.450302 [0.1190]	-	0.553448 [0.9953]	-0.08047 [0.3529]	-
GDP_{t-1}	1.863.447 [0.5968]	-1.919.252 [0.0304]*	1.363.251 [0.8128]	-0.404068 [0.6612]	3.269881 [0.4502]
GDP_{t-2}	-1.394.550 [0.3097]	1.774.159 [0.2299]	1.259.512 [0.8732]	0.764143 [0.8122]	-2.656598 [0.5680]
GDP_{t-3}	0.235791 [0.1017]	-	-2.519.775 [0.1434]	-0.32271 [0.6043]	-
T_{t-1}	-0.00016 [0.1376]	0.017611 [0.3524]	-0.041578 [0.7306]	4.43E-05 [0.1317]	-0.006468 [0.5356]
T_{t-2}	-0.011843 [0.1351]	-0.007474 [0.0344]*	-7.283.575 [0.1162]	0.003157 [0.3736]	0.002636 [0.1932]
T_{t-3}	0.008976 [0.9788]	-	9.540.246 [0.1336]	-0.006078 [0.9898]	-
$ENRG_{t-1}$	0.001708 [0.7121]	-0.001121 [0.4819]	0.001708 [0.0405]*	-0.000671 [0.6157]*	0.000588 [0.0642]
$ENRG_{t-2}$	-0.001352 [0.2035]	0.002074 [0.5493]	-0.001352 [0.4514]	0.000265 [0.4634]	0.000762 [0.0260]*
$ENRG_{t-3}$	-0.000843 [0.0137]*	-	-0.000843 [0.3294]	0.000492 [0.5967]	-
EXC_{t-1}	0.000106 [0.5321]	-1.715.542 [0.8783]	0.000106 [0.0016]*	-0.009349 [0.8326]	0.061165 [0.1384]
EXC_{t-2}	-2.43E-05 [0.6899]	1.426.460 [0.0038]*	-2.43E-05 [0.1924]	0.01397 [0.9910]	-0.039872 [0.0015]*
EXC_{t-3}	-5.01E-05 [0.5145]	-	-5.01E-05 [0.0039]*	-0.001373 [0.0011]*	-
Adj R-Squared	0.938749	0.976639	0.860811	0.819103	0.991683

Figure 2 – Impulse Response Function in Indonesia



Impulse Response Functionis a phase in VAR to determine variable shocks towards recent value and future value as a result of endogen variables existing in the model (Ronayne, 2011; Neuenkirch, 2013). Figure 2 illustrates the Impulse respone fuction of Indonesia. Overall, macroeconomic variables respond the change of carbon dioxide emission. When shocks occur, it takes a relatively longer time for variables to be in the equibrium position. GDP response begins to appear in the period of 10^{th} year. As illustrated, in 1^{st} year to 9^{th} year GDP is in its equibrium when shock is absent. Trade responses appear in the third period to fifth period having positive response of steady increase for the following years. Exchange rate variable indicates that it responds the emission starting from the 4^{th}year, showing non-fluctuated and positive response toward carbon emission.

Figure 3 shows Malaysia's Impulse Response Function demonstrating a shock on GDP. It takes 10 years or more to return its GDP to equibrium. Trade response occurs in the 3^{rd} to the 8^{th} year and afterwards trade response becomes negative or declining due to the shock. Following this, in the 9^{th} year to 20^{th} year less fluctuation occurs due to decreasing shock. However, trade variable does not reach its equibrium yet. As a result, it requires more than 11 years to reach its equibrium position.

Figure 3 – Impulse Response Function in Malaysia

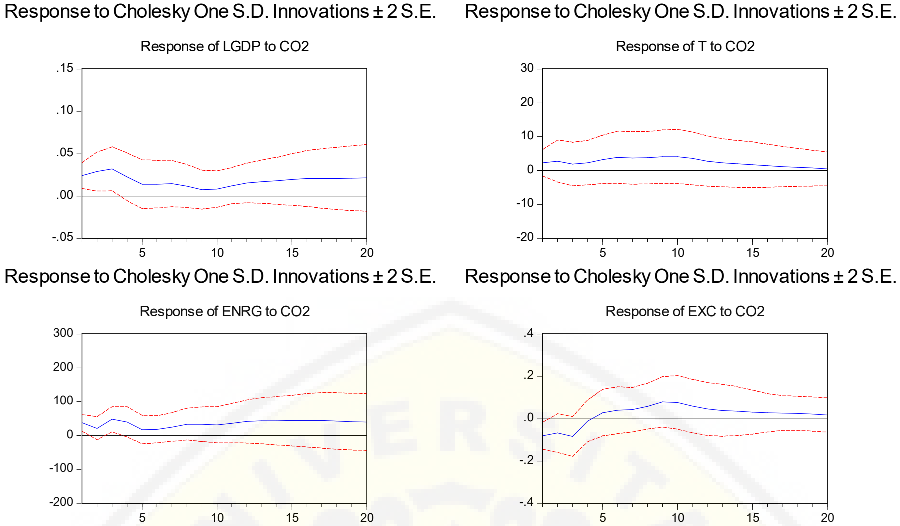
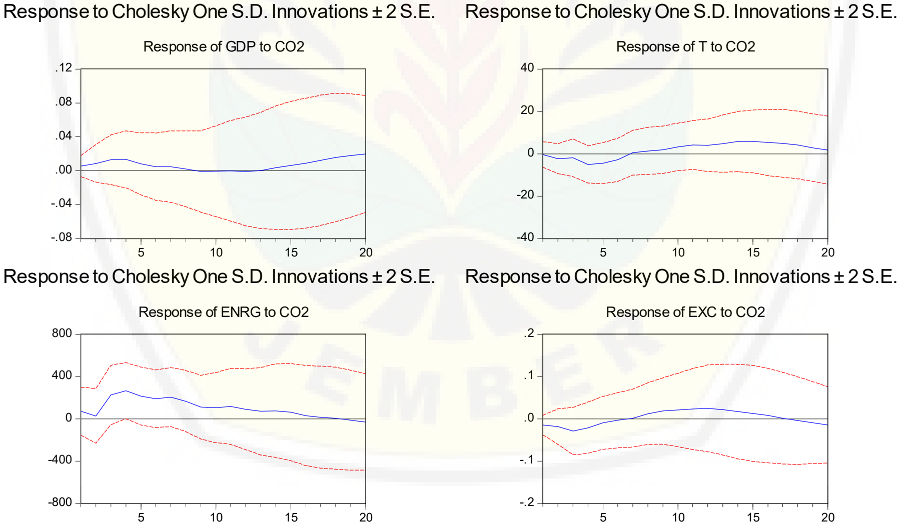


Figure 4 – Impulse Response Function in Singapore



Impulse Reponse Function results for Singapore is demonstrated in Figure 4. GDP response towards carbon dioxide emission appears in the early period and tends to increase positively until the last period. Trade response occurs in the period as early as 2nd and 3rd year then fluctuates positively. It then responds negatively after the shocks in carbon dioxide emission variable. Energy consumption response appears in the 1st year to the 3rd year, constantly continuing its response towards carbon emission in the 5th year to 20th year. Exchange rate variable positive response occurs from the 1st year to 20th year, showing its steady increase.

Figure 5 – Impulse Response Functionin The Philipiness

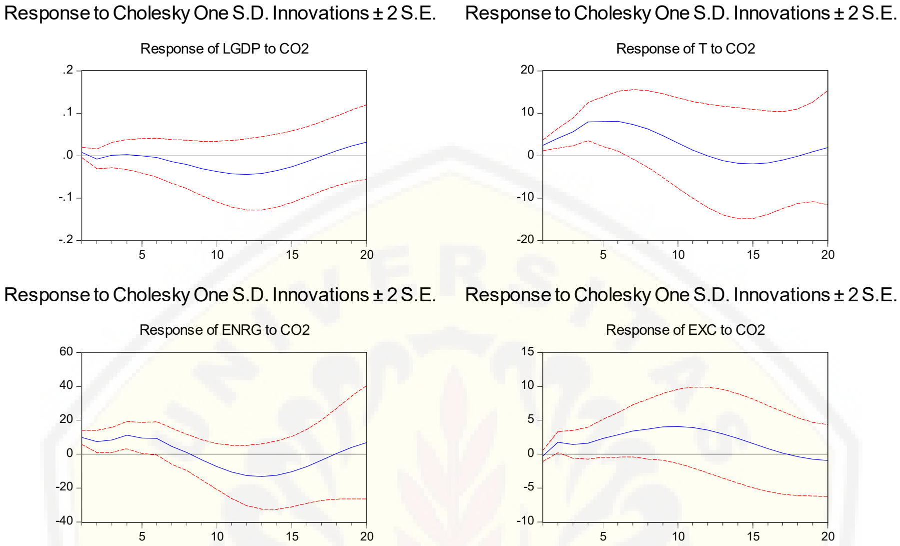


Figure 5 clearly portrays the result of the Philippines' Impulse Response Function. GDP response occurs in the 2nd period in which GDP experiences negative responses. However, it continues to increase until the last period. It means it takes more than 17 years for GDP to reach its equibrium position after the carbon emission shock in the 3rd year. Trade response to the carbon emission occurs in each period while shock exists in the early to last year of period. Energy consumption shows its positive response starting from the 2nd year after the shock in carbon emission variable and continuing until the last period. For the exchange rate variable, response shows a constant positive movement from the early to the last period.

Figure 6 demonstrates the result of Impulse Response Function of Thailand. It is clearly noticed that GDP response is visible in the early year since GDP fluctuates in the 1st year. Negative movement of GDP response occurs in the 3rd year and continues to decrease with an absent of shock until the last period. Meanwhile, trade response towards carbon dioxide emission fluctuates starting from the 1st to 5th year after the shock and decrease afterwards until the 20th year. Energy consumption responds negatively from the 1stto the 5th year. Consequently, it reaches its equibrium in the 5th year, narrowing its movement until the last period. Exchange rate response towards the energy consumption fluctuates positively from the 1st to 12th year.

Figure 6 – Impulse Response Function in Thailand

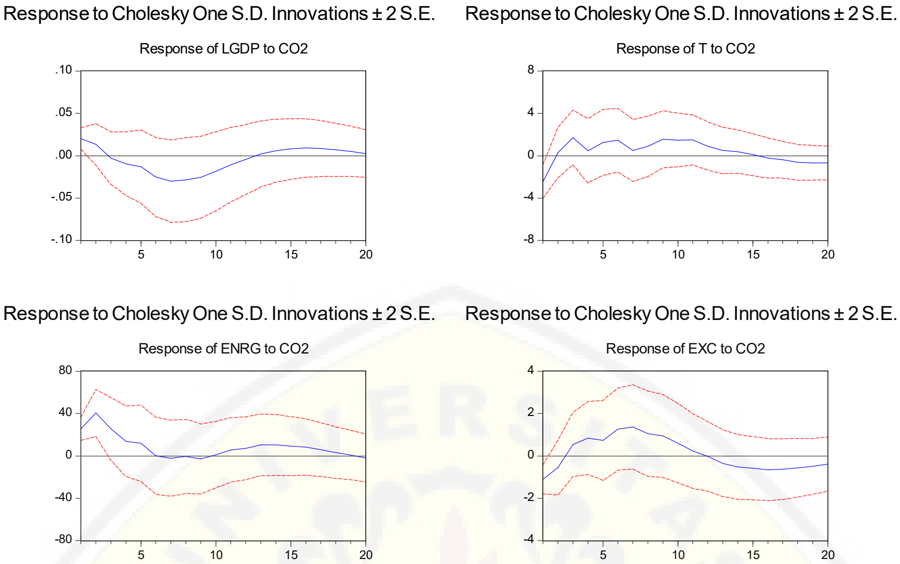


Table 4 – Variance Decomposition in Indonesia

Period	*S.E.*	*CO2*	*LGDP*	*T*	*Enrg*	*Exc*
1	0.107519	100	0	0	0	0
2	0.138255	72.23761	9.001587	8.524873	5.34568	4.890248
3	0.157288	70.29425	7.574879	8.278273	4.131417	9.721176
4	0.172516	66.17373	6.359649	12.38484	4.197923	10.88386
5	0.201219	69.6384	6.136029	11.38037	3.993568	8.851632
6	0.224085	66.29365	5.171959	13.74978	4.935176	9.849434
7	0.27138	65.22519	4.745417	12.07521	8.603453	9.350726
8	0.314361	61.20362	4.041441	14.9411	10.38735	9.42649
15	1.119172	48.82309	5.46081	11.94208	26.54502	7.228994
16	1.341328	47.32198	5.611472	11.93795	27.97279	7.155801
17	1.618921	46.44417	5.887798	11.47505	29.21924	6.973748
18	1.944982	45.37344	6.021154	11.42149	30.29351	6.890412
19	2.342251	44.79019	6.234332	11.1637	31.06573	6.746054
20	2.811706	44.03154	6.347738	11.11182	31.80942	6.699476

Variance Decomposition test (VD) is used to calculate variable estimation, which is differences before and after shock of those variables or other variables. The result of VD test shows that all macroeconomic variables contribute to the determination of carbon dioxide emission in Indonesia. Energy consumption variable becomes the greatest contributor to carbon dioxide emission with 31.80%, while exchange rate variable contributes 14.44% and exchange rates is 10.88% respectively.

Table 5 – Variance Decomposition in Malaysia

Period	*S.E.*	*CO2*	*LGDP*	*T*	*Enrg*	*Exc*
1	0.316299	100	0	0	0	0
2	0.457739	77.44903	9.687594	2.382339	2.282756	8.198278
3	0.544288	71.201	7.946756	10.43705	1.815767	8.599427
4	0.594993	62.96638	9.771834	14.18233	3.79517	9.284281
5	0.6297	57.71252	10.69058	16.52282	6.130459	8.943616
11	0.812039	39.58115	6.90317	43.66152	4.240809	5.613351
12	0.844644	37.7034	6.625911	46.4732	4.004894	5.192587
15	0.927802	34.00636	6.696053	51.48099	3.397757	4.418838
16	0.950409	33.20019	6.814116	52.47659	3.245173	4.263923
17	0.970667	32.52665	6.924485	53.30003	3.114462	4.134378
18	0.988879	31.95632	7.015986	54.00367	3.002526	4.02149
19	1.005394	31.46596	7.083553	54.62462	2.905965	3.919902
20	1.020525	31.03705	7.1288	55.18563	2.821665	3.826849

Table 5 displays the result of Malaysia's variance decomposition. VD test shows that trade variable contributes the most for carbon dioxide emission as evidenced by the VD value of 55.62%. Summing up, carbon emission is mostly influenced by trade variable in Malaysia.

Table 6 – Variance Decomposition in Singapore

Period	*S.E.*	*CO2*	*LGDP*	*T*	*Enrg*	*Exc*
1	1.577751	100	0	0	0	0
2	1.978126	81.61123	0.257289	12.0939	6.037499	7.53E-05
8	4.277725	31.52614	25.15018	16.84814	13.00862	13.46692
9	4.424921	29.66346	26.05425	15.98469	13.68401	14.61359
10	4.585696	27.7473	27.29649	15.03063	13.4494	16.47618
11	4.695574	26.65708	27.36586	14.33608	12.96624	18.67474
12	4.747468	26.29957	27.29508	14.04969	12.77272	19.58294
13	4.800138	26.55785	27.18274	13.77989	12.55207	19.92745
14	4.863886	27.24542	26.65147	13.64225	12.22777	20.23308
15	4.919218	27.85443	26.0576	13.90601	12.03968	20.14228
16	4.97647	28.59381	25.53988	14.24149	11.91038	19.71445
17	5.051664	29.54266	24.9618	14.51783	11.84444	19.13327
18	5.142057	30.12765	24.58202	14.84957	11.96113	18.47964
19	5.2394	30.22968	24.54301	15.09655	12.14023	17.99053
20	5.338557	30.18051	24.63229	15.14651	12.28266	17.75802

The table 6 above indicates that all variables contribute greatly to carbon dioxide emission in Singapore. GDP variable is on the top rank to affect emission as much as 46.81%. Exchange rate variable contributes 20.23% and trade variable gives 20.16% respectively.

Table 7 – Variance Decomposition in The Philippines

Period	*S.E.*	*CO2*	*LGDP*	*T*	*Enrg*	*Exc*
1	0.051522	100	0	0	0	0
2	0.071833	96.34459	0.702063	0.653708	0.229146	2.070492
9	0.130385	76.28139	1.381197	11.02778	0.321081	10.98855
10	0.135083	73.62905	1.406498	12.0937	0.318056	12.55269
11	0.140471	72.12445	1.439666	12.35452	0.311373	13.76999
12	0.145394	71.42215	1.558742	12.43181	0.351209	14.23609
13	0.149408	71.24793	1.708604	12.1612	0.357272	14.52499
14	0.151961	71.23202	1.935928	11.84883	0.384621	14.5986
15	0.153205	71.12614	2.189558	11.6686	0.38911	14.62659
18	0.157202	69.50052	2.791736	13.31914	0.379719	14.00888
19	0.162091	69.36477	2.748592	14.17319	0.363893	13.34956
20	0.169392	69.96427	2.57871	14.6571	0.346836	12.45308

Based on the Philippines' VD test, trade and exchange rate variable are both the highest contributor to carbon dioxide emission as much as 14.65% and 14.53% respectively.

Table 8 – Variance Decomposition in Thailand

Period	*S.E.*	*CO2*	*LGDP*	*T*	*Enrg*	*Exc*
1	0.138368	100	0	0	0	0
2	0.245669	92.94527	1.355202	0.233232	0.55702	4.909273
3	0.317524	89.70829	2.935047	0.220729	0.761909	6.374023
6	0.490132	83.52062	3.631272	1.091922	2.919028	8.83716
7	0.539674	83.52159	3.09912	1.309814	3.457454	8.61202
8	0.588194	83.77078	2.693186	1.459338	3.60261	8.47409
9	0.632065	83.90472	2.354871	1.607726	3.867335	8.265343
13	0.786186	84.35499	1.532629	2.212502	4.635303	7.26458
19	0.973335	84.91997	1.0597	2.759319	5.153795	6.107222
20	1.001026	84.98499	1.016971	2.822721	5.211117	5.964201

The table above illustrate the variance decomposition result for Thailand. It is obvious that all variable does not contribute less to carbon emission in the country. The highest contributor is the exchange rate for 8.83% indicating that it affects the carbon emission in Thailand.

5. Discussion of VAR analysis result on the determination of Carbon Dioxide Emission in ASEAN

The result of VAR test for Indonesia indicates that energy consumption is the only variable affecting significantly to the increase of carbon dioxide emission. Carbon emission in Indonesia is determined by the energy consumption of the government, industrial sectors and transportation. The emission is also influenced by the forest fires caused by illegal logging and peat lands fires (Olivier *et al.*, 2014). However, advanced technology also increases effectiveness of energy consumption (Hossain, 2011; Begum *et al.*, 2011). Indonesia's vast range of forests plays the greatest role to maintain carbon dioxide emission cycle both in Indonesia and in the world (Schwarze *et al.*, 2006). Thus, the increase of effective energy consumption will not affect the increase of carbon dioxide emission in Indonesia.

Meanwhile, in Malaysia, energy consumption variable contributes greatly to carbon emission in the country. This is due to the quite high development of industrial sector and trade in the country (Alam *et al.*, 2016). It then proves that the economy activity in Malaysia affects carbon emission determination. Such condition supports the empirical evidences in the several researches done by Mustapa & Bekhet 2016; Azlina *et al.*, 2014) and reject the empirical findings in the research by Saboori *et al.*, 2012.

For Singapore, the significant variable affecting carbon emission is energy consumption and exchange rate. The condition is mostly supported by the level of carbon emission determination caused by trade and industrial sectors (Chandran and Tang, 2013; Katircioğlu, 2014; Ang and Goh, 2016). The findings support EKC theory and correspond with researches done by Sumabat *et al.,* 2016; Saidi dan Hammami, 2015.

Empirical evidences indicate that trade and exchange rate variable contribute greatly in the Philippine's carbon emission. It occurs because there is a significant development in trade volumes (Thompson *et al.*, 2014; Wu *et al.*, 2014; Cabalu *et al.*, 2015). This findings support the research done by (Zakarya *et al.*, 2015; Ang and Goh, 2016) and conclude that macroeconomic variable correlates with carbon dioxide emission in the Philippines.

VAR test also reveals that trade and exchange rate variable are those significantly affecting carbon dioxide emission in Thailand. However, macroeconomic variable contribute less to carbon emission compared to other countries. Our research findings provide illustration that carbon dioxide emission in Thailand is affected by macroeconomic variables yet the contribution is not as much as those of other countries'. Carbon dioxide emission determination is mostly caused by agricultural and industrial sectors (Thepkhun *et al.*, 2013; Katircioğlu, 2014; Supasa *et al.*, 2016).

6. Conclusion

The test of macroeconomy indicator corellation towards carbon dioxide emission in ASEAN 5 using Vector Autoregressive (VAR) concludes that macro economy indicator affects carbon dioxide emission in each country. Each country displays different results. The analysis reveals that the correlation of macroeconomy indicator with carbon dioxide emission in Indonesia is affected by consumption level, meanwhile in Malaysia it is affected by the exchange rates. In Singapore, energy consumption and exchange rates affect the emission whereas in the Phillipines, emission is affected by consumption energy. Thailand's carbon emission is influenced by energy consumption and exchange rates. Thus, the development of carbon dioxide emission movement tend to fluctuate differently in each developing country. Therefore, it is crucial to have an effective policy to reduce the level of carbon dioxide emission in ASEAN 5 countries by inovating macro policy such as developing environment-friendly industries.

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