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Article

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CO_2 Emissions, Economic Growth, Energy Consumption, and Household Expenditure for Indonesia: Evidence from Cointegration and Vector Error Correction Model

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ABSTRACT

The present study analyses the causal relationship between CO_2 emissions, energy consumption, value added of three development sectors and household final consumption expenditure in Indonesia using annual data from 1975 to 2014. We applied ADF and PP unit root tests, Johansen co-integration test, and Granger causality test based on vector error correction modelling. Our results indicated that although CO_2 emission and energy consumption have a mutual effect, increase CO_2 emissions tend given greater effect on energy consumption. CO_2 emissions, energy consumption, the value added of industry sector and household final consumption expenditure have a significant effect on the added value of agriculture sector and service sector, while the added value of agriculture sector is a key factor that driven increases the added value of service sector. In the long term, we discover that a cointegration relationship occurring when energy consumption, household final expenditure, and the value added of three development sectors, respectively, are determined as the dependent variables in the model. Based on these results, we concluded that energy conservation and mitigation policies which accompanied the application of energy-saving technologies should be an important priority on the sustainable development planning in Indonesia, especially in order to reduce CO_2 emissions and accelerate economic growth rate in Indonesia.

Keywords: CO_2 Emission, Energy Consumption, The Value Added of Development Sectors, Household Final Consumption Expenditure
JEL Classifications: D12 O44 Q43 Q56

1. INTRODUCTION

The critical issues concerning environmental degradation, energy security, and sustainable economic development are increasingly taken into account by developed and developing countries in the world. Studies over the last three decades have shown that energy has become one of the most fundamental factors in the development process, particularly for its contribution to the performance of agriculture, industry, and services in a country (Hinrichs and Kleinbach, 2012; Yazdi and Shakouri, 2014; Javid and Sharif, 2016). For modern communities that currently rely heavily on various types of energy in their daily lives, the increased availability of energy services will certainly stimulate economic activities (Reddy and Assenza, 2009). However, energy use has a negative effect on environmental sustainability because it indirectly produces CO_2 emissions from the energy incineration. Energy consumption accounts CO_2 emissions which one of the main cause of global warming and climate change. Therefore, the efforts to effectively reduce CO_2 emissions should be applied to the strategic plans of the energy and economic sectors in a country (International Energy Agency, 2015).

IEA (2018) classified energy users and producers of CO_2 emissions from energy combustion into seven groups, namely industry, transportation, residential, commercial and private services, agriculture/forestry, fisheries, and unspecified energy users.

Whilst most categories of energy users are part of the three main development sectors in a country, that are industry, agriculture, and services. These development sectors complement each other and concurrently contribute to the added value of a country's national income. Activities of these three main development sectors are highly dependent on the availability of energy as their input and indirectly promote the amount of CO_2 emissions. In addition, economic growth on three main sectors also depends heavily to demand of goods and services in the domestic and global markets. In the domestic market, household expenditure is considered as one indicator that reveals the capability of domestic people to consume goods and services produced by the development sectors. In addition, household consumption also produces CO_2 emissions from non-energy sources which certainly also harmful to environmental sustainability in a country.

Indonesia is the most populous country in Southeast Asia, and the fourth most populous country in the world with an average population growth of 1.38% per year during 1994–2014 (World Bank, 2018). During 1994–2014, Indonesia's energy consumption increased by 1.91% per year and is predicted to multiply along with the growing population and economic growth in Indonesia. Based on the annual report of IEA (2018), most of the energy demand in Indonesia is still dominated by several types of energy produced from fossil sources. Indonesia's dependency on fossil fuels even now is exceptionally high, causing fossil energy reserves in the country to be limited and CO_2 emissions from burning energy continuously increasing (Purwanto et al., 2015). During the period of 2005–2014, the amount of CO_2 emissions from energy combustion in Indonesia increased approximately by 5.12% annually, while the total CO_2 emissions in Indonesia increased nearly by 5.58% per year.

Indonesia's economic growth is relatively stable with a GDP growth of 4.83% in average during the periods of 1994–2014 (Table 1). This economic growth is inseparable from the performance and contribution of the three main development sectors on Indonesia's national income. Throughout the same period, the average annual growth of the value added of agriculture, industry, and services sector was increased by 3.05%, 4.82%, and 5.60% respectively. Based on its composition and contribution to Indonesia's national income, the industry, and service sector are the leading development sectors that contribute prominently to Indonesia's national income with an average of more than 80% of total gross domestic products over three recent decades.

Economic growth in the three main sectors is influenced by several factors, one of which is the growth in demand for goods and services in the domestic and global markets. In the domestic market, the final amount of household expenses is an economic indicator that reflects the growth in the level of public consumption, specifically energy needs. The growth of energy consumption in domestic indicates the ability of households to meet their energy needs based on the type and price of energy products. Energy costs as a household expenditure are considered to be influenced by income levels, individual lifestyles, and changes in the types and prices of energy consumed by the general public. However, we presume that changes in income and welfare states do not always encourage people to consume more energy. Generally, people will consume energy as much as necessary to support their main daily activities such as cooking, lighting, transportation, etc. In other words, energy efficiency is applied more by households than in any other users categories. One reason for this efficacy is they tried to anticipate the risk of greater spending in the future due to the surge of energy prices (Abidin et al., 2014; Haseeb et al., 2014; Ekpung, 2014; Van Der Bank and Van Der Bank, 2014; Danbaba et al., 2016; Zomorrodi and Zhou, 2017; Luong et al., 2017; Baran and Yilmaz, 2018; Abidin et al., 2018).

Based on this interpretation, we argue that increased CO_2 emissions and energy consumption in a country may be related to economic growth in the three main development sectors and final household expenditure. Therefore, in this paper, we analyze the causal relationship between CO_2 emissions, energy consumption, the added value of three development sectors, and household final consumption expenditure in Indonesia. This paper will also emphasize and recommend the right policy implications for Indonesian policymakers in the efforts to develop sustainable development strategies that are in line with the conditions and challenges faced by energy users in the three main development sectors and residential (households). This paper is organized as follows: The second section explains data sources, model specifications, and methodology; the third section reports empirical findings and then provide brief discussions. Meanwhile, the last section will present the conclusions, and recommendations for policymakers in Indonesia.

2. LITERATURE REVIEWS

In previous studies, CO_2 emissions, and the increase in energy consumption were inclined to be correlated with some general

Table 1: The growth of population, economic development, energy consumption and CO_2 emissions in Indonesia, 1994–2014

Indicators	1994	1999	2004	2009	2014
Population [(a)]	193.95	208.61	223.61	239.34	255.13
Gross domestic product [(b)]	404.00	432.15	540.44	710.85	942.18
The value added of agriculture [(b)]	67.01	73.45	85.30	102.11	124.20
The value added of industry [(b)]	181.25	204.43	250.05	307.85	393.41
The value added of service, etc.[(b)]	147.23	147.64	195.18	283.23	401.08
Household final consumption expenditures [(b)]	209.29	273.67	325.80	405.28	522.58
Energy use [(c)]	118.64	143.61	176.64	201.87	225.51
Total CO_2 emissions [(d)]	221.41	241.99	337.64	446.41	464.18
CO_2 emission from energy combustions [(d)]	178.68	262.40	315.93	364.97	436.53

Sources: World Development Indicators (2018) and International Energy Agency (2018) [(a)] in millions of people, [(b)] in billions constant US$, [(c)] in million tonnes of oil equivalent, [(d)] in millions of CO_2

economic indicators, such as national income or gross domestic products, imports, exports, foreign direct investment, openness of trade, etc. (Alam et al., 2012; Asafu-Adjaye, 2000; Fatai et al., 2004; Azam et al., 2015a; 2015b; Saboori et al., 2012; Shahbaz et al., 2013; Wahid et al., 2013; Chandran and Tang, 2013; Kigpiboon, 2013; Kobayashi et al., 2013; Alshehry and Belloumi, 2014; Al Mamun et al., 2014; Henry, 2014; Zhang, 2017; Al-Fatlawi, 2018). However, these studies were not considering the conditions, challenges and economic growth of the three main development sectors. Furthermore, some of the previous studies assumed that the increased income per capita will boost the growth of energy consumption and CO_2 emissions. In some countries, this approach may not be appropriate to be applied due to the large income gap between the rich people and the poor people, as well as the gap of population amongst those criteria. In addition, energy cost as part of household final consumption expenditure often does not addition although the income level of peoples increased. In other words, changes in the economic level of the community as measured by per capita income do not substantially reflect the growth of energy use in residential (Haseeb et al., 2014; Chidoko, 2014; Hofman, 2014; Gideon, 2014; Adebambo et al., 2014; Shahid et al., 2014; Zomorrodi and Zhou, 2016; Haseeb et al., 2017).

The causal link between energy consumption and CO_2 emissions in Indonesia has been investigated by several scientists. Empirical evidence for a bi-directional relationship between energy consumption and CO_2 emissions was found by Shahbaz et al. (2013) and Hwang and Yoo (2012). Whilst, empirical evidence for the unidirectional relationship from CO_2 emissions to energy consumption was discovered by Chandran and Tang (2013). On the contrary, empirical evidence for unidirectional relationships from energy consumption to CO_2 emissions was found by Alam et al. (2016) and Diputra and Baek (2018). However, Wahid et al. (2013) and Saboori and Sulaiman (2013) did not found an interrelationship between energy consumption and CO_2 emissions in Indonesia.

For the case in Indonesia, The causal link between energy consumption and economic growth has been investigated by several researchers using various of energy-economic indicators, which then produced various findings under four hypotheses, i.e., growth, conservation, feedback, and neutral. The unidirectional relationship from energy consumption to economic growth (growth hypothesis) was expressed by Asafu-Adjaye (2000), Wahid et al. (2013), Chandran and Tang (2013), Haseeb and Azam (2015), and Soares et al. (2014). In contrary, Hwang and Yoo (2012), Soile (2012) and Azam et al. (2015b) found a unidirectional relationship from economic growth to energy consumption (conservation hypothesis). The empirical evidence for a mutual link between energy consumption and economic growth (feedback hypothesis) was discovered by Chiou et al. (2008) and Mahadevan and Asafu-Adjaye (2007). Whereas, empirical studies by Soytas and Sari (2003), Fatai et al. (2004), Shahbaz et al. (2013), Saboori and Sulaiman (2013), Yildirim et al. (2014), and Azam et al. (2015a) found that energy consumption and economic growth in Indonesia did not have a significant relationship (neutral hypothesis).

The causal link between economic growth and CO_2 emissions in Indonesia had been investigated by many scientists. Empirical evidence for a two-way relationship between GDP and CO_2 emissions had been found by Shahbaz et al. (2013) and Saboori and Sulaiman (2013), while empirical evidence for a one-way relationship from GDP to CO_2 emissions was found by Alam et al. (2016), Wahid et al. (2013), Chandran and Tang (2013), Hwang and Yoo (2012), and Saboori et al. (2012). Specifically, the relationship between economic development and environmental degradation in Indonesia was also investigated using the environment Kuznets curve (EKC) approach by Saboori et al. (2012), Saboori and Sulaiman (2013), as well as Alam et al. (2016). An empirical study by Saboori et al. (2012) and Saboori and Sulaiman (2013) discovered the absence evidence of the EKC hypothesis, while Alam et al. (2016) found empirical evidence that supports the EKC hypothesis.

Overall, these previous studies have produced conflicting conclusions related to the relationship and influence of economic growth on energy consumption and CO_2 emissions, and vice versa. These findings may not be appropriate when used as a reference in determining strategies and policies in Indonesia. Moreover, Indonesia had several differentiations compared to other developing countries in the world, especially in term of challenges, conditions and situations encountered related to energy, economy, and environment. The income and welfare gap between the rich and the poor is tremendous, and hence the per capita income may be inappropriate in projecting the average income and expenditure of Indonesian people. In addition, there is a considerable imbalance in economic growth between the agriculture, and two other development sectors (industry and services sector). Differences in economic structure, activities, and categories of energy users in the three development sectors, undeniably build the assumption that economic growth in each development sector may have a varied contribution to the growth rate of energy consumption and CO_2 emissions from energy combustion in Indonesia.

3. DATA AND METHODOLOGY

Our empirical study uses annual data series from 1975 to 2004 for Indonesia obtained from the World Development Indicators (2018) that is produced by the World Bank. In this paper, carbon-dioxide emissions are expressed in thousand tonnes of CO_2, energy consumption is expressed in terms of thousand tonnes of oil equivalent, whereas the value added of three main development sectors and household final expenditures are expressed in millions of constant 2010 US$. We transform all variables in logarithmic forms in order to address the issue of heteroskedasticity and induces stationarity in the variance-covariance matrix (Chang, 2010; Fatai et al., 2004; Ahmad et al., 2016). Furthermore, in order to explore the causal links between the variables, we develop specified multiple regression equations as follows:

$$lnCO_t=\alpha_1+\beta_1 lnEC_t+\beta_2 lnVA_t+\beta_3 lnVI_t+\beta_4 lnVS_t+\beta_5 lnHE_t+\mu_t \quad (1)$$

Where, α is intercept, β_i (i=1,2,3,4,5) are coefficient of independent variables, $lnCO_2$ denotes the natural logarithms of CO_2 emissions, lnEC denotes the natural logarithms of energy consumptions, lnVA denotes the natural logarithms of value added of agriculture sector; lnVI denotes the natural logarithms of value added of industry sector, lnVS denotes the natural logarithms of value added of services sector, and lnHE denotes the natural logarithms of household final expenditures. The descriptive statistics of the entire data are represented in Table 2.

The estimation process in this study is consisting of four stages. The first stage is to examine the stationarity of the series, ensuring all series are integrated in the same order. A series is said to be non-stationary if it has a non-constant mean, variance and autocovariance over time. If a non-stationary series has to be differenced *d* times to become stationary, then it is said to be integrated of order *d* or I(*d*). This stationary step is essential because the causality tests are very sensitive to the stationarity of data series (Stock and Watson**,** 1989), while the majority of macroeconomic series are non-stationary (Nelson and Plosser, 1982). In this paper, we examine the stationarity of dataset using ADF unit root test as proposed by Dickey and Fuller (1981) and PP unit root test as recommended by Phillips and Perron (1988). The adoption of PP unit root test as a complement of ADF unit root test is motivated by the argument mentioning that the ADF test has low power to reject a unit root. Therefore, PP unit root test is used to re-validate the serial correlation in unit root testing. By combining these two tests, the order of integration for all series is robust. Moreover, we tested the stationarity of all series with intercept only and expecting all series are simply stationary at first difference forms.

The second stage is to determine the number of optimum lag by VAR procedure. There are five criterions commonly used for selecting an optimum lag order for VAR, i.e., Final Prediction Error Criterion (FPE), Akaike information criterion (AIC) and Hannan-Quinn Information Criterion (HQ), sequential modified LR statistic test (LR) and Schwarz information criterion (SC). Considering that optimum lag order selected by these criterions are probably not similar, we choose optimum lag that is nominated by two or more criterions. The third step is to examine the presence of cointegration, or the long run relationship among all variables in the equation model. Cointegration is a combination of the linear relationship of variables that are not stationary at level. Since all variables should be cointegrated at same level, so when we found that all variables are cointegrated, it is indicating these variables are in an equal stochastic trend, this will have the same direction of movement in the long run. Cointegration test is an extension of the stationary test. For the cointegration test, we need to ensure the stationarity of data being used. If there are one or more variables that have different levels of integration, the variables cannot be cointegrated (Engle and Granger, 1987). In this paper, we applied the Johansen cointegration test (Johansen, 1988) to check the existence of cointegration among variables. This test consists of two statistic tests, i.e., trace test and the Max-Eigen test.

Table 2: Descriptive statistics

Statistics	LCO	LEC	LVA	LVI	LVS	LHE
Mean	12.215	18.511	13.314	14.178	13.983	14.432
Median	12.301	18.641	13.341	14.364	14.108	14.518
Maximum	13.365	19.234	13.937	15.090	15.109	15.374
Minimum	10.896	17.532	12.677	12.955	12.740	13.246
SD	0.647	0.532	0.350	0.610	0.654	0.605

SD: Standard deviation

Once the cointegration test confirmed that there is one or more cointegration relationship among the variables in the model, the vector error correction model (VECM) will be applied for Granger causality test in the last step. VECM is the method that is applicable only if a long-run relationship between the variable is present. Engle and Granger (1987) stated that once the variables are determined to be cointegrated, there is always a corresponding error correction term (ECT) exists, implying that changes in the dependent variable are a function of the level of disequilibrium in the cointegrating relationship as captured by the ECT. The empirical equations of the VECM Granger causality are modelled as follows:

$$\Delta lnCO_t = \alpha_{10} + \sum_{i=1}^{p} \beta_{11i}\Delta lnCO_{t-i} + \sum_{i=1}^{p} \beta_{12i}\Delta lnEC_{t-i} + \sum_{i=1}^{p} \beta_{13i}\Delta lnVA_{t-i} + \sum_{i=1}^{p} \beta_{14i}\Delta lnVI_{t-i} + \sum_{i=1}^{p} \beta_{15i}\Delta lnVS_{t-i} + \sum_{i=1}^{p} \beta_{16i}\Delta lnHE_{t-i} + \psi_1 ECT_{t-1} + \varepsilon_{1t} \quad (2)$$

$$\Delta lnEC_t = \alpha_{20} + \sum_{i=1}^{p} \beta_{21i}\Delta lnCO_{t-i} + \sum_{i=1}^{p} \beta_{22i}\Delta lnEC_{t-i} + \sum_{i=1}^{p} \beta_{23i}\Delta lnVA_{t-i} + \sum_{i=1}^{p} \beta_{24i}\Delta lnVI_{t-i} + \sum_{i=1}^{p} \beta_{25i}\Delta lnVS_{t-i} + \sum_{i=1}^{p} \beta_{26i}\Delta lnHE_{t-i} + \psi_2 ECT_{t-1} + \varepsilon_{2t} \quad (3)$$

$$\Delta lnVA_t = \alpha_{30} + \sum_{i=1}^{p} \beta_{31i}\Delta lnCO_{t-i} + \sum_{i=1}^{p} \beta_{32i}\Delta lnEC_{t-i} + \sum_{i=1}^{p} \beta_{33i}\Delta lnVA_{t-i} + \sum_{i=1}^{p} \beta_{34i}\Delta lnVI_{t-i} + \sum_{i=1}^{p} \beta_{35i}\Delta lnVS_{t-i} + \sum_{i=1}^{p} \beta_{36i}\Delta lnHE_{t-i} + \psi_3 ECT_{t-1} + \varepsilon_{3t} \quad (4)$$

$$\Delta lnVI_t = \alpha_{40} + \sum_{i=1}^{p} \beta_{41i}\Delta lnCO_{t-i} + \sum_{i=1}^{p} \beta_{42i}\Delta lnEC_{t-i} + \sum_{i=1}^{p} \beta_{43i}\Delta lnVA_{t-i} + \sum_{i=1}^{p} \beta_{44i}\Delta lnVI_{t-i} + \sum_{i=1}^{p} \beta_{45i}\Delta lnVS_{t-i} + \sum_{i=1}^{p} \beta_{46i}\Delta lnHE_{t-i} + \psi_4 ECT_{t-1} + \varepsilon_{4t} \quad (5)$$

$$\Delta lnVS_t = \alpha_{50} + \sum_{i=1}^{p} \beta_{51i}\Delta lnCO_{t-i} + \sum_{i=1}^{p} \beta_{52i}\Delta lnEC_{t-i} + \sum_{i=1}^{p} \beta_{53i}\Delta lnVA_{t-i} + \sum_{i=1}^{p} \beta_{54i}\Delta lnVI_{t-i} + \sum_{i=1}^{p} \beta_{55i}\Delta lnVS_{t-i} + \sum_{i=1}^{p} \beta_{56i}\Delta lnHE_{t-i} + \psi_5 ECT_{t-1} + \varepsilon_{5t} \quad (6)$$

$$\Delta lnHE_t = \alpha_{60} + \sum_{i=1}^{p} \beta_{61i}\Delta lnCO_{t-i} + \sum_{i=1}^{p} \beta_{62i}\Delta lnEC_{t-i} + \sum_{i=1}^{p} \beta_{63i}\Delta lnVA_{t-i} + \sum_{i=1}^{p} \beta_{64i}\Delta lnVI_{t-i} + \sum_{i=1}^{p} \beta_{65i}\Delta lnVS_{t-i} + \sum_{i=1}^{p} \beta_{66i}\Delta lnHE_{t-i} + \psi_6 ECT_{t-1} + \varepsilon_{6t} \quad (7)$$

The VECM Granger causality confirms the directions of causality in the long and short terms. ECT_{t-1} (ECT) represents error correction period that defines the effectiveness of feedback or correction mechanism in stabilizing disequilibrium in the model. A single equation of which has a negative sign and statistical significance at 5% level ensuring the existence of a co-integration and adjustment of disequilibrium in the model (Narayan, 2005). However, if the cointegration test implies there are more than one cointegration equation, we apply the wald to determine the significance of error correction term (ECT) based on the chi-square statistics. Similarly, we also using the Wald test for all short-run coefficients in order to conclude the direction of short-run causality relationship between the variables.

4. EMPIRICAL RESULTS

Table 3 shows the results of unit root test for all data series. We tested the unit root for all series only with an intercept. The result of ADF and PP unit root tests indicated that all data series did not stationary when tested at a level, but when they are converted to a different first form, they are stationary at 1% significance level. This result confirms that we can employ Johansen cointegration test procedure to examine the cointegration relationship amongst the variables. However, firstly we should determine the optimal lag length for our equation models using the vector autoregression (VAR) specification.

Table 4 reports the results of optimal lag length selection. It can be seen that Final Prediction Error Criterion (FPE), AIC and Hannan-Quinn Information Criterion (HQ) suggests optimal lag length is three, sequential modified LR statistic test (LR) suggest the optimal lags for the model is two lags, while Schwarz Information Criterion (SC) suggests the optimal lags for the model is one.

Table 3: The result of ADF and PP unit root tests

Series	ADF		PP	
	Level	1st different	Level	1st different
lnCO	−1.829	−6.026***	−1.977	−6.136***
lnEC	−2.060	−6.022***	−2.265	−6.022***
lnVA	−0.435	−5.507***	−0.423	−5.504***
lnVI	−2.340	−4.639***	−2.340	−4.639***
lnVS	−1.032	−4.187***	−0.932	−4.187***
lnHE	−2.287	-4.061***	−2.287	−4.018***

I denotes testing with intercept only; I+T denotes testing with intercept and trend.
***,**,* denotes series significant at 1%, 5%, and 10% levels, respectively

Table 4: Lag length selection

Lag	LR	FPE	AIC	SC	HQ
0	NA	3.63E-14	−13.920	−13.659	−13.828
1	390.447	5.82E-19	−24.989	−23.160*	−24.344
2	59.879*	3.94E-19	−25.538	−22.142	−24.341
3	45.296	3.53e-19*	−26.108*	−21.145	−24.359*

*Indicates lag order selected by the criterions. AIC: kaike information criterion

Based on these findings, we selected three lags as the optimal lag length in our equation models and then applied the cointegration test in order to check whether the variables are cointegrated. we expected there is least one cointegration relationship among the variables in the model.

Table 5 reports the results of cointegration test as determined within the Max-Eigen and Trace tests. In this step, we check the cointegration relationship among the variables within a specification model that uses an intercept both in the cointegration equation (EC) and VAR. It can be seen that the trace and max-eigen statistics suggest the number of cointegration equation (CE) in the vector error correction (VEC) specification is five. Based on this result, we decided to employ five cointegration equations on the VECM and then apply Granger causality test in order to explore the short-run and long-run causality relationships between the variables.

Table 6 reports the result of Granger causality based the VECM. First, we found that energy consumption effect to CO_2 emissions within 10% significance level, while CO_2 emissions effect to energy consumption within 1% significance level. It is indicated that although energy consumption and CO_2 emissions have a mutual relationship, CO_2 emissions tend greater effect to energy consumption. this condition implies that environment changes that caused by CO_2 emissions indirectly driven increase energy consumption in Indonesia. Therefore, implementation of energy-saving technology that environment-friendly should be more widely applicable by energy users in Indonesia in order to reduce CO_2 emissions that cause energy combustions. Furthermore, the determination of energy conservation and mitigation policies certainly should be serious attention by the Indonesian policymakers and certainly should be considering the diversity of energy users in Indonesia.

Our results also discovered that energy consumption and household final consumption expenditure have a significant effect on the value added of agriculture sector at 1% significance level, while CO_2 emission and the value added of industry sector have a significant effect on the value added of agriculture sector at 10% significance level. These results indicated that the growth of energy consumption, the value added of Industry, CO_2 emissions and household final consumption expenditure are a determinant factor that significantly influenced the value added of agriculture sector.

Table 5: The result of cointegration test

Hypothesized number of CE (s)	Eigenvalue	Trace statistic		Max-eigen statistic	
		Value	0.05 CV	Value	0.05 CV
None*	0.9619	255.0672	95.7537	117.6025	40.0776
At most 1*	0.8094	137.4647	69.8189	59.6788	33.8769
At most 2*	0.6174	77.7860	47.8561	34.5917	27.5843
At most 3*	0.5218	43.1943	29.7971	26.5562	21.1316
At most 4*	0.3549	16.6381	15.4947	15.7781	14.2646
At most 5	0.0236	0.8600	3.8415	0.8600	3.8415

*Denotes rejection of the hypothesis at the 0.05 level

Table 6: The result of granger causality test

DV	Short-run (χ^2)					
	ΔlnCO	ΔlnEC	ΔlnVA	ΔlnVI	ΔlnVS	lnHE
ΔlnCO		6.917*	4.613	1.343	4.664	0.464
ΔlnEC	11.739***		3.859	0.129	1.077	4.536
ΔlnVA	7.168*	18.450***		5.456	4.988	12.714***
ΔlnVI	1.186	6.091	3.820		4.996	1.841
ΔlnVS	7.123*	17.055***	10.864**	12.023***		5.772
ΔlnHE	1.551	4.353	2.392	2.276	1.872	
DV	**The coefficients of error correction term equations (t-stat)**					**ECT (χ^2)**
	ECT 1	**ECT 2**	**ECT 3**	**ECT 4**	**ECT 5**	
ΔlnCO	−0.520	3.754*	−4.188	−4.735	3.388**	10.933*
ΔlnEC	−0.858***	0.264	2.240*	0.454	−0.422	19.983***
ΔlnVA	0.017	0.352**	−0.363	−0.823***	0.305**	28.806***
ΔlnVI	0.093	1.858**	−1.883	−2.776**	1.611**	21.602***
ΔlnVS	0.243	1.784***	−1.427*	−2.807***	1.217**	41.572***
ΔlnHE	0.098	0.881	−0.386	−0.889	0.597	25.131***

***, **, * denotes significant at 1%, 5% and 10% respectively

therefore, the availability of energy sources and economic policies that potentially increased the value added of agriculture sector considered as a critical requirement to support the sustainable development of agriculture sector in Indonesia.

Furthermore, we found that an increase or decrease on CO_2 emission, energy consumption, the added value of agriculture sector and household final consumption expenditure did not affect the added value of industry sector and service sector, respectively. Meanwhile, the value added of industry sector and the value added of service sector did not have a significant relationship. These facts implied that economic growth in Industry sector and service sector, respectively, did not depend on another development sectors and the issue of energy security and environment emissions did not hamper increase economic growth in these sectors. Therefore, energy and economic policies can applicable widely in both these sectors and certainly expected provide a positive contribution that supports accelerate sustainable development in Indonesia.

Moreover, our result revealed that the growth of energy consumption, CO_2 emissions, and the added value of three development sectors did not influence the growth of household final consumption expenditure in Indonesia. This finding indicates that household final consumption expenditure is unpredictable and commonly depend on the stability prices of goods and services in the domestic market. This condition probably also implies that Indonesian people, especially household, are more selective and efficient spending their income to fulfil their daily needs. Therefore, fiscal and monetary policies which more siding to domestic people certainly should be considered by the Indonesian policymakers in order to improve people's purchasing power in the domestic market.

In the long term, we found five empirical findings that confirmed existence cointegration relationship that statistically significant at 1% level on five equation models, i.e., when energy consumption, the value added of three development sectors and household final consumption expenditure were consecutively determined as the dependent variable in the specification of VECM. In other words, these results reconfirm empirical findings from the cointegration test that suggest the existence of a long-run or cointegration relationship among CO_2 emission, energy consumption, the value added of three development sectors and household final consumption expenditure in Indonesia.

5. CONCLUSION AND POLICY IMPLICATIONS

The present study investigates the causal link between CO_2 emissions, energy consumption, the value added of three development sectors, and household final consumption expenditure in Indonesia using annual data from 1975 to 2014. Overall, our estimation procedures are consists of four stages. First, we examined the stationary series data series using ADF and PP unit root tests. Once all series were confirmed stationary only within first difference form, we then determined the optimal lag length for our equation model using the VAR procedure in the second step. In the third step, we check the cointegration relationship between the variables using Johansen cointegration test and found evidence cointegration relationship between the variables. Therefore, in the last step, we then apply the Granger causality test based VECM in order to explore the short-run and long-run relationships between the variables.

Based on our results, we concluded that CO_2 emissions have a greater impact on energy consumption. In other words, energy users could potentially end up consuming more energy in the attempt to minimize environmental impacts caused by CO_2 emissions. Therefore, policies and strategies in developing efficient and environmental-friendly alternative energy must be implemented by policymakers in Indonesia in order to reduce the environmental impact caused by energy utilization. For energy users, the application of green technology might be more effective in dealing with the risk of environmental impacts, limited non-renewable energy resources, and the surge of energy prices in the future.

Our findings also found that CO_2 emissions caused energy combustion potentially influenced the productivity and income of agriculture sector. Agriculture commodities are one of the production inputs in a number of manufacturing industries and also one of the main commodity which traded in the services sector. Agriculture commodity is the people's basic needs which highly dependent on the number of demands and the growth rate of household consumption. Thus, strategies and policies that potentially will encourage the performance and value added of agriculture sector should be the main concern of the Indonesian policymakers, since agriculture commodities are not only driven the activities of another development sectors but also have become an important commodity for Indonesian people.

Furthermore, we concluded that economic growth in all development sectors, energy consumption and CO_2 emissions did not influence the growth rate of household final consumption expenditures in Indonesia. It is implied that most of the Indonesian people are more likely to be selective and efficient in consuming goods and services for their daily basics, particularly their energy needs. Moreover, economic growth in industry sector and service sector also did not have a significant relationship with other indicators. This finding shows that the increase in CO_2 emissions, energy consumption, the value added of agriculture, as well as household final consumption expenditure did not substantially affect the economic growth in industry sector and service sector. Thus, the conservation and energy mitigation policies may be widely applicable in these sectors and certainly expected will encourage the performance and income of these sectors in the short and long terms.

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