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Energy Consumption and CO2 Emissions in Indonesia's Human Development

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Abstract

This study analyzes the causality relationship between energy usage, education, health, and CO2 emissions in Indonesia. In a 21-year data analysis from 2000 to 2020, "autoregressive vectors" were used to represent the causal link between variables. The World Bank contributed the data for this research. In this study, we look at investigates the causality link between electricity usage, education, health, and CO2 emissions in Indonesia. We found that energy usage has a significant positive relationship with CO2 emissions, which means that the higher the energy consumption in Indonesia, the more threatened environmental sustainability in Indonesia is. Energy usage also has a negatively impact on the health and education of the Indonesian population. Education itself significantly increases the efficiency of energy use in Indonesia so education plays a crucial function in the efficiency of energy consumption in Indonesia. Health does not have a significant impact on environmental sustainability. Indonesia needs to make energy consumption efficient and protect the environment. The human capital that is enhanced through education is an important factor in maintaining environmental sustainability and energy consumption efficiency in Indonesia.

Keyword : Energy Consumption,CO2 Emissions,Indonesia, Human Development, Human Capital
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Background

Energy is the “fuel” needed for economic growth and increased prosperity. It is this electrical energy that keeps factories working and allows us to enjoy a comfortable environment in our homes through heating and air conditioning. For this reason, all countries where the economy is growing also recorded an increase in their energy consumption (Woldemedhin et al.,2022 ; Güler et a.,2022).

There is scientific evidence that access to modern energy, such as electricity, promotes economic growth and human progress. This is because the availability of energy directly affects productivity, health, education, drinking water supply, communication services, as well as a long list of benefits and services. There is a direct the link between energy use and living quality of the population (Jeon, 2022). However, once a certain HDI index value is reached, along with the increase in per capita consumption, there is no longer any significant increase in the index (Widarni & Bawono, 2020).

Renewable energy will continue to grow until it becomes the protagonist in covering the ever-increasing energy needs around the world. Renewable publications, led by solar PV, with natural gas, will we can provide more than half of this expansion.driven by increased natural gas liquefied (LNG) trade, accounting for another third. The promotion of renewable technologies must be based on the use of fossil fuels to sustain population growth and the expansion of the world economy. This means a slowdown in the increase in greenhouse gas emissions (Adams & Nsiah, 2019 ; Jouybari et al.,2022).

Various types of primary energy, and electricity consumption will increase mainly due to the increasing electrification of society, both due to the progressive introduction of electric vehicles and due to improvements in electrical technology for household and industrial purposes. In contrast, oil and coal will see their share in world demand diminish, though, while natural gas becomes more prominent in this new scenario (Tang & Tan, 2013 ; Wang et al.,2021).

The future clearly points to electricity as the main energy vector, with the hope that renewables will cover all of the world's energy demands (Azam et al.,2021 ; Olmstead & Yatchew, 2022). This study investigates the causality link between energy consumption, education, health, and CO2 emissions in Indonesia.

Research Method

In a 21-year data analysis from 2000 to 2020, "autoregressive vectors" were used to represent the causal link between variables. The World Bank contributed the data for this research. In this study, we look at investigates the causality relationship between energy consumption, education, health, and CO2 emissions in Indonesia. The following multivariate regression model was used to evaluate, through cointegration techniques :

$EC_t = \beta_0 + \beta_1 E_t + \beta_2 H_t + \beta_3 CE_t + e_t$ eql 1

$E_t = \beta_0 + \beta_1 EC_t + \beta_2 H_t + \beta_3 CE_t + e_t$ eql 2

$H_t = \beta_0 + \beta_1 EC_t + \beta_2 E_t + \beta_3 CE_t + e_t$ eql 3

$CE_t = \beta_0 + \beta_1 EC_t + \beta_2 E_t + \beta_3 H_t + e_t$ eql 4

Description :

EC : Energy consumption

E : Education
H : Health
CE : CO_2 emissions
e : error term
t : time series
β : the magnitude of the effect of causality
eql: equation

This study uses vector calculations where each regression relationship will be brought together so that each variable will alternately become the dependent variable and the independent variable. The zero theory of Dickey-Fuller, taken from the PP test, and p=1 is the formula in $\Delta yt = (\rho - 1)yt\text{-}1 + ut$, in which Δ – for the first time different operators. This research used the following equation for the "unit root test":

$$\Delta Y1 = \alpha 0 + \beta 0T + \beta 1Yt\text{-}1 + \sum\_(i\text{-}1)\text{^}q\ \alpha 1\Delta Yt\text{-}1 + et$$

Description:

Y as the variable is being examined for unit root
T as the variable which indicates the "linear trend," the "lag difference" means is $\Delta Yt{-}1$, $\alpha 0$ are shown as "constant term," with the "t" as a "time trend" indicator. The alternative and null hypotheses for the "unit root test" are as follows:
H0: $\alpha=0$
H1: $\alpha\neq0$

Result and Discussion

Before a causality or VAR assumption can be satisfied, a stationarity test must be performed. To determine whether a sequence is not stationary., apply the Augmented Dickey-Fuller test. The following observations were made after doing the unit root test:

Table 1: ADF's Unit Root Test on EC, CE, H, and E data.

Variable	Unit Root	Include in the examination Equation	Statistics for the ADF Test	5% Critical Value	Description
Energy consumption (EC)	Level	Intercept	1.127994	0.9957	
	First Diff	Intercept	-3.288039	0.0332	Stationer
CO2 emissions (CE)	Level	Intercept	-0.152050	0.9303	
	First Diff	Intercept	-3.501360	0.0197	Stationer

Health (H)	Level	Intercept	-0.598411	0.8501	
	First Diff	Intercept	-3.732511	0.0123	Stationer
Education (E)	Level	Intercept	0.011282	0.9491	
	First Diff	Intercept	-4.861012	0.0012	Stationer

The EC, H, CE, and E data are stationary at the first difference. The Augmented Dickey-Fuller test is -3.501360 with a critical value of 0.0197. Smaller than the p-value, in this case, the CE data shows stationary at the first difference compared to the original data. From here, we can take the next step in defining vector analysis.

Both the causality and VAR tests need sufficient lag length sensitivity. Before doing a VAR analysis or a causality test, it is critical to choose the most appropriate time lag for the circumstance. In this experiment, the Akaike Information Criteria (AIC) was employed to establish the optimum time lag. The lag test yielded the following results:

Table 2 : AIC value at Lag 0 to 3 EC, E, H and CE data.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-143.8469	NA	160.1929	16.42743	16.62529	16.45471
1	-102.3411	59.95283*	9.993153	13.59345	14.58275	13.72986
2	-81.57406	20.76700	8.221279	13.06378	14.84453	13.30933
3	-39.44782	23.40347	1.390662*	10.16087*	12.73305*	10.51554*

The results of the Optimum Lag test are shown in Table 2. The length of the Lag variables EC, E, H, and CE is at FPE, AIC, SC, and HQ at Lag 3 according to the AIC value at Lag 0 to 3. The first lag will be picked since the results of the four criteria are identical. As a result, the best lag, according to the test criteria, is lag 3.

Table 4 : Vector Model Analysis

	EC	E	H	CE
EC	0.536206	-1.251993	-0.068139	1.369756
	(0.63182)	(0.51605)	(0.09386)	(0.86259)
	[0.84867]	[-2.42612]	[-0.72598]	[1.58795]
E	-0.283976	-0.768750	-0.058793	0.768296
	(0.47183)	(0.38537)	(0.07009)	(0.64417)
	[-0.60186]	[-1.99482]	[-0.83879]	[1.19270]
H	5.779576	-14.43686	-2.231168	39.27673
	(8.52791)	(6.96531)	(1.26686)	(11.6428)
	[0.67772]	[-2.07268]	[-1.76119]	[3.37348]
CE	0.480740	-0.395801	-0.077260	1.001634

	(0.23790)	(0.19431)	(0.03534)	(0.32479)
	[2.02079]	[-2.03699]	[-2.18615]	[3.08394]
C	-18.70075	308.9908	4.524219	-108.6887
	(93.4854)	(76.3558)	(13.8877)	(127.632)
	[-0.20004]	[4.04672]	[0.32577]	[-0.85158]
R-squared	0.988431	0.969577	0.880726	0.966888
Adj. R-squared	0.960664	0.896561	0.594470	0.887420
Sum sq. resids	13.32234	8.887436	0.294002	24.83194
S.E. equation	1.632320	1.333224	0.242488	2.228539
F-statistic	35.59804	13.27903	3.076702	12.16693
Log likelihood	-22.83253	-19.18930	11.48997	-28.43672
Akaike AIC	3.981392	3.576588	0.167781	4.604080
Schwarz SC	4.624438	4.219635	0.810827	5.247127
Mean dependent	32.03498	45.31088	2.812170	43.70584
S.D. dependent	8.230219	4.145352	0.380784	6.641847

The relationship between EC and EC itself is significantly negative, with a coefficient of 0.536206 and a t-statistic of 0.84867, the relationship between EC and E is significantly negative, with a coefficient of -1.251993 and a t-statistic of -2.42612, which means the lower the EC, the higher E. Similarly, the relationship between EC and H is significantly negative with a coefficient of -0.068139 and a t-statistic of -0.72598, meaning that the lower the EC, the higher the H. The relationship between EC and CE is positively significant, as evidenced by the coefficient of 1.369756 and the t-statistic of 1.58795. This shows that the decreasing level of energy consumption will encourage the level of education, this is also in line with when the level of energy consumption is low, the level of health will be higher. Then, when the level of energy consumption is high, it will encourage high CO2 emissions as well.

Table 5 : Granger Causality

Null Hypothesis:	Obs	F-Statistic	Prob.
E does not Granger Cause EC	18	1.19661	0.3561
EC does not Granger Cause E		0.75087	0.5443
H does not Granger Cause EC	18	0.35170	0.7888
EC does not Granger Cause H		2.40272	0.1230
CE does not Granger Cause EC	18	3.03223	0.0750
EC does not Granger Cause CE		1.62688	0.2396
H does not Granger Cause E	18	0.93517	0.4564
E does not Granger Cause H		2.28702	0.1353
CE does not Granger Cause E	18	1.89499	0.1889

E does not Granger Cause CE		2.27943	0.1362
CE does not Granger Cause H	18	0.52842	0.6719
H does not Granger Cause CE		0.44582	0.7251

The results of Granger causality analysis with variables EC, E, H, and CE indicate that there is no one-way relationship between variables EC, E, H, and CE. This happens because the level of significance (p-value) is smaller. or equal to 0.05.

Conclusion

Energy consumption has a significant positive relationship with CO2 emissions, which means that the higher the energy consumption in Indonesia, the more threatened environmental sustainability in Indonesia is. Energy consumption also has a The sequence is not stationary. impact on the health and education of the Indonesian population. Education itself significantly increases the efficiency of energy use in Indonesia so that education plays an critical role in the efficiency of energy consumption in Indonesia. Health does not have a significant impact on environmental sustainability. Indonesia needs to make energy consumption efficiency and protect the environment. Human capital that is enhanced through education is an important factor in maintaining environmental sustainability and energy consumption efficiency in Indonesia.

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