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MEASURING THE LEVEL OF FOSSIL ENERGY CONSUMPTION, ECONOMIC DEVELOPMENT, AND INTERNATIONAL TRADE ON CO_2 EMISSION PRODUCTION IN INDONESIA

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Abstract: Environmental health and climate change have become a global concern; there has been an increase in the amount of CO_2 emissions from 1,720 million tons of CO_2 equivalent in 2020 to 2,950 million tons of CO_2 equivalents which has caused an increase in air temperature and widespread global warming. The purpose of this research is to see the relationship between energy consumption in the form of fossil energy, economic development, international trade and CO_2 production in Indonesia. This research was built within the framework of a quantitative approach with an error correction model estimation model, data obtained from the world bank and world development indicators for the period from 1994-2021. Furthermore, the data is processed with the help of the STAT.17 application. Research to answer the question, do fossil energy consumption, economic development and international trade have short-term and long-term effects on the production of CO_2 emissions in Indonesia. This study found that fossil energy consumption has both short and long term effects on CO_2 emissions. Meanwhile, the variables of economic development and international trade only have a short-term effect. Thus this research is expected to be able to become the basis for strengthening to encourage the use of renewable energy towards sustainable development. This research is one of the comprehensive studies on economic development and environmental health.

Keywords: Fossil Energy Consumption, Economic Development, Trade , CO_2 Emissions.

INTRODUCTION

Tropical rain forests have become a characteristic of Indonesia as a country which is on the equator. The presence of the area is an attraction for people to create agricultural and mining areas that trigger deforestation, release large amounts of carbon dioxide into the atmosphere, and become one of the triggering factors for global warming not just deforestation. However, progress in the energy sector is also one of the triggers for global warming. Globally, Indonesia is ranked fifth as the largest coal producer (Dunne 2019) , ranked sixth as the world's largest methane emitter in 2021. In addition, CO_2 emissions will continue to increase until 2021 reaching the highest level with an average concentration of 414.2 ppm.

Economic development and environmental health are in a vortex of debate in the unification of the two concepts at the level of sustainable development because of the inherent contradictions in the goals that are both at the theoretical level and at the public policy level. Economic development is the key to treating environmental degradation (Saboori, Sulaiman, and Mohd 2012; Asikha, Alam, and Al-amin 2021) (Ali et al. 2020) . Environmental health is becoming a consensus, pushing governments in various countries to provide mature financial services, financing, investment and project funds based on environmental protection (wang Xiaoxia, Jiaoya Huang, Xiang Ziman 2021) (Tran 2021; Karedla, Mishra, and Patel 2021) . This is a stimulus for the birth of a green financial model that significantly promotes renewable energy and indirectly strengthens market openness and improves the economy (Chien-chiang Lee, Fuhao Wang 2023) .

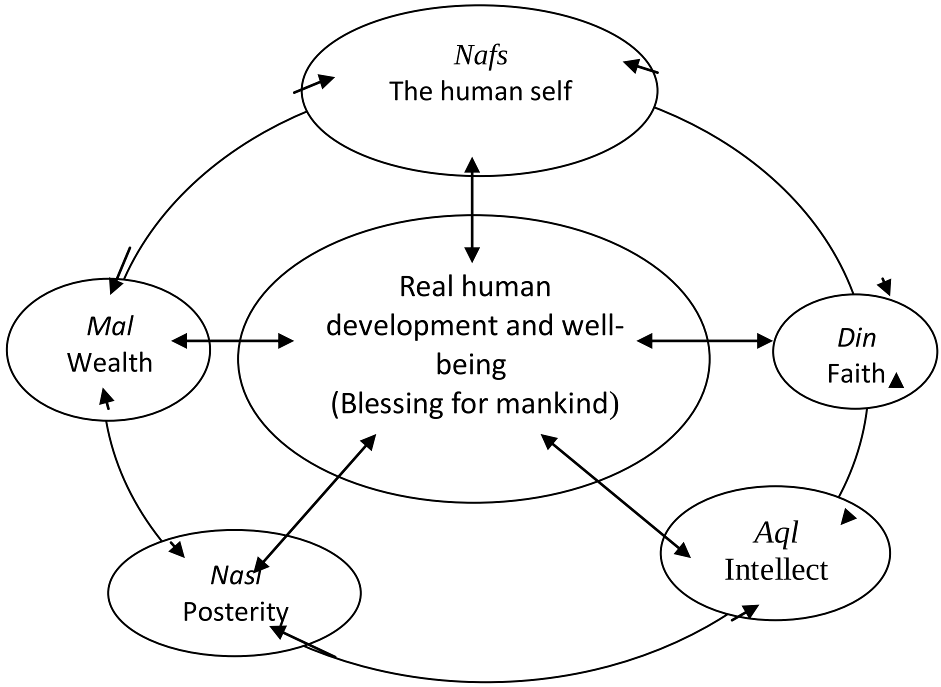
In line with this, basically several researchers have paid more attention to the topic of studying the relationship between economic development and CO_2 emissions. For example, research conducted by Sylvia and Sunitiyoso (20S22) which identified variables and parameters related to business and emissions in the petrochemical industry, in its findings showed that process optimization can reduce the amount of emissions and there is a significant reduction when using bio-based raw materials and applying advanced technology. Guven, Aydın, and Kayalica (2022) in their research tested the impact of energy consumption, economic structure, population and manufacturing output on CO_2 emissions in developing countries which in their findings showed primary energy supply to be the strongest factor in the production of CO_2 emissions. In line with the findings of Raghutla and Chittedi (2020) (Ghazouani, Boukhatem, and Yan 2020; Pao and Tsai 2011) , energy consumption increases emissions. However, the findings of these variables also increase economic output.

For the past studies have indicated that the long-term cointegration relationship between financial development, technology and energy consumption has a significant positive effect on economic output (Raghutla & Chittedi, 2020). The results of previous research conducted by Soytas et al., (2007) energy consumption has no effect on economic development. In contrast to the results of Akram's research, (2012) which states that CO_2 emission consumption has a negative significant relationship with economic growth. Soytas et al., (2007) has found trade variable results do not have a significant relationship with the use of CO2 emission.

Another research was conducted by Ashraf and Uctum (2021) which *tested greenfield foreign direct investment and mergers* & acquisitions in the environment in the form of sectoral CO_2 emissions, where *greenfield foreign direct investment* is polluting in developing countries while mergers and acquisitions reduce pollution. Referring to this research, the existing findings still do not show the harmony of the results so that there is a gap for conducting further studies and if you look at it it is still relatively rare to do research on fossil energy consumption, economic and financial development in relation to CO_2 emissions specifically in Indonesia with a development-style perspective. The concept of Maqhoshid Shariah version of Umar Chapra.

Umar Chapra (2008) The concept of maqashid Shariah which includes 5 pillars is not absolute in a single order it can be seen from the placement of priorities as al-Shatibi does not always follow the order of al-Ghazali as well as Fakhr al-Din al-Razi, so that the concept needs to be adjusted to the times. The position of man as caliph makes man not only the goal of the builder but as a means of development.

Figure 1. Al-Maqāsid Al--Sharī'ah Human Development and Well-Being to be realized by ensuring the enrichment of the following five ingredients for every individual. Adaption from Chapra (2008).



In the relationship of the five pillars of Al-Maqāsid Al-Sharī'ah (figure 1) with sustainable development, Chapra emphasizes the pillar of nasl posterity which explicitly states that a future civilization will not be realized without preparing a generation that is physically, mentally and spiritually strong so that to achieve this it needs poper upbringing, moral and intellectual development; marriage and familiy integrity; need fulfillment; freedom from fear; conflict and insecurity; and clean and healthy environment which directly supports the achievement of enricment of self, faith, intellect and wealth towards sustainable human development. Healthy and clean environment is a common thread between Chapra's Al-Maqāsid Al-Sharī'ah concept and the need to protect the environment including controlling the production of CO_2 emissions. Thus, through research, it is unique in bringing the concept of development in Islam and emphasizing that economic growth and sustainable development are not only followed by GDP. However, it must realize the goals of Al-Maqāsid Al-Sharī'ah.

Energy as a holistic commodity needs in the country to generate sustainable economic growth and employment (Ito 2017) , as well as long-term increased economic development due to industrial development. Research findings by Bamisile et al. (2022) show that there is a positive correlation between economic development calculated based on the GDP of the African continent and CO_2 emissions. It is predicted that some countries on the African continent will experience an increase in CO_2 emissions in 2022 compared to 2018.

The research aims to see how the effect of primary energy consumption from fossil energy sources, economic and financial development on the production of CO_2 emissions in Indonesia in its status as a developing country and as a member of the G20. The questions in this study consist of 3 namely, *first.* Does the consumption of fossil energy affect the production of CO_2 emissions in Indonesia? *Second,* does economic development affect the production of CO_2 emissions in Indonesia? *Third,* does financial development affect the production of CO_2 emissions in Indonesia? The question then becomes the basis for formulating a hypothesis as a temporary answer.

H1a: Fossil energy consumption has an effect on the production of CO_2 emissions in the short term in Indonesia.

H1b: Fossil energy consumption has a long-term effect on the production of CO_2 emissions in Indonesia.

H2a: Economic development has an effect on the production of CO2 emissions in the short term in Indonesia.

H2b: Economic development has a long-term effect on the production of CO_2 emissions in Indonesia.

H3a: International trade has a short-term effect on the production of CO_2 emissions in Indonesia.

H3b: International trade has a long-term effect on the production of CO_2 emissions in Indonesia.

METHODS

This study uses a quantitative approach with an *error correction model* (ECM) model specifically for *time series data types*. The selection of the model is based on argumentation, when the data is not stationary at the level stage. However, it is stationary at the same level of data differentiation and there is cointegration between the variables tested (Widarjono 2018) . Data taken from *the World Development Indicator database* for the period 1994-2021. Variable descriptions and data sources are shown in table 1. CO_2 as a representation of carbon dioxide (CO_2) emissions, economic development is indicated by the square of economic development by looking at GDP per capita with a base year using 2010 (GDP), fossil energy consumption is taken from the value fossil fuel energy consumption (FEC) and Trade.

Table 1. Variable descriptions and data sources

Variable	Variable Description	Source
CO2	Per capita CO2 emissions	World development indicators (WDI)
GDP	Per capita real GDP current US$	World Bank (WI)
FEC	Fossil Fuel Energy Concumption (% of total)	World development indicators (WDI)
TR	International Trade	World development indicators (WDI)

Source: Author

This study builds on a model adopted from (Koshta and Samad 2020; Ali et al. 2020) to investigate the existence of the EKC hypothesis. The EKC curve hypothesis is a hypothesis formulation developed and demonstrated by Grossman and Krueger in 1991 in equation 1 on the basis of the Kuznets curve (inverted U) coined by Simon Kuznets in 1995 (Shahbaz 2018) .

$CO_2it = \beta_0 + \beta_1 EDit + \beta_2 EDit + \varepsilon it$ ....(1) **General model**

CO_2it is expressed as per capita carbon dioxide emissions, EDit represents economic development, εit refers to *the error term* , t represents the year and i represents the country. In verifying the accuracy of the EKC hypothesis, then GDP, FEC, TR are presented as independent variables in equation 2.

VAR/VECM analysis using Granger Causality aims to see the relationship between one variable and changes in other variables. We adopt the equation model in the research of Eka, Maruto, and Basuki (2019) , in the following we present the equation for the CO2 emission variable.

$CO_2it = \beta_0 + \beta_1 CO2t + \beta_2 GDPt + \beta_3 FECt + \beta_4 FDt + \varepsilon t$........................(2)

Derived model

$CO_2it = \beta_0 + \beta_1 LDCO2t + \beta_2 LDGDPt + \beta_3 LDFECt + \beta_4 LDDt + \varepsilon t$.........(3)

$CO_2it = \beta_0 + \beta_1 L2DCO2t + \beta_2 L2DGDPt + \beta_3 L2DFECt + \beta_4 L2DDt + \varepsilon t$ ......(4)

$CO_2it = \beta_0 + \beta_1 L3DCO2t + \beta_2 L3DGDPt + \beta_3 L3DFECt + \beta_4 L3DDt + \varepsilon t$.......(5)

GDP per capita variable equation

$GDPit = \beta_0 + \beta_1 CO2t + \beta_2 GDPt + \beta_3 FECt + \beta_4 FDt + \varepsilon t$..............................(6)

$GDPit = \beta_0 + \beta_1 LDCO2t + \beta_2 LDGDPt + \beta_3 LDFECt + \beta_4 LDDt + \varepsilon t$...........(7)

$GDPit = \beta_0 + \beta_1 L2DCO2t + \beta_2 L2DGDPt + \beta_3 L2DFECt + \beta_4 L2DDt + \varepsilon t$....(8)

$GDPit = \beta_0 + \beta_1 L3DCO2t + \beta_2 L3DGDPt + \beta_3 L3DFECt + \beta_4 L3DDt + \varepsilon t$....(9)

Fossil energy consumption variable equation

$FECit = \beta_0 + \beta_1 CO2t + \beta_2 GDPt + \beta_3 FECt + \beta_4 FDt + \varepsilon t$........................(10)

$FECit = \beta_0 + \beta_1 LDCO2t + \beta_2 LDGDPt + \beta_3 LDFECt + \beta_4 LDDt + \varepsilon t$......(11)

$FECit = \beta_0 + \beta_1 L2DCO2t + \beta_2 L2DGDPt + \beta_3 L2DFECt + \beta_4 L2DDt + \varepsilon t$..(12)

$FECit = \beta_0 + \beta_1 L3DCO2t + \beta_2 L3DGDPt + \beta_3 L3DFECt + \beta_4 L3DDt + \varepsilon t$....(13)

National financial development variable equation

$FDCit = \beta_0 + \beta_1 CO2t + \beta_2 GDPt + \beta_3 FECt + \beta_4 FDt + \varepsilon t$……………........(14)

$FDCit = \beta_0 + \beta_1 LDCO2t + \beta_2 LDGDPt + \beta_3 LDFECt + \beta_4 LDFDt + \varepsilon t$....(15)

$FDCit = \beta_0 + \beta_1 L2DCO2t + \beta_2 L2DGDPt + \beta_3 L2DFECt + \beta_4 L2DFDt + \varepsilon t$...(16)

$FDCit = \beta_0 + \beta_1 L3DCO2t + \beta_2 L3DGDPt + \beta_3 L3DFECt + \beta_4 L3DFDt + \varepsilon t$....(17)

Information:

CO_2 = CO_2 emissions per capita

GDP = total per capita GDP in 2015 base year

FEC = percentage of total consumption of fossil energy from the total

FD = financial development taken from the percentage of international trade

LD, L2D, L3D = lag level first different quarter 1, 2 and 3

The analytical tool in the research that we use is the Stata 17 application which includes several stages of data analysis as follows:

- Unitroot test

At this stage we tested the stationary process using the concept of Dicky Fuller's Augment approach, abbreviated as ADF, which was introduced by Dickey and Fuller (1981) . ADF stationary schochastic approach in *time series* research with time series data and average expected value, constant and variance. The Augment Dicky Fuller (ADF) test aims to add lagged variables to the equation at a higher level of derivatives to improve data with autocorrelation, heteroscedasticity and multicollinearity. If the data is declared non-stationary, then a higher level test must be carried out, namely the first lever different and so on.

- Optimal Lag Length Determination Test

Determining the Optimal Lag length limit aims to determine the lag limit in the VAR/VECM model which influences each variable on other variables. Determination of the optimal lag gives a significant response in the correlation of each related variable.

- Cointegration Test

The next step is to carry out the cointegration test; we use the Johansen cointegration test approach. The purpose of the cointegration test is to see whether there is a long-term correlation between the dependent variable and the independent variable.

- Stability Test

The purpose of the stability test is to find out whether the variables using the first fifth are feasible to be tested in the VECM model.

- *Error Correlation Model (VECM)* Estimation Test

Error Correlation Model (VECM) is a model used to determine the correlation between dependent and independent variables in the long and short term. The determination of this estimate can be seen from the results of stationarity, if the stationary level results do not show good results then proceed to the first different level which is already stationary, then you can use this model.

RESULT AND DISCUSSION

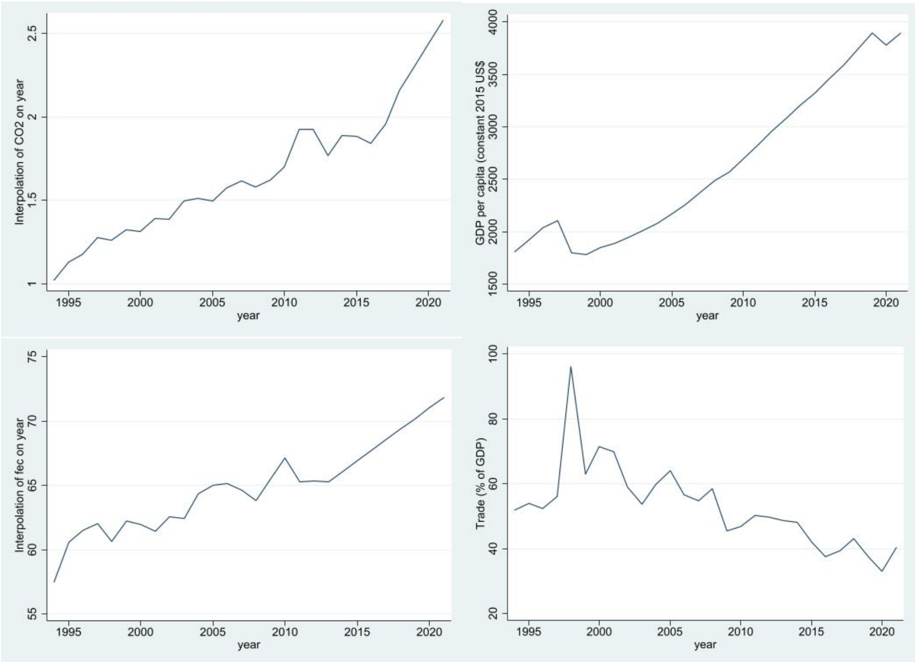
This study uses data on CO_2 emission per capita (CO_2), constant per capita GDP (GDP), consumption of fossil fuels (FEC), as well as import-export trade variables (Trade). The research data period is from 1994 – 2021, so the number of observations is 28 observations. The following is a description of the statistical variables in this study.

Table 2. Statistical description

Variable	N	mean	sd	min	max
CO_2	28	1,662	0.394	1,022	2,577
GDP	28	2,626	732.5	1,784	3,893
FEC	28	64.86	3,440	57.47	71.86
Trade	28	52.94	12.84	32.98	96.19

Source: Data are processed

Figure 2. line plots



Source: Eviews

Stationarity Test

The stationary test used is augmented Dickey Fuller or known as ADF with the condition that if the p-value is smaller than the significance level, then H0 is rejected.

Table 4 Level stationary test

Variable	Prob Value	Decision
CO_2	0.9929	Not stationary
GDP	0.9951	Not stationary
FEC	0.7520	Not stationary
Trade	0.1521	Not stationary

Source: Data are processed

Based on the results of the level test or I (0) in table 4, the probability value of all variables consisting of CO_2, GDP, FEc and Trade is greater than 0.05, so table 4 shows that the data is not stationary. So it is necessary to test the first level differencing stage I (1). The following will present the results of the data stationarity test in table 5.

Table 5 Stationary test at the first difference stage

Variable	Prob Value	Decision
CO_2	0.0002	stationary
GDP	0.0022	stationary
FEC	0.0000	stationary
Trade	0.0000	stationary

Source: Data are processed

It can be seen in table 5, the probability value is smaller than alpha (0.005). Thus all variables including CO_2, GDP, FEC and Trade experience stationarity after conducting the first difference test, then will proceed to the next stage of determining the optimal lag length limit.

Optimal Lag Length Determination

Determination of the optimal leg length based on the results that have been recommended. To determine the optimal lag length using a comparison of the Final Prediction Error (FPE), Aike Information Criterion (AIC), Hannan-Quin (HQIC) and Schwarz Criterion (SBIC) models which will be presented in the following table.

Table 6 Optimal Lag count comparison

Lag	LL	LR	df	p.s	FPE	AIC	HQIC	SBIC
0	-200,853				90258	22,762	22,789	22,959
1	-146,380	108,950	16	0.000	1332940	18,487	18,623	108,950
2	-140,825	11.110	16	0.803	5944330	19,647	19,893	
3	-96,207	89.236*	16	0.000	762,326*	16.4675*	16.8221*	

Source: Data are processed

Table 6 shows that the optimal lag is determined by the criteria of AIC, SBIC, LR and HQ recommending a lag of 3. So it can be concluded that the selection of the optimal lag in this study is lag 3.

Stability test

Table 7 Stability test

Eigenvalue	Modulus
	-
1,061,682	106168
0.5187299	0.51873

Source: Data are processed

Based on table 7, we can see that the modulus value is less than 1, so the VAR test is declared stable.

Cointegration Test

The next step is to do a cointegration test using Johansen. The cointegration test aims to find out the variables that have been tested for stationarity at a feasible level and meet the requirements in the integration stage. In this study using the trace statistics method, that is, if the value of the trace statistic is greater than the critical value with a significance level of 5%, thus the data in this study have indications of cointegration between variables. Here we present it in table 8.

Table 8 Johansen Cointegration Test

Max rank	Params	LL	Eigenvalue	Trace Statistics	Critical Value 5%
0	36	-146.33105		100.2478	47.21
1	43	-119.13497	0.95129	45.8556	29.68
2	48	-102.77756	0.83757	13.1408*	15.41
3	51	-96.77505	0.48673	1.1358	3.76
4	53	-96.20717	0.06115		

Source: Data are processed

It can be seen in table 8 that there is cointegration between variables because the trace statistical value of 100.2478 is greater than the critical value of 47.21. Cointegration between variables shows that CO_2 emissions, real GDP values, fossil energy consumption, and international trade have a long-term stability or balance relationship. Thus the variables involved adjust to each other to meet the level of stability in the long run or also called *long run equilibrium.*

Error Correction Model (ECM) Estimation Test

The last stage is the Error Correction Model estimation test or commonly abbreviated as ECM. The ECM test aims to determine the short and long term relationships between the dependent variable and the independent variable.

Table 9 Short Term Test

	Coef.	St. Err.	t-value	p-values	[95% Conf	interval]	Sig
CO2							
L	1951	1,272	1.53	.125	-.542	4,445	
CO2							
LD	1,289	1,055	1.22	.222	-.779	3,357	
L2D	-3.88	2,231	-1.74	082	-8,253	.493	*
L3D	-1,531	.782	-1.96	.05	-3,064	001	*
GDP							

LD	005	003	1.52	.128	-.001	.01	
L2D	0	001	-0.46	.648	-.001	001	
L3D	002	001	1.62	.105	0	005	
FEC							
LD	.226	.141	1.60	.109	-.05	.501	
L2D	-.022	.05	-0.43	.664	-.119	076	
L3D	-.059	.028	-2.12	.034	-.113	-.004	**
Trade							
LD	.02	014	1.51	.131	-.006	047	
L2D	006	005	1.29	.198	-.003	.016	
L3D	.015	.009	1.58	.115	-.004	.033	
Constant	-.45	.347	-1.30	.194	-1.13	.23	
GDP							
CO2							
L	59,081	2205535	0.03	.979	-4263.688	4381851	
LD	249,065	1829,509	0.14	.892	-3336,707	3834836	
L2D	184,668	3868,406	0.05	.962	-7397.267	7766604	
L3D	-1136189	1355,873	-0.84	.402	-3793651	1521274	
GDP							
LD	.778	5.203	0.15	.881	-9.42	10,975	
L2D	.441	.909	0.49	.628	-1.34	2,222	
L3D	-.203	2,516	-0.08	.936	-5,134	4,729	
FEC							
LD	-18,462	243,668	-0.08	.94	-496,043	459,119	
L2D	-13,513	85,987	-0.16	.875	-182,044	155,018	
L3D	-91,122	48.04	-1.90	058	-185,278	3,033	*
Trade							
LD	3,445	23.53	0.15	.884	-42,674	49,564	
L2D	9,793	8,433	1.16	.246	-6,736	26,321	
L3D	-.007	16,084	-0.00	1	-31,531	31,517	
Constant	89,572	601,406	0.15	.882	-1089,161	1268.306	
FEC							
CO2							
L	10,766	25.95	0.41	.678	-40,094	61,627	
LD	13,273	21,526	0.62	.537	-28,917	55,462	
L2D	-21,809	45,515	-0.48	.632	-111,016	67,399	
L3D	-.207	15,953	-0.01	.99	-31,475	31.06	

GDP							
LD	.02	061	0.33	.742	-.1	.14	
L2D	002	011	0.22	.828	-.019	.023	
L3D	008	.03	0.29	.774	-.05	.067	
FEC							
LD	1.116	2,867	0.39	.697	-4,503	6,735	
L2D	-.967	1012	-0.96	.339	-2.95	1016	
L3D	-.676	.565	-1.20	.232	-1,784	.432	
Trade							
LD	.117	.277	0.42	.671	-.425	.66	
L2D	.018	099	0.18	.859	-.177	.212	
L3D	041	.189	0.22	.827	-.329	.412	
Constant	-2,303	7,076	-0.33	.745	-16,172	11,565	
Trade							
CO2							
L	-169,114	144,981	-1.17	.243	-453,271	115,044	
LD	-74.44	120,263	-0.62	.536	-310,151	161,271	
L2D	256,861	254.29	1.01	.312	-241,538	755.26	
L3D	249,751	89,128	2.80	005	75,063	424,439	***
GDP							
LD	-.365	.342	-1.07	.286	-1,035	.306	
L2D	-.066	.06	-1.10	.27	-.183	051	
L3D	-.119	.165	-0.72	.472	-.443	.205	
FEC							
LD	-13,085	16018	-0.82	.414	-44,479	18,309	
L2D	3,927	5,652	0.69	.487	-7.152	15,005	
L3D	11011	3.158	3.49	0	4,822	17.2	***
Trade							
LD	-1,894	1,547	-1.22	.221	-4,925	1.138	
L2D	-1,707	.554	-3.08	002	-2,794	-.621	***
L3D	-1,007	1,057	-0.95	.341	-3,079	1,066	
Constant	31,141	39,533	0.79	.431	-46,343	108,625	
Mean dependent var	1,575		SD dependent var		0.211		
Number of obs	17,000		Akaike crit. (AIC)		.		

**** p<.01, ** p<.05, * p<.1*

Source: Data are processed

It can be seen in Table 9 above that the table shows a short-term relationship between the CO2 variable as an independent variable and

GDP per capita, consumption of fossil energy and international trade as the dependent variable. Based on the table above, the following is the interpretation of each related variable:

- In the short term, changes in CO_2 emissions during the past 2 quarters significantly affect current CO_2 emissions with a probability value of 0.082 <0.1. If CO_2 emissions in the past 2 quarters increased by 1 metric tons per capita, it would cause changes in current CO_2 emissions to decrease by 3.88 metric tons per capita.
- In the short term, changes in CO_2 emissions during the past 3 quarters significantly affect current CO_2 emissions with a probability value of 0.05 <0.10. If CO_2 emissions in the past 2 quarters increased by 1 metric tons per capita, it would cause changes in current CO_2 emissions to decrease by 1,531 metric tons per capita.
- In the short term, changes in fossil energy consumption during the past 3 quarters significantly affect current CO_2 emissions with a probability value of 0.034 <0.05. If the consumption of fossil energy in the past 3 quarters increased by 1 percent, it would cause the current change in CO_2 emissions to decrease by 0.059 metric tons per capita.
- In the short term, changes in fossil energy consumption during the past 3 quarters significantly affect GDP per capita at this time with a probability value of 0.058 <0.10. If the consumption of fossil energy in the past 3 quarters increased by 1 percent, it would cause the current per capita GDP change to decrease by 91,122 US$.

- In the short term, changes in CO_2 emissions during the past 3 quarters significantly affect international trade at this time with a probability value of 0.005 <0.01. If CO_2 emissions in the past 3 quarters increased by 1 metric ton per capita, it would cause a change in the current level of international trade to increase by 249,751 percent.
- In the short term, changes in fossil energy consumption during the past 3 quarters significantly affect international trade at this time with a probability value of 0 < 0.01. If the consumption of fossil energy in the past 3 quarters increased by 1 metric tons per capita, it would cause changes in the current level of international trade to increase by 11,011 percent.
- In the short term, changes in international trade during the past 2 quarters significantly affect international trade at this time with a probability value of 0.002 < 0.01. If international trade in the past 2 quarters increased by 1 percent, it would cause changes in the level of international trade at this time to decrease by 1,707 percent.

Table 10 Long Term Test

	coefficient	std. err.	Z	P>z	[95%conf.	interval]	sig
CO2							
GDP	0.0000476	.0001382	0.34	0.731	-.0002233	.00031	
FEC	-0.1218972	.0211066	-5.78	0.000	-.1632654	-.08052	***
Trade	0.0168271	.0139136	1.21	0.227	-.010443	.04409	
_cons	5.28386						

**** p<.01, ** p<.05, * p<.1*

Source: Data are processed

In table 10 above it can be seen the results of the long-term test estimation in this study. In the long term, changes in fossil energy consumption significantly affect CO_2 emissions with a probability value of 0.000 <0.01. If fossil energy consumption increases by 1 percent, it will cause changes in CO_2 emission levels to decrease by 0.1218972 metric tons per capita.

The following hypothesis testing confirms how these variables are related to the production of CO_2 emissions, especially in Indonesia.

H1a: Fossil energy consumption has an effect on the production of CO_2 emissions in the short term in Indonesia.

H1b: Fossil energy consumption has a long-term effect on the production of CO_2 emissions in Indonesia.

Through the estimation of the ECM model, fossil energy influences the production of CO2 emissions both in the short and long term, thus the hypothesis *is accepted*.

H2a: Economic development has an effect on the production of CO_2 emissions in the short term in Indonesia.

H2b: Economic development has a long-term effect on the production of CO_2 emissions in Indonesia.

The ECM model estimates that economic development has an effect on the production of CO_2 emissions only in the short term, so only hypothesis H2a *is accepted* and H2b is rejected because economic development has no effect.

H3a: International trade has a short-term effect on the production of CO_2 emissions in Indonesia.

H3b: International trade has a long-term effect on the *production of CO_2 emissions in Indonesia.*

International trade ECM model estimation only affects the production of CO_2 emissions in the short term so that only the hypothesis H2a *is accepted* and H2b is rejected due to international trade no effect.

This confirms that the consumption of fossil energy drives an increase in CO_2 emissions in Indonesia. This finding is in line with (Srinivasan 2015) (Brahmbhatt, Haddaoui, and Page 2017) indicating a one-way relationship between energy consumption and CO_2 emissions and a long-term relationship with economic growth in India. In addition, the existing findings are further strengthened by research (Alqaralleh 2020) in its findings describing the business cycle relationship that is formed, where economic growth increases environmental degradation, then after a certain level of growth occurs in the form of income, the business cycle shows that environmental improvements will eventually occur in line with economic growth. Therefore, the use of green-based energy can reduce climate change and maintain economic development. A slightly different theme from research (Guris 2013) (Balsalobre-Lorente et al. 2022; Alola, Doganalp, and Obekpa 2022; Adedoyin et al. 2020) showing a qualitative relationship between consumption of different energy sources and CO_2 emissions. The energy sources in question are nuclear, fossil and renewable energy.

Development is the goal of every country to create progress and development in that country, where development covers various aspects such as economy, health, environment and socio-political order. Chapra (2008) (Ahmed 2011) in his concept of *Maqashid shariah* places the five main pillars namely religion, mind, soul, lineage and wealth as the foundation of sustainable development because economic development and environmental health must go hand in hand. However, in reality, economic development and environmental health are often confronted so that in some cases, economic development is considered as a cause of environmental damage in a country. Economic development can be measured from several elements such as the value of GDP, the development of the business sector by looking at the value of international trade and the progress of the industrial world in a country. Industrial development itself is inseparable from the high and low use of energy to support the sector. One of them is energy that comes from fossil energy. Reducing dependence on fossil fuels can maintain the balance of nature and indirectly reduce environmental damage and create air with low carbon emissions. So that the earth and the wealth contained therein can still be felt by future generations. The essence of the long-term impact of high CO_2 emissions as a result of the massive use of fossil energy is environmental damage which results in the next generation not being able to enjoy a clean environment.

CONCLUSION

Referring to the estimation results using *the error correction model* (ECM), it shows that consumption of fossil energy in a country increases CO_2 emission products which can trigger global warming and climate change, although it cannot be denied that the use of energy is essential, including in supporting the industrial sector. In addition, economic development that is oriented towards the value of GDP also has a short-term effect on CO_2 emissions. The findings confirm the need for green economy-oriented alternative energy to be one of the solutions to overcome the current phenomenon. In line with the concept of development according to Chapra (2008) which emphasizes that development must be oriented towards achieving welfare which is measured not solely by the value of GDP. However, far from this, builders must rely on achieving the goals of *Maslahah*.

This research certainly does not escape from limitations beyond the researcher's control so that it can become a space for further discussion for future researchers. Some of them, the addition of new variables, a qualitative approach with more open new perspectives and other innovations can be in the form of using models. In addition, through this research it is able to provide policy implications to specific stakeholders in industry and related ministries such as the ministries of Energy and Mineral Resources and Cooperatives and SMEs.

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