Bashir, Abdul; Thamrin, K. M. Husni; Farhan, Muhammad et al.

Article

The causality between human capital, energy consumption, CO2 emissions, and economic growth : empirical evidence from Indonesia

International Journal of Energy Economics and Policy

Reference: Bashir, Abdul/Thamrin, K. M. Husni et. al. (2019). The causality between human capital, energy consumption, CO2 emissions, and economic growth : empirical evidence from Indonesia. In: International Journal of Energy Economics and Policy 9 (2), S. 98 - 104.
doi:10.32479/ijeep.7377.

IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2019, 9(2), 98-104.

EJ EconJournals

The Causality between Human Capital, Energy Consumption, CO_2 Emissions, and Economic Growth: Empirical Evidence from Indonesia

Abdul Bashir[1], K. M. Husni Thamrin[2]*, Muhammad Farhan[3], Mukhlis[1], Dirta Pratama Atiyatna[1]

[1]Department of Development Economics, Economics Faculty, Universitas Sriwijaya, Palembang, Indonesia, [2]Department of Management, Economics Faculty, Universitas Sriwijaya, Palembang, Indonesia, [3]Department of Accounting, Economics Faculty, Universitas Sriwijaya, Palembang, Indonesia.*Email: kemasmuhammadhusnithamrin@fe.unsri.ac.id

Received: 14 November 2018 **Accepted:** 06 February 2019 **DOI:** https://doi.org/10.32479/ijeep.7377

ABSTRACT

This study to investigate the causality between human capital, energy consumption, CO_2 emissions, and economic growth in Indonesia. The data used world development indicator has obtained from the World Bank database during 1985-2017. The analysis method used vector error correction model. The finding of this study, first, there is the validity of long-run balance causality exists only for the model of human capital nor energy consumption; second, neither CO_2 emissions per capita nor real gross domestic product (GDP) per capita cause human capital in the long-run causality nor short-run; Third, there is no causal evidence from the human capital, CO_2 emission per capita, and real GDP per capita to consumption energy per capita, but in the short-run, there is causal evidence between CO_2 emission and energy consumption; fourth, there is no causal evidence from the human capital, consumption energy per capita, and real GDP per capita toward CO_2 emission per capita, but human capital, consumption energy, and economic growth cause CO_2 emission in the short-run; and the last finding, there is no causal evidence from the human capital, consumption energy per capita, and CO_2 emission per capita to real GDP per capita, neither in the long-run causality and short-run.

Keywords: Human Capital, Energy Consumption, Carbon Dioxide Emission, Economic Growth, Vector Error Correction Model Granger Causality
JEL Classifications: J24, Q43, Q53, Q56

1. INTRODUCTION

The challenge faced by most developing countries, especially Indonesia, at present is how to create consistent economic growth without sacrificing environmental aspects. The current economic driver in Indonesia is based on industry, it is estimated that the growth of energy consumption in Indonesia continues to increase every year, in the period 1990-2016 the average growth of energy consumption in Indonesia reached 5.39%. One of the most influential studies in looking at causality between energy consumption, CO_2 emissions and economic growth is the study carried out by Ãng (2007) for the case of France in 1960-2000, in his study applying the co-integration method and vector error correction model (VECM) in which the findings indicate that there is a long-term relationship between the three variables, so there is also short-term causality from energy consumption to economic growth.

Meanwhile, that expected by each country is the realization of sustainable economic development; economic development can be realized if supported by high human capital. Like studies conducted by Solow (1986) and Hartwick (1977) in his study economic development there are two terms, namely (1) the existence of weak sustainability which assumes that human capital can replace natural capital; and (2) strong sustainability assumes that human capital and natural capital complement each other, but cannot be exchanged. In the economic literature, the criteria for a weak sustainability approach are also used in the study Amsalu et al. (2014) in his study observing scarce resources that can be replaced with human capital.

One of the problems faced by Indonesia is the exploitation of natural resources that are still very dominant, if it cannot be overcome as early as possible, it will have an impact on environmental damage in the future. Meanwhile, government supervision of the use and management of natural resources is still low. In addition, there are still many land management using traditional technology, and industries that use fossil fuels. Even though in the reform era Indonesia has a significant commitment to changes in environmental policy in Indonesia, and at the beginning of Indonesia's reforms it agreed to reduce CO_2 emissions by 25% until 2020. In addition, in the environmental policy, the country of Indonesia is also committed to reducing home gas emissions glass up to 41%, of course, it depends on the support of other countries and international financial institutions (Shahbaz et al., 2013).

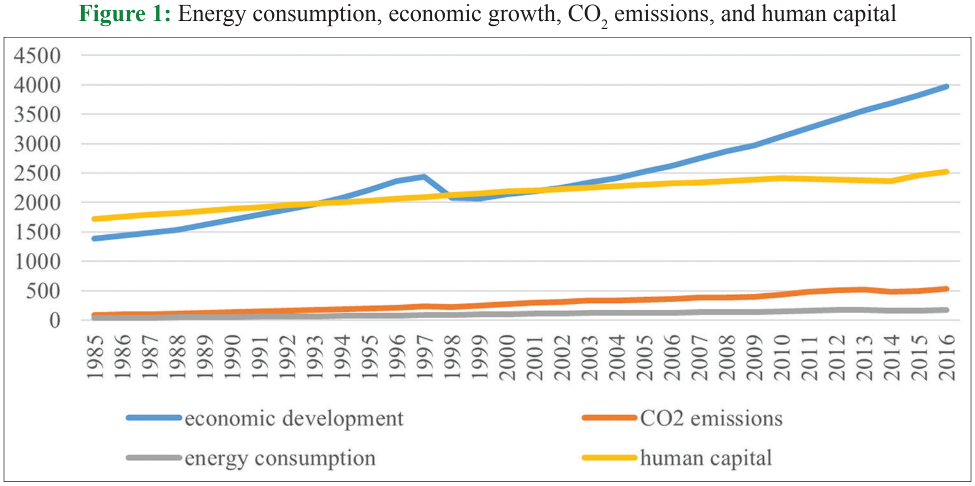
Meanwhile, trends in energy consumption, CO_2 emissions, economic development, and human capital show the fluctuating trend (Figure 1), the average growth of energy consumption from 1985 to 2016 reached 5.39%, while the average CO_2 emissions, per capita income, and human capital reached 6.11%, 3.52%, and 1.25%. The increase in energy consumption needs is inseparable from the economic activity of a country, of course, this requires an appropriate strategy to encourage economic growth without sacrificing environmental aspects so that the environmental problems that are feared by this country will be overcome properly. Another study that also supports this study is the study conducted by Soytas et al. (2010) for the case of the United States, in his study using the Granger causality test and found that Granger's energy consumption caused carbon emissions, however, between energy consumption and economic growth there was no causal relationship. These results indicate that economic growth may not be the main solution to the challenges of the current global environment.

The dynamic relationship between economic growth, energy consumption and pollution is also studied by Halicioglu (2009) for the Turkey case in 1960-2005, using a co-integration test, the findings indicate that there is a long-term influence on energy use, income and foreign trade on CO_2 emissions, and the long-term effects of CO_2 emissions, energy consumption and external trade country on per capita income. Overall, estimates of results indicate that environmental pollution must be reflected in Turkey's macroeconomic policies to effort reduce CO_2 emissions. In addition, studies have been conducted by Suri and Chapman (1998) and Richmond and Kaufmann (2006) found that only developed countries have succeeded in controlling the level of energy consumption and reached a turning point in the existence of the environmental Kuznets curve (EKC).

Meanwhile, several studies also have to investigate the relationship between human capital and economic growth, because human capital also recognized as the principal indicators of economic development (Bashir et al., 2018). The impact of human capital on the economic growth gained prominence in many of the literature. The economic development in the future will increase of the human capital, while in some the literature assumes that human capital can to changes production pattern and consumption because the development of human capital investment in the developing countries will provide an economic return by increasing income per capita (Bashir et al., 2018; Costantini and Monni, 2008; Siddiqui and Rehman, 2017). Therefore, we assume that changes of economic development in the future will increase of the human capital and change the economic structure, of course, the changes that occur will cause changes in all macroeconomics aspect in the future which will also impact to economic growth, energy consumption, and CO_2 emissions.

Based on the problems background has described, there have not been many studies linking the variables of energy consumption, CO_2 emissions, and economic growth with human capital. Therefore, the objective of this study is to investigate the causality between human capital, energy consumption, CO_2 emissions, and economic growth in Indonesia. In the next session, we will explain the literature review. The third session explained the analytical methods and quantitative approaches to answering research problems. Furthermore, the fourth session will explain the results and discussion, and the final session will present the conclusions of our study.

Figure 1: Energy consumption, economic growth, CO_2 emissions, and human capital



Source: World Development Indicator (2017), BPRS (2017), FRED (2017)

2. LITERATURE REVIEW

The first study of the relationship between economic development and energy consumption has been conducted by Kraft and Kraft (1978) in his study using data in the United States in 1947-1974 and found that causality runs from energy consumption to gross national product. Furthermore, this study can be the basis for further study in this field. For example, a more recent study by Cheng and Wei (1997) which investigated the relationship between energy consumption and economic growth in the Taiwan case in 1955-1993 through a modified version of the Granger causality test.

Some previous researchers have found a causal relationship in the direction of economic growth and increased use of energy (Al Mamun et al., 2014; Yildirim et al., 2014; Rezitis and Ahammad, 2015; Islam et al., 2017; Nuryartono and Rifai, 2017; Bimanatya and Widodo, 2018). Furthermore, Masih (1997) in his study found that has the relationship in long-term between energy consumption, economic growth, and prices in Korea and Taiwan and find the same causality between price and energy use, and prices with economic growth. In addition, study by Stern (2011) estimates that there is a long-term relationship between energy consumption and economic development in the United States, which is in line with previous research that applies Granger causality to investigate the relationship between these two parameters in study Stern (1993). In his study Stern (1993) also explained that the methodology that is most suitable for studying this relationship is multivariate analysis.

Meanwhile, study by Paul and Bhattacharya (2004) examine the relationship between energy use and economic growth in India in 1950-1996, in his study, found that has a two-way causal relationship between economic development and energy use by applying the standard version of the Granger causality test. In addition, in the newer study conducted by Wolde-rufael (2014) conducted panel analysis of 15 developing countries in 1975-2010, using the bootstrap panel causality method, which controls cross-sectional dependence and heterogeneity within countries. In Belarus and Bulgaria electricity consumption was found to cause economic growth, in the Czech Republic, Latvia, Lithuania, and Russia found that economic growth led to electricity consumption. Interestingly, only Ukraine is estimated to have a two-way causality between the two parameters. Whereas other countries that were also observed did not indicated causality relationship.

In addition, study by Shahbaz and Lean (2012) mentions that sustainable economic development will be achieved in tandem with sustainable environmental conservation. Researchers in the economic field have examined the relationship between economic growth and environmental indicators for answer existence the Environmental Kuznets Curve (EKC). This theory states that the level of environmental degradation will increase along with economic development and at a certain point (turning point) in achieving economic growth, the level of environmental degradation will decrease along with increasing which is marked by a U-inverted curve.

Many EKC studies also include other exogenous variables in their estimates in addition to income levels and economic growth, such as energy consumption, foreign direct investment, and trade openness. While the study was conducted Suri and Chapman (1998) indicated that both developed and developing countries that are going through the industrialization stage will increase the demand for energy which is high enough to initially for the increased export. Furthermore, study by Akbostancı et al. (2009) testing the existence of EKC in Turkey using a co-integration analysis of time-series data in 1968-2003, in his research found that there is a monotonous relationship that increases monopolistically between CO_2 emissions and per capita income, the conclusion of his study indicated that EKC does not apply to Turkey. Other study by Ozturk and Acaravci (2010) state that energy conservation policies, such as rationing energy consumption and controlling carbon emissions, are likely to have no adverse effect on the real output growth of Turkey, that result supports the opinion by Stern (2004) which states that developing countries are currently estimated to have better performance compared to developed countries in controlling environmental degradation.

3. RESEARCH METHOD

The scope of this study to investigate the causality between human capital, energy consumption, CO_2 emissions, and economic growth in Indonesia. Data observations during 1985-2017, which were obtained from the world development indicator database CD-room 2017. The variables used were human capital (index), energy consumption (energy consumption per capita), CO_2 emissions (CO_2 emissions per capita), and economic growth (gross domestic product [GDP] real per capita).

Several stages of testing that must be done are, (1) testing the unit root to see the time series economic data behaviour, whether the data used is stationary or not, can be seen as the first step in the formation of a time series model, which among others can performed using the Dickey-Fuller augmented test (Dickey and Fuller, 1979); (2) tested co-integration and temporal Granger causality using the maximum likelihood approach from Johansen (Johansen, 1988). According to Engle and Granger (1987) if two variables integrate with the first differences and co-integrated, then both unidirectional and bidirectional Granger causality must exist, at least as long as the two variables have a common trend for causality in Granger terminology, and not according to structural terminology, least there is unidirectional; (3) the third stage includes replacing the VECM and testing it's exogenity. Engle and Granger (1987) show that with co-integration, there is always a corresponding error correction representation, which implies that changes in the dependent variable are caught by the error correction term (ECT) as well as changes in explanatory variables.

3.1. The Unit Root Test

The most common and widely used test to stationary data test is the Augmented Dickey-Fuller test (ADF test) criteria. The concept of testing the Augmented Dickey-Fuller Test is that if a time series data is not stationary at zero order (level), then the stationary data can be searched through the next order so that the stationary level is obtained at the first order (first difference), and the second difference. Before conducting the ADF test, it is necessary to pay attention to the plot of data to be tested. This test has the following equation presented.

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \gamma_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t \quad (1)$$

Where: ΔY_t is the first difference from Y; β_1 is a constant value or intercept; β_2 is the regression coefficient for trends; is the regression coefficient for Y lag; is the regression coefficient for Y lag difference; ε is error term; m is lag; and t is the time period.

3.2. Johansen Co-integration Test

The most common and widely used co-integration test is the Johansen test. This study also uses the Johansen co-integration test, to see if there is a maximum possibility of the Johansen co-integration test (Johansen, 1988) to determine the long-term relationship between the variables being investigated. In checking Granger causality analysis also needs to be done to get good results from the test results by choosing the right optimal lag length. The integration framework with Johansen takes its starting point in the vector error correction (VECM) model, while the equation can be presented as follows:

$$x_t = A_1 x_{t-p} + \ldots + Apx_{t-p} + By_t + \varepsilon_t \quad (2)$$

Where x_t is a vector of endogenous variables, and A represents an autoregressive matrix. y_t is a deterministic vector and B represents the parameter matrix. ε_t is the vector of innovation, and p is the lag length.

3.3. The VECM Granger Causality

Furthermore, to investigated the direction of causality between the human capital (HC), energy consumption (EC), CO_2 emission (CO_2), and economic growth (EG) in the context of the time-series data. Then the VECM Granger causality equation model can be seen as follows:

$$\Delta \ln HC_t = \alpha_{1t} + \sum_{i=1}^{n-1} \rho_{1t,1} \Delta \ln HC_{t-1} + \sum_{i=1}^{n-1} \beta_{1t,1} \Delta \ln EC_{t-1} + \sum_{i=1}^{n-1} \gamma_{1t,1} \Delta \ln CO2_{t-1} + \sum_{i=1}^{n-1} \delta_{1t,1} \Delta \ln EG_{t-1} + ECT_{t-1} + \varepsilon_{1t} \quad (3)$$

$$\Delta \ln EC_t = \alpha_{2t} + \sum_{i=1}^{n-1} \rho_{2t,1} \Delta \ln HC_{t-1} + \sum_{i=1}^{n-1} \beta_{2t,1} \Delta \ln EC_{t-1} + \sum_{i=1}^{n-1} \gamma_{2t,1} \Delta \ln CO2_{t-1} + \sum_{i=1}^{n-1} \delta_{2t,1} \Delta \ln EG_{t-1} + ECT_{t-1} + \varepsilon_{2t} \quad (4)$$

$$\Delta \ln CO2_t = \alpha_{3t} + \sum_{i=1}^{n-1} \rho_{3t,1} \Delta \ln HC_{t-1} + \sum_{i=1}^{n-1} \beta_{3t,1} \Delta \ln EC_{t-1} + \sum_{i=1}^{n-1} \gamma_{3t,1} \Delta \ln CO2_{t-1} + \sum_{i=1}^{n-1} \delta_{3t,1} \Delta \ln EG_{t-1} + ECT_{t-1} + \varepsilon_{3t} \quad (5)$$

$$\Delta \ln EG_t = \alpha_{4t} + \sum_{i=1}^{n-1} \rho_{4t,1} \Delta \ln HC_{t-1} + \sum_{i=1}^{n-1} \beta_{4t,1} \Delta \ln EC_{t-1} + \sum_{i=1}^{n-1} \gamma_{4t,1} \Delta \ln CO2_{t-1} + \sum_{i=1}^{n-1} \delta_{4t,1} \Delta \ln EG_{t-1} + ECT_{t-1} + \varepsilon_{4t} \quad (6)$$

Where t is time period (t = 1..., t); l is lag of each variable; lnHC is human capital index; lnEC is energy consumption per capita; $\ln CO_2$ is CO_2 emission per capita; and lnEG is GDP real per capita; ECT is error correction term and ε_{1t}, ε_{2t}, ε_{3t}, ε_{3t} is assuming error rates on the model (error term).

4. RESULT AND DISCUSSION

The diagnostic test has conducted in the model, the result indicated that no evidence of serial correlation and heteroscedasticity. In addition, the normality test using the Jarque-Bera test (JB test) indicated that the null hypothesis is accepted which means the sample size observed is normally distributed (Table 4). Based on a criterion such as Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC) indicated that obtained optimal lag length is one. The first stage, we tested the unit root with the ADF test criteria has presented in Table 1.

Based on test result in Table 1 indicated that the overall, the variable of human capital, energy consumption, CO_2 emissions, and economic growth indicate stationary in the first difference, with the test statistic value smaller than the critical value on the ADF or MacKinnon criteria for at 5% confidence level and the probability value smaller than 0.05.

Table 2 summarizes the results of the co-integration analysis using the Johansen maximum likelihood approach using maximum eigenvalue and trace statistics. VAR = I is used in the Johansen estimation procedure. The estimation procedure assumes that there is no deterministic trend in X_t variables, and that the data generation process does not contain trend terms. Then the constant term is included in the estimate. Both produce evidence to reject the null hypothesis that vectors are co-integrated at zero degrees for coin vector integration at a 5% significance level.

On the basis of these results, the long-term relationship between government spending and income received statistical support in the case of the Indonesia state in the period 1985-2017. After testing that variables are co-integrated, VECM can be applied. Residual lags from regressions that co-integrated with the right amount of lag are included in the Granger causality test structure. The length of the lag structure depends on the error correction model that is estimated. Structured error correction models through a series of diagnostic tests include serial correlations on the basis of inspection of autocorrelation functions of residuals and also reported lagrange multipliers.

In Table 3, the estimation results of the four models show that there are two models that have a long-term causality, namely the model of human capital and energy consumption, while the model of

Table 1: Unit root test at first difference

Variable	ADF test	t-Statistic			summary
		1%	5%	10%	
Δ(lnHC)	−9.794175	−3.699871	−2.976263	−2.627420	*stationary
Δ(lnEC)	−5.852157	−3.661661	−2.960411	−2.619160	*stationary
Δ($\ln CO_2$)	−6.346703	−3.670170	−2.963972	−2.621007	*stationary
Δ(lnEG)	−4.065769	−3.661661	−2.960411	−2.619160	*stationary

*Indicates statistical significance at the 1%, 5%, and 10% level.
Source: Author calculation

Table 2: Johansen co-integration test results

Trace test				
Null hypothesized (H_0)	**Eigenvalue**	**Trace statistic**	**Critical value 0.05**	**Prob.****
None*	0.964678	157.5567	47.85613	0.0000
At most 1*	0.790167	63.94589	29.79707	0.0000
At most 2*	0.426719	20.22552	15.49471	0.0090
At most 3*	0.152920	4.646887	3.841466	0.0311
Maximum eigenvalue test				
Null hypothesized (H_0)	**Eigenvalue**	**Max-eigen statistic**	**Critical value 0.05**	**Prob.****
None*	0.964678	93.61085	27.58434	0.0000
At most 1*	0.790167	43.72037	21.13162	0.0000
At most 2*	0.426719	15.57863	14.26460	0.0308
At most 3*	0.152920	4.646887	3.841466	0.0311

Max-eigenvalue test indicates 4 co-integrating equation (s) at the 0.05 level. *Denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) P values

Table 3: The long-run causality from VECM estimates result

ECM	C	$\Delta(\ln HC_{t-1})$	$\Delta(\ln EC_{t-1})$	$\Delta(\ln CO_{2t-1})$	$\Delta(\ln EG_{t-1})$	ECT_{t-1}	Summary
Δ(lnHC)	−0.002	0.372	−0.018	−0.032	0.098	0.044	R^2=0.635; Adj. R^2=0.470;
	(0.004)	(0.179)	(0.032)	(0.015)	(0.043)	(0.016)	F-stat=3.860; AIC=−6.843;
	[−0.431]	[2.077]***	[−0.570]	[−2.176]***	[2.279]***	[2.756]***	SC=−6.376
Δ(lnEC)	0.026	0.026	−0.206	0.093	−0.188	0.252	R^2=0.349; Adj. R^2=0.057;
	(0.023)	(1.058)	(0.188)	(0.087)	(0.255)	(0.094)	F-stat=1.197; AIC=−3.291;
	[1.156]	[0.024]	[−1.091]	[1.078]	[−0.738]	[2.678]***	SC=−2.824
$\Delta(\ln CO_2)$	0.278	−6.175	0.320	−0.509	−0.359	0.490	R^2=0.715; Adj. R^2=0.587;
	(0.070)	(3.271)	(0.584)	(0.268)	(0.787)	(0.290)	F-stat=5.571; AIC=−1.034;
	[3.969]***	[−1.888]	[0.549]	[−1.900]	[−0.456]	[1.686]	SC=−0.567
Δ(lnEG)	0.024	0.413	0.225	0.001	−0.160	0.022	R^2=0.189; Adj. R^2=−0.175;
	(0.023)	(1.063)	(0.190)	(0.087)	(0.256)	(0.095)	F-stat=0.521; AIC=−3.283;
	[1.042]	[0.388]	[1.186]	[0.011]	[−0.626]	[0.232]	SC=−2.816

Significant level at ***1%, **5%, and *10%. AIC: Akaike Information Criterion

Source: Author calculation.

CO_2 emissions and economic growth not have long-term causality. Statistically, the first model indicates that the ECT coefficient is 0.044, which means that there is the validity of long-term balance relationship between energy consumption, CO_2 emissions, and economic growth, this implies that 4.4% imbalance of the previous period shocks reunited into long-run equilibrium at the current period is positive. In other words, there is a long-term causality of energy consumption, CO_2 emissions and economic growth in human capital.

In the model, there is a negative effect on previous year's CO_2 emissions on human capital, which is the show from the coefficient value of −0.032, this means that a 1% increase in CO_2 emissions will reduce human capital by 0.032%. This finding indicates that increasing CO_2 emissions will have a negative impact on human capital in Indonesia. While economic growth has a positive effect on human capital, which is indicated from the coefficient value of 0.098, this implies that a 1% increase in economic growth will increase human capital by 0.098%. These findings indicate that economic growth has a positive impact on improving human capital in Indonesia. Whereas for the previous year's energy consumption and human capital have the insignificant effect on human capital.

Likewise, the second model in energy consumption, which has an ECT coefficient of 0.252, this means that there is the validity of long-run equilibrium relationship between human capital, CO_2 emissions, and economic growth, this implies that 25.2% imbalance of previous period shocks reunited into long-run equilibrium in the current period positively. In other words, there is a long-term causality from human capital, CO_2 emissions, and economic growth towards energy consumption. However, partially indicated that all independent variables such as human capital, CO_2 emissions, economic growth, and energy consumption previous year has insignificant effect on energy consumption.

The estimation results of the third model indicate that there is no long-term balance between human capital, energy consumption, and economic growth on CO_2 emissions. However, partially, the estimation results indicated that human capital has a negative effect on CO_2 emissions, as evidenced from the coefficient value of −6175, which means that increasing human capital of 1%, will reduce CO_2 emissions at 6.17%. This finding indicates that increasing human capital will have a negative impact on CO_2 emissions. Likewise, the fourth model indicates that there is no long-term balance between human capital, energy consumption, and CO_2 emissions toward economic growth. Statistically, the variables of human capital, energy consumption, and CO_2 emissions have no effect on economic growth.

After to estimating long-run balance, this section we also estimate the short-term causality model, in the first model testing the null hypothesis (H_0) on short-term causality is that past lags of consumption energy, CO_2 emission, and economic growth jointly no affect human capital, in other words, the null hypothesis is accepted. However, statistically, only CO_2 emission and economic growth have the Chi-square probability

Table 4: The short-run causality from VECM estimates result

Dep. variable	χ^2 and P				Inference (short-run causality)
	$\Delta(\ln HC_{t-1})$	$\Delta(\ln EC_{t-1})$	$\Delta(\ln CO_{2t-1})$	$\Delta(\ln EG_{t-1})$	
Δ(lnHC)	-	2.499 0.287	16.683*** 0.000	5.227* 0.073	Δ(lnEC) on Δ(lnHC): No short-run Δ(lnCO2) on Δ(lnHC): Short-run Δ(lnEG) on Δ(lnHC): Short-run
Δ(lnEC)	1.130 0.568	-	4.909* 0.086	1.489 0.475	Δ(lnHC) on Δ(lnEC): No short-run Δ(lnCO2) on Δ(lnEC): Short-run Δ(lnEG) on Δ(lnEC): No short-run
$\Delta(\ln CO_2)$	19.866*** 0.000	5.350* 0.070	-	19.865*** 0.000	Δ(lnHC) on Δ(lnCO2): Short-run Δ(lnEC) on Δ(lnCO2): Short-run Δ(lnEG) on Δ(lnCO2): Short-run
Δ(lnEG)	0.173 0.917	2.318 0.313	0.044 0.978	-	Δ(lnHC) on Δ(lnEG): Short-run Δ(lnEC) on Δ(lnEG): No short-run Δ(lnCO2) on Δ(lnEG): No short-run
Test statistics					
Serial correlation (LM test)		Breusch-Godfrey			10.71452 (0.8268)
Normality test		Jarque-Bera test			10.32000 (0.2525)
Heteroscedasticity test		Breusch-Pagan-Godfrey			197.8683 (0.1718)

Significant level at ***1%, **5%, and *10%. VECM: Vector error correction model.
Source: Author calculation.

value is greater than 0.05, then the null hypothesis is rejected, which means that there is no short-term causality between CO_2 emission and economic growth toward human capital (Table 4). The same process is repeated in the second model to test short-term causality between past lags of the human capital, CO_2 emission, and economic growth jointly no affect consumption energy, in other words, the null hypothesis is accepted. However, statistically, only CO_2 emission have Chi-square probability value is >0.05, the null hypothesis is rejected, which means that there is a short-term causality between CO_2 emission and consumption energy.

Meanwhile, the CO_2 emission model in short-run causality indicated that human capital, energy consumption, CO_2 emission, and economic growth jointly have short-term causality, in other words, the null hypothesis is rejected, which means that between human capital, energy consumption, and economic growth of CO_2 emissions has causality short-term. However, the economic growth model in short-run causality indicated that human capital, energy consumption, CO_2 emission, and economic growth jointly have no short-term causality, in other words, the null hypothesis is accepted, which means that between human capital, energy consumption, and economic growth of CO_2 emissions has no short-term causality.

The empirical results of this study are mostly consistent with the study by Ozturk and Acaravci (2010); Soytas et al. (2007); and Akbostancı et al. (2009), and but different than the study by Halicioglu (2009) The overall results indicates that rationing consumption energy and controlling carbon emissions, are likely to have no adverse effect on the real GDP per capita. Meanwhile, empirically, the development of human capital has the impact on controlling CO2 emissions and energy consumption in Indonesia.

5. CONCLUSIONS

This study investigates the long run causality between human capital, energy consumption, CO_2 emissions, and economic growth in Indonesia by using the VECM based Granger causality models during 1985-2017. Empirical results suggest an evidence of a long-term and short-term causality between variables at 1%, 5%, and 10% significance level in Indonesia. The main results for the existence and direction of Granger causality are as follows:

1. Neither CO_2 emissions per capita nor real GDP per capita cause human capital in the long-run causality nor short-run. Therefore, the Indonesian government's policy in developing human capital is appropriate for controlling energy consumption and CO_2 emissions reduction.
2. There is no causal evidence from the human capital, CO_2 emission per capita, and real GDP per capita to consumption energy per capita, but in the short-run, there is causal evidence between CO_2 emission and energy consumption.
3. There is no causal evidence from the human capital, consumption energy per capita, and real GDP per capita toward CO_2 emission per capita, but human capital, consumption energy, and economic growth cause CO_2 emission in the short-run. This also evaluated as no evidence the EKC hypothesis at causal framework used the linear logarithmic model in the long-run.
4. The other most interesting result is that there is no causal evidence from the human capital, consumption energy per capita, and CO_2 emission per capita to real GDP per capita, neither in the long-run causality and short-run. Therefore, the Indonesian government policy in conservative energy policy and CO_2 emissions reduction policy in the long-run without impeding economic growth.
5. There is the validity of long-run balance causality exists only for the model of human capital nor energy consumption.

REFERENCES

Akbostancı, E., Türüt-Aşık, S., Tunç, G.İ. (2009), The relationship between income and environment in Turkey: Is there an environmental Kuznets curve? Energy Policy, 37(3), 861-867.

Al Mamun, M., Sohag, K., Mia, M.A.H., Uddin, G.S., Ozturk, I. (2014), Regional differences in the dynamic linkage between CO2 emissions, sectoral output and economic growth. Renewable and Sustainable Energy Reviews, 38, 1-11.

Amsalu, D.W., Jacobsen, J.B., Lundhede, T.H. (2014), Economic assessment of use values of near-natural forestry compared with rotational forestry in Denmark. European Journal of Forest Research, 133(4), 611-622.

Ang, J.B. (2007), CO2 emissions, energy consumption, and output in France. Energy Policy, 35, 4772-4778.

Bashir, A., Susetyo, D., Azwardi, A., Suhel, S. (2018), The relationship between economic growth, human capital, and agriculture sector: Empirical evidence from Indonesia. International Journal of Food and Agricultural Economics, 6(4), 35-52.

Bimanatya, T.E., Widodo, T. (2018), Fossil fuels consumption, carbon emissions, and economic growth in Indonesia. International Journal of Energy Economics and Policy, 8(4), 90-97.

Cheng, B.S., Wei, T. (1997), An investigation of co-integration and causality between energy consumption and economic activity in Taiwan. Energy Economic, 19, 435-444.

Costantini, V., Monni, S. (2008), Environment, human development and economic growth. Ecological Economics, 64(4), 867-880.

Dickey, D.A., Fuller, W.A. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366a), 427-431.

Engle, R.F., Granger, C.W.J. (1987), Co-integration and error correction: Representation, estimation, and testing. Econometrica, 55(2), 251-276.

Halicioglu, F. (2009), An econometric study of CO 2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, 37, 1156-1164.

Hartwick, J.M. (1977), Intergenerational equity and the investing of rents from exhaustible resources. American Economic Review, 67(5), 972-974.

Islam, R., Ghani, A.B.A., Mahyudin, E. (2017), Carbon dioxide emission, energy consumption, economic growth, population, poverty and forest area: Evidence from panel data analysis. International Journal of Energy Economics and Policy, 7(4), 99-106.

Johansen, S. (1988), Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 12(2-3), 231-254.

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

Masih, A.M.M. (1997), On the temporal causal relationship between energy consumption, real income, and prices: Some new evidence from Asian-energy dependent NICs based on a multivariate cointegrationnector error-correction approach. Journal of Policy Modeling, 19(4), 417-440.

Nuryartono, N., Rifai, M.A. (2017), Analysis of causality between economic growth, energy consumption and carbon dioxide emissions in 4 ASEAN countries. International Journal of Energy Economics and Policy, 7(6), 141-152.

Ozturk, I., Acaravci, A. (2010), CO2 emissions, energy consumption and economic growth in Turkey. Renewable and Sustainable Energy Reviews, 14(9), 3220-3225.

Paul, S., Bhattacharya, R.N. (2004), Causality between energy consumption and economic growth in India : A note on conflicting results. Energy Economics, 26, 977-983.

Rezitis, A., Ahammad, S. (2015), The relationship between energy consumption and economic growth in south and Southeast Asian countries: A panel VAR approach and causality analysis. International Journal of Energy Economics and Policy, 5(3), 704-715.

Richmond, A.K., Kaufmann, R.K. (2006), Is there a turning point in the relationship between income and energy use and/or carbon emissions? Ecological Economics, 56(2), 176-189.

Shahbaz, M., Hye, Q.M.A., Tiwari, A.K., Leitão, N.C. (2013), Economic growth, energy consumption, financial development, international trade and CO2emissions in Indonesia. Renewable and Sustainable Energy Reviews, 25, 109-121.

Shahbaz, M., Lean, H.H. (2012), Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. Energy Policy, 40(1), 473-479.

Siddiqui, A., Rehman, A.U. (2017), The human capital and economic growth nexus: In East and South Asia. Applied Economics, 49(28), 2697-2710.

Solow, R.M. (1986), On the intergenerational allocation of exhaustible resources. The Scandinavian Journal of Economics, 88(1), 141-149.

Soytas, U., Sari, R., Ewing, B.T. (2007), Energy consumption, income, and carbon emissions in the United States. Ecological Economics, 62, 482-489.

Stern, D.I. (1993), Energy and economic growth in the USA: A multivariate approach. Energy Economics, 15(2), 137-150.

Stern, D.I. (2004), Environmental Kuznets curve. Encyclopedia of Energy, 2, 517-525.

Stern, D.I. (2011), The role of energy in economic growth. Annals of the New York Academy of Sciences, 1219(1), 26-51.

Suri, V., Chapman, D. (1998), Economic growth, trade and energy: Implications for the environmental Kuznets curve. Ecological Economics, 25(2), 195-208.

Wolde-Rufael, Y. (2014), Electricity consumption and economic growth in transition countries: A revisit using bootstrap panel granger causality analysis. Energy Economics, 44, 325-327.

Yildirim, E., Aslan, A., Ozturk, I. (2014), Energy consumption and GDP in ASEAN countries: Bootstrap-corrected panel and time series causality tests. The Singapore Economic Review, 59(02), 1450010.