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Coal-Based Economy Kuznet Kurve's Environmental Approach in East Kalimantan Province

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Abstract
The focus of this study is to investigate the relationship between economic growth and carbon emissions proxied by coal in East Kalimantan province for the 2009-2021 data period. The analysis model uses standard EKC with the Robust Least Square method. The results of the analysis explain that the standard EKC is not obtained significantly. The two variables do not have causality and long-term relationships (cointegration). East Kalimantan's economic growth tends to increase emissions or is not yet environmentally. Changes in the coal-based economic structure are carried out gradually and sensitivity and involvement of all parties are needed to reduce carbon emissions.

Abstrak
Fokus penelitian ini adalah menginvestigasi hubungan antara pertumbuhan ekonomi dengan emisi karbon yang diproksi dengan batu bara di provinsi Kaltim periode data 2009-2021. Model analisis menggunakan EKC standar dengan metode Robust Least Square. Hasil analisi menjelaskan bahwa EKC standar tidak diperoleh secara signifikan. Kedua variable tidak terjadi kausalitas dan hubungan jangka panjang (kointegrasi). Pertumbuhan ekonomi Kalimantan Timur cenderung meningkatkan emisi atau belum ramah lingkungan. Perubahan struktur ekonomi berbasis batu bara dilakukan secara bertahap dan diperlukan kepekaan serta keterlibatan semua pihak untuk mengurangi emisi karbon.

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1. Introduction

Structurally, the economy of East Kalimantan (East Kalimantan) consists of 5 main sectors dominated by the mining and industrial sectors and contributes around 60-70% with the main coal mining materials, other sectors that contribute significantly are agriculture, trade and construction. The economic growth of East Kalimantan ranges from 2.5-6.5%/year or an average of 2.2618%, with an average per capita income (constant price-2010) of Rp 126.7770 million/year, making East Kalimantan's economy the largest in the Kalimantan region. The contribution of the five main sectors is presented in Figure 1.

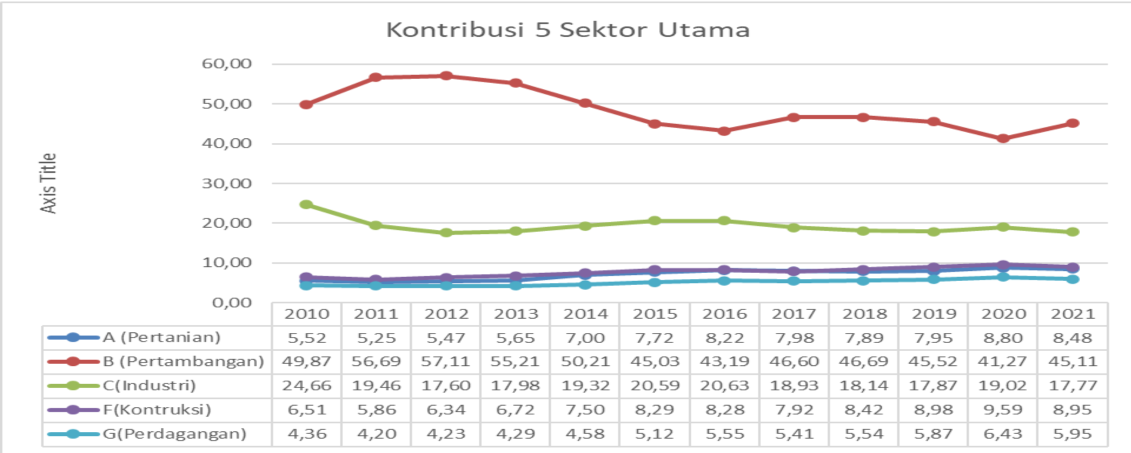

Figure 1. Main Sectors of East Kalimantan
Source: Data Processing Results, 2024.

East Kalimantan's economic growth tends to decline due to external factors (decline in export prices of main commodities) and reached its lowest point in 2020 due to the Covid-19 outbreak. In the next period, East Kalimantan's economy experienced a revival due to the global economic recovery and relatively high coal price increases. East Kalimantan's economic growth is presented in Figure 2.

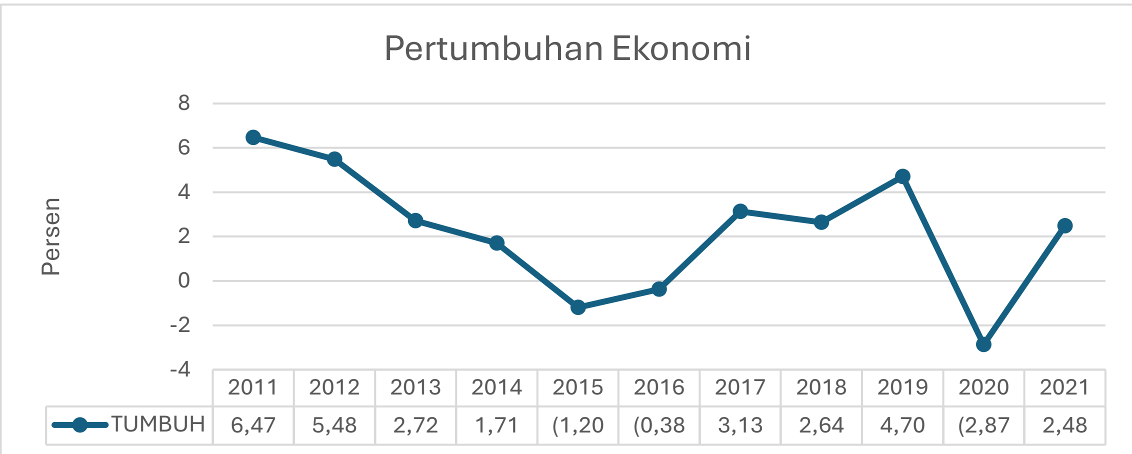

Figure 2. East Kalimantan's Economic Growth
Source: Data Processing Results, 2024.

East Kalimantan's coal production in 2009-2021 averaged 235.1950 million tons/year, although it was declining, but the average production growth reached 7.0148%, which was produced by two business groups/permits PKB2B and IUP, where the percentage of PKB2B production was greater than that of IUP. Regionally, several areas that produce large amounts of coal are Paser Regency, Kutai Kartanegara and East Kutai.

As an energy source, coal is very strategic to drive the regional and national economy because it is an input (electricity) in various activities, such as industry and transportation and trade so that electricity consumption continues to increase along with the increase in population and economic capacity. On the other hand, the increase in electricity consumption from coal has a serious environmental impact, namely increased carbon emissions that can cause negative effects in social and economic activities as well as ecology.

As an area with an economic base of non-renewable natural resources, East Kalimantan is one of several provinces that emit large carbon emissions. Therefore, the concentration of carbon emissions in this study is proxied from the base of economic activities that are the source of emissions. This means that the increase in coal exploitation can reflect and become a source of degradation, especially carbon emissions.

Research related to the impact of economic growth on the environment or emissions and based on the Environmental Kuznet Curve (EKC) has been widely carried out at the country level, either using series, cross or pooled data with various methods and results. Liu et al., (2007) in Shenzhen China with standard EKC; Tan et al., (2014) in Singapore with EKC plus variable control and Fodha et al., (2010) in Tunisia with cubic model EKC.

This research focuses on coal as an energy source that reflects the concentration of carbon emissions, as an impact of economic growth in the province of East Kalimantan which is based on natural resources. Therefore, this research has a scientific contribution related to emissions. First, it is carried out in the province with the largest economic capacity on the island of Kalimantan. Second, a very large coal production capacity at the national level. Third, as one of the provinces with large GHG emissions at the national level, finally, scientific information/overview of the quality of East Kalimantan's economic growth was obtained. This research consists of several parts, Literature review, Methods, Results and Analysis, and finally Conclusion.

2. Literature Review

The relationship between economic growth and environmental degradation, which is characterized by the concentration of carbon emissions, occurs all over the world, especially in developing countries. According to Tianisa et al., (2019) India as the country with the worst pollution level in the world because it uses large amounts of coal. Bhave and Shresta (2020) also explained that the increase in emissions is due to the increase in coal consumption. In addition to being more efficient due to less advanced technology, energy consumption is more using non-renewable materials (fossils), such as coal and oil.

The concept of EKC became popular in the early 1990s when it was introduced by Grossman and Krueger in the 1992 World Development Development Report (Shafik and Bndyopadhyay, 1992). The Environmental Kuznet Curve (EKC) is a name that describes an inverted U-curve and explains the relationship between pollution and economic development. The name is derived from the Kuznet inverted U-curve that explains the relationship between income inequality and economic development. Panayotou (1993) is also a researcher who coined the term Environmental Kuznet Kurve (EKC) or inverted U curve in the 1990s. This curve means that environmental degradation will increase along with economic growth to the maximum point, after which there will be a transition, where economic growth will begin to improve the quality of the environment.

Some studies that explain the relationship between economic growth and degradation or emissions such as: Li et al., (2011), this study was conducted in 30 provinces in China from 1985 to 2007 using a dynamic OLS model, explaining, a 1% increase in GDP will increase carbon emissions between 0.41% - 0.43%. A 1% increase in GDP per capita will increase 0.48%-0.50% of energy and will increase 0.41%-0.43% of carbon emissions . Kasman and Duman (2015), research data in the European Union with a panel from 1992-2010, explained that there is a relationship with the EKC pattern between income and the environment (carbon emissions) but it applies reciprocally to Asian countries. Apergis, E Payne (2010), This study was conducted in the Commonwealth of Independent States for the period 1992-2004 with a long-term EKC model explaining, in the long run energy and income have a positive and significant effect on carbon emissions.

Ssali et. Al., (2019), with research data in 6 sub-Saharan African countries data from 1980-2014 using the Cointegration and EKC panel model explained, in the long term, if economic growth increases by 1%, emissions will increase by 16%, while if energy use increases by 1%, carbon emissions (CO2) will increase by 49%. Isik et al., (2018), with research data in China using a *fully* *modified OLS* model, explained that GDP and energy consumption have a significant effect on carbon emissions in all provinces.

Salahuddin et al., (2017) research data in Kuwait with a data period of 1980–2013 using the VECM model, explained, that economic growth, electricity consumption, and FDI are related to CO2 emissions. Begum et al., (2015) with a model (DOLS) explained, that in Malaysia in 1980-1990 carbon emissions increased at a time when there was an increase in economic growth and EKC was invalid. In the long term, energy consumption and economic growth are positively related to carbon emissions.

Based on several studies that have been conducted in various countries with different models focusing on economic growth, it can be concluded that income is positively correlated with carbon emissions and generally occurs directly. Therefore, in this study, a standard EKC model with a direct relationship was used, to test the same phenomenon on a smaller scope (East Kalimantan province).

3. Method

This study uses a data series from 2009 to 2021 sourced from BPS East Kalimantan. The estimation model used is standard EKC (inverted U) or quadratic regression and uses the Robust Least Square method with indications of positive b1 and negative b2 coefficient values. In addition to the standard EKC model, Cubic EKC or EKC with several variable instruments with various methods has been widely used. In general, the relationship between economic growth and emissions that are proxied with the standard EKC model coal is formulated as follows:

PRODBTBRA = f (PDRBKAP, PDRBKAP ^{2}) or
PRODBTBRA= a + b1 PDRBCAP + b2 PDRBCAP ^{2} + e

To obtain unbiased estmation, several statistical tests were carried out, such as: stationary test, lag time length, cointegration and causality. The explanation of the variables used is in Table 1.

Table 1. Variable and Unit Names and Sources.

No.	Variable Name	Unit	Source
1	PRODBTBRA	Million tons	BPS Kaltim
2	PDRBKAP	Rp.Million	BPS Kaltim

Source: Data Processing Results, 2024.

4. Results and Discussion

4.1. Descriptive Statistical Value

The descriptive analysis of the data used including mean, maximum, minimum, standard deviation and normality test presented in Table 2 explains, that the data of the two variables are distributed normally so that it is suitable for estimation.

Table 2. Descriptive Analysis of Research Data

Descriptive/Variable Value	PDRBKAP	PRODBTBRA
Mean	126.7771	235.1950
Maximum	133.8687	294.2500
Minimum	116.9463	179.3700
Std. Dev.	4.727478	29.38403
Jarque-Bera	0.345856	0.008080
Probability	0.841198	0.995968
Sum	1521.325	2822.340
Sum Sq. Dev.	245.8396	9497.632
Observations	12	12

Source: Data Processing Results, 2024.

4.2. Statistical Test

4.2.1. Stationary Test

To obtain an unbiased estimate, the research data should have an unchanged/constant mean and standard deviation so that it is necessary to conduct a stationary test. Based on the results of the stationary test with ADF, the data used is stationary at level 1 (first defferent) as evidenced by an absolute value of ADF greater than the test critical value or probability of less than 5%. The results of the stationary test are presented in Table 3.

Table 3. Results of the ADF test of the PRODBTBRA and PDRBKAP variables

Variable	PRODBTBRA	PDRBKAP
Probability	0.0084	0.0004
Augmented Dickey-Fuller test statistic	-2.987387	-5.018587
Test critical values: 1% level	-2.886101	-2.937216
5% level	-1.995865	-2.006292
10% level	-1.599088	-1.598068

Source: Data Processing Results, 2024.

4.2.2. Lag Time Length Test

Furthermore, to determine the length of indifference or lag time, several tests were used and gave results, that the length of lag time is 1 with the smallest indication of AIC value is 14.09551. As presented in Table 4.

Table 4. The results of the test to determine the length of lag time

Was	LogL	LR	FPE	AIC	SC	HQ
0	-69.97204	ON*	6124.146	14.39441	14.45492	14.32802
1	-64.47756	7.692267	4711.853*	14.09551*	14.27706*	13.89635*
2	-61.66062	2.816942	6999.501	14.33212	14.63471	14.00019

Source: Data Processing Results, 2024.

4.2.3. Cointegration Test

To identify the existence of long-term relationships between variables, the Cointegration test (Trace and Eigenvalue) was used with the Johansen method. The test results are presented in Tables 5 and 6 which explain, that the Trace Statistic and Max-Eigen statistical values are smaller than the Critical Value of 5% so that it can be concluded that the two variables do not have a long-term relationship or there is no cointegration.

Tabel 5. Unrestricted Cointegration Rank Test (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.635492	10.11429	12.32090	0.1140
At most 1	0.002219	0.022212	4.129906	0.9030

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Tabel 6. Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized		Max-Own	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.635492	10.09208	11.22480	0.0786
At most 1	0.002219	0.022212	4.129906	0.9030

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

4.2.4. Causality Test

The causality test was carried out to identify a reciprocal relationship between the PRODBTBRA variable and the PDRBKAP, based on the test results explained that there was no causal relationship between the two variables because the probability value was more than 5%. The results of the causality test are presented in Table 7.

Table 7. Results of the causality test of the variables PRODBTBRA and PDRBKAP

Null Hypothesis:	Obs	F-Statistic	Prob.
PRODBTBRA does not Granger Cause PDRBKAP	11	2.23504	0.1733
PDRBKAP does not Granger Cause PRODBTBRA		0.29543	0.6016

Source: Data Processing Results, 2024.

4.3. Estimated Results

The results of estimating the relationship between coal production and economic growth with the Environmental Kuznet Curve (EKC) model approach were carried out using the Robust Least Square method. The estimated results are presented in Table 8.

Table 8. Estimation Results of the EKC Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	4.323039	5.281291	0.818557	0.4130
D(PDRBKAP,1)	5.360736	1.239245	4.325806	0.0000
D(PDRBKAP,1)^2	-0.340712	0.210588	-1.617903	0.1057
				Robust Statistics
R-squared	0.521740		Adjusted R-squared	0.402175
Rw-squared	0.782467		Adjust Rw-squared	0.782467
Akaike info criterion	15.08124		Black criterion	19.42141
Deviance	2677.398		Scale	14.79734
Rn-squared statistic	19.34193		Prob(Rn-squared stat.)	0.000063
				Non-robust Statistics
Mean dependent var	10.44364		S.D. dependent var	33.88269
S.E. of regression	29.79947		Sum squared resid	7104.066

Source: Data Processing Results, 2024.

Based on the results of the estimates in Table 9. The GDP variable was significant at the level of 5% while the quadratic GDP variable was not significant. This means that the criteria for the inverted U model are met or obtained from the standard EKC model (positive GDP coefficient and negative quadratic GDP) but are not significant. This condition explains that the increase in GDP at the beginning of the period increases the emissions that are proxied with coal production to the maximum level, then the subsequent increase in GDP will reduce emissions, but this condition occurs with a small probability or outside the tolerance limit of the EKC model does not occur significantly. In other words, increasing economic growth in East Kalimantan will increase carbon emissions sourced from coal or East Kalimantan's economic growth is not environmentally friendly. On the other hand, there is no causality between the two variables and long-term relationships.

Some studies that have similar results to this study so that EKC does not occur significantly such as: Begum et al., (2015), Isik et al., (2018). While the different ones are: Apergis, E Payne (2010), Kasman and Duman (2015); Xuemei et al., (2011) for ESD and ES pollutants and Liu et al., (2007). The diversity of results obtained can occur due to differences in the amount and type of data, models and methods, but the conclusions obtained have described the existing conditions of facts (data) and have contributed knowledge.

5. Conclusion

Based on the results of the analysis and discussion, several conclusions are prepared as follows:

1) The relationship between economic growth and carbon emissions with coal proxies is a positive sign, increasing economic growth will increase emissions.

2) The standard EKC model was obtained but not significant. The decrease in emissions due to increased growth after the maximum point occurs with a small probability outside the tolerance limit or the EKC model is not obtained.
3) There is no long-term relationship between economic growth and emissions because the cointegration test is not significant.

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