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GREENHOUSE GAS CAUSALITY WITH ECONOMIC GROWTH GROUP OF TWENTY

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Abstract: This study analyzes the causality of carbon dioxide, economic growth, energy consumption, and trade openness in eight G20 countries. The purpose of this research is to analyze how the causality of carbon dioxide, economic growth, energy consumption, and trade openness in the eight G20 countries. The data used in this research is panel data using the Vector Auto Regression (VAR) method using Eviews 10. The results show that (i) there is a one-way causal relationship, namely carbon dioxide and economic growth, (ii) there is a two-way causality between energy consumption and carbon dioxide, and (iii) there is no causality between trade openness and carbon dioxide. Research also shows results that the EKC theory applies in eight G20 countries (Saudi Arabia, India, India, Japan, South Korea, Russia, China, and Turkey).

Keywords: Carbon Dioxide, Economic Growth, Energy Consumption, Trade Openness

I. INTRODUCTION

Economic growth is often not in harmony with environmental sustainability. Just as the world economy is facing two significant problems; environmental impact and urgency of money. The Group of Twenty (G20) is heavily dependent on non-renewable resources. Various concrete results have been agreed upon as global issues. One of them is the green economy development transition. Group of Twenty (G20) countries agreed to accelerate the energy transition, including ensuring the achievement of sustainable global development targets by 2030. Accumulation of hazards due to global warming and threats to the depleting availability of human resources to find solutions for sustainable energy human life in the future future through the concept of Sustainable Development. Making sustainable development through a green economy a balance of growth in the economic, social and environmental aspects of the development process. In addition, the efficient use of natural resources can create a potential spike in green growth by accelerating the energy transition process. In this study, the impact of efficient use of natural resources from a green economy perspective is measured for the cases of eight Asian countries that are members of the Group of Twenty (G20), namely Saudi Arabia, India, Indonesia, Japan, South Korea, Russia, Tiongkok, and Türkiye. The following reasons were the main motivators for choosing these eight countries as case studies. First, countries in the Asian region have a very high dependence on fossil fuels, and the topic of green economic recovery is urgently needed for them. Planning in the zero-carbon economy for these countries requires in-depth study because of the need for more effective structures and mechanisms in the green economy. Second, the use of natural resources in the Asian region is quite high.

II. LITERATURE REVIEW

The Kuznets Environment Curve (EKC) is one of the hypotheses used to explain and identify the relationship between economic growth and the environment (Grossman & Kruger (1992) in Susanti, 2018)). Simon Kuznets was the pioneer of the Environmental Kuznet Curve (EKC) hypothesis which describes an inverted U-shaped curve explaining the long-run relationship between economic growth and environmental quality, where environmental damage for future generations is caused by development or economic growth itself. In other words, the Environmental Kuznet Curve (EKC) explains that countries with low-income levels will tend to focus more on increasing income so they don't pay attention to the impact of environmental quality on future generations. The success of economic development is synonymous with increased economic growth. This increase in economic growth will also trigger an increase in environmental degradation up to a certain inflection point. So, after passing the turning point there will be an increase in economic growth which will be followed by a decrease in environmental degradation. Economic activities carried out continuously will result in a decrease in environmental quality.

The classic theory of economic growth was reported by Adam Smith in the 18th century, Adam Smith argued that economic growth was due to technological progress and population development. According to Boediono (2001), economic growth is a process of increasing output per capita in the long run. Economic growth here includes three aspects, including: 1. Economic growth is a process (economic aspect), an economy develops or changes from time to time. 2. Economic growth is related to an increase in per capita output, in this case there are two important aspects, namely: total output and population. Per capita output is the total output divided by the population. 3. Economic growth is related to the perspective of time, an economy is said to grow if in a long enough period of time (five years) there is an increase in output per capita.

III. METHODOLOGY

This research was conducted in eight G-20 countries which are included in the Asian region, including Saudi Arabia, India, Indonesia, Japan, South Korea, Russia, Tiongkok and Turkey from 2000 to 2021. The type of research used is quantitative research. Quantitative research is analysis in the form of numbers so that it can be measured and calculated using mathematical or statistical tools. In addition to using quantitative methods, this study also uses the Vector Auto Regression (VAR) method.

Data analysis method

3.1 Data Stationarity Test

In this study, the stationarity test of the data used Augmented Dickey-Fuller (ADF) at the same degree (level or different) to obtain stationary data. Data is said to be stationary if it fulfills three conditions, namely the mean and variance are constant over time, and the covariance between data only depends on (lag) (Widarjono, 2007). Gujarati (2003) describes the stationarity test equation with ADF analysis in the following equation:

$$\Delta F_t = \alpha_0 + \gamma F_{t-1} + \beta \sum \sum_{t=1}^{p} \Delta F_{t-i+1} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.1)$$

Where:

ΔF_t = Form of first difference/ second difference

α_0 = Intersep

γ = The variable being tested for stationarity

p = Length of lag used

ε_t = *error term*

3.2 Optimal Lag Determination

To determine the optimal lag in the stationarity test, the following criteria are used:

$$Akaike\ Information\ Criterion\ (AIC): -2\left(\frac{1}{T}\right) + 2\ (\kappa + T) \ldots\ldots\ldots \quad (3.2)$$

$$Schwarz\ Information\ Criterion\ (SIC): -2\left(\frac{1}{T}\right) + \kappa\frac{\log(T)}{T} \ldots\ldots\ldots \quad (3.3)$$

$$Hannan - Quinn\ (HQ): -2\left(\frac{1}{T}\right) + 2\kappa\log(\frac{\log(T)}{T}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.4)$$

Where:

1 = Number of observations

κ = Estimated parameters

Determination of the number of lags is determined by the information criteria recommended by Final Prediction Error (FPE), Aike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn (HQ). Where the results in the lag length test (Lag Length) are determined by the highest number of stars recommended from each of the lag length test criteria.

3.3 Cointegration Test

The cointegration test used in this study is the Johansen cointegration. The Johansen test can be seen with an autoregressive model with the order p as follows:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + B\pi_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.5)$$

Where:

y_t = k-vector on non-stationary variables

π_t = d-vector on deterministic variables

ε_t = Innovation vector

Then the equation can be rewritten as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Pi_t \Delta y_{t-1} + B\pi_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.6)$$

Where:

$$\Pi = \sum_{i=1}^{p} A_i - \mathrm{I}, \Pi_i = -\sum_{j=i+1}^{p} A_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.7)$$

3.4 Stability Test of the Vector Auto Regression (VAR) Model.

The stability of the Vector Auto Regression (VAR) model can be seen in the modulus value of each variable. The Vector Auto Regression (VAR) model is said to be stable if the modulus value is at radius < 1, and unstable if the modulus value is > 1. If the largest Modulus value is less than one and is at the optimal point, then the composition is in an optimal position and the VAR is stable.

3.5 Granger Causality Test

Granger causality test to determine the causal relationship between variables in the study. The Granger Causality test is intended to see the effect of each variable on other variables one by one.

3.6 Analysis of Impulse Response Function (IRF)

The Impulse Response Function (IRF) test describes the rate of shock of a variable against other variables in a certain period. The Impulse Response Function (IRF) function is able to see the effect of the shock of a variable on other variables until the effect disappears or returns to the balance point.

3.7 Decomposition of Test Variances

The variance decomposition will provide information about the proportion of the movement of the shock effect on a variable to the shock of other variables in the current and future periods. This analysis aims to describe the relative importance of each variable in the VAR system due to shock.

IV. RESULT AND DISCUSSION

4.1 Stationarity Test

Table 4.1 ADF Test Results Using the Intercept at the First Difference Level

Variabel	ADF t-Statistik	Prob	Keterangan
Karbon Dioksida	-13,38195	0,0000	Stasioner
GDP	-14,65439	0,0000	Stasioner
Konsumsi Energi	-13,57199	0,0000	Stasioner
Keterbukaan Perdagangan	-13,39452	0,0000	Stasioner

Source: Eviews 10 (processed)

From the data test above, all variables have met the stationarity requirements of the ADF test data where the ADF t-statistic value is smaller than the Mc Kinnon Value of 5 percent at the first difference level. Because all data variables are stationary at the first difference level, the next step in VAR estimation can be carried out, namely determining the optimal lag length.

4.2 Optimal Lag Determination

Table 4.2 Lag Length Testing Lag Length Testing

Panjang *Lag*	LogL	LR	FPE	AIC	SC	HQ
0	-7869,753	NA	4.00e+34	91.02605	91.09895	91.05562
1	-7136,761	**1423.614***	**1.01e+31***	**82.73713***	**83.10167***	**82.88502***
2	-7127,992	16.62586	1.09e+31	82.82072	83.47690	83.08693
3	-7124,195	7.022959	1.26e+31	82.96180	83.90961	83.34632

Source: Eviews 10 (processed)

From table 4.2 above it can be seen that the optimal lag length lies in lag 1. Selection of lag 1 as the optimal lag because based on the results of eviews the highest number of stars is in lag 1. Then because the optimal lag length has been found, a further test can be carried out, namely the cointegration test.

4.3 Cointegration Test

Table 4.3 Cointegration Test Results (Johansen's Cointegration Test)

Hypothesized No. of $CE_{(s)}$	Eigenvalue	Trace Statistic	0,05 Critical Value	Prob
None	0.121395	38.42966	40.17493	0.0741
At most 1	0.055176	15.91068	24.27596	0.3861
At most 2	0.031717	6.034947	12.32090	0.4317
At most 3	0.002450	0.426778	4.129906	0.5770

Source: Eviews 10 (processed)

From table 4.3 above, it can be explained that in the 5 percent test level (0.05), there are four rank variables not related to cointegration. This can be proven from the trace statistical value which is smaller than the Critical Value of 0.05, which means that H_0 is accepted and H_1 is rejected or in other words, the variables used do not have a long-term relationship (cointegration) with one another. Therefore, estimation of VECM in this study cannot be used. Then use the Vector Auto Regression (VAR) stability test.

4.4 Vector Auto Regression (VAR) Model Stability Test

Table 4.4 VAR Estimation Stability Test Results

Root	Modulus
0.945604 - 0.037327i	0.946340
0.945604 + 0.037327i	0.946340
0.886311 - 0.024423i	0.886648
0.886311 + 0.024423i	0.886648

Source: Eviews 10 (processed)

From table 4.4 above, it can be explained that the model used is stable. This can be seen from the modulus range with an average value of less than one. Thus, the results of IRF (Impluse Response Function) and VDC (Variance Decomposition) analysis are valid and can be further tested, namely the Granger causality test.

4.5 Granger Causality Test

Table 4.5 Granger Causality Test Results

Null Hypothesis	Obs	*Lag 3* F-Statistik	Prob
GDP does not Granger Cause CO2	173	9.59337	7.E-06
CO2 does not Granger Cause GDP		3.74539	**0.0123**
EC does not Granger Cause CO2	173	6.41804	**0.0004**
CO2 does not Granger Cause EC		5.90459	**0.0007**
TO does not Granger Cause CO2	173	0.07391	0.9739
CO2 does not Granger Cause TO		0.46274	0.7087

Source: Eviews 10 (processed)

From the table above it can be seen that the GDP variable does not statistically significantly affect carbon dioxide as evidenced by the Prob value greater than 0.05, namely 7.E-06. Meanwhile, the carbon dioxide variable statistically significantly affects GDP as evidenced by the Prob value which is less than 0.05, namely 0.0123. So, it can be concluded that there is one-way causality between GDP and carbon dioxide, that is, only carbon dioxide affects GDP.

The energy consumption variable statistically significantly affects carbon dioxide with a Prob value of less than 0.05, namely 0.0004. Meanwhile, the carbon dioxide variable statistically significantly affects energy consumption as evidenced by the Prob value which is less than 0.05, namely 0.0007. So, it was concluded that there is a two-way causality between energy consumption and carbon dioxide.

The trade openness variable does not statistically significantly affect carbon dioxide and vice versa, the carbon dioxide variable does not statistically significantly affect trade openness as evidenced by the Prob value which is greater than 0.05, namely 0.9739 and 0.7087 (the results of both accept the null hypothesis). So, it can be concluded that there is no causality whatsoever for the two variables of trade openness and carbon dioxide.

4.6 Impulse Response Function (IRF) Analysis

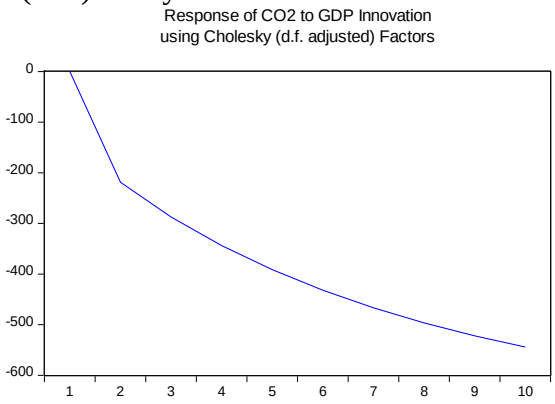

Figure 4.1 Results of Carbon Dioxide IRF Analysis on GDP Shock

From Figure 4.1 above, it can be explained that the response of carbon dioxide to the GDP variable shock is from the first period to the tenth period experiencing a negative trend. This is shown from the IRF line which tends to be below the horizontal line until the tenth period.

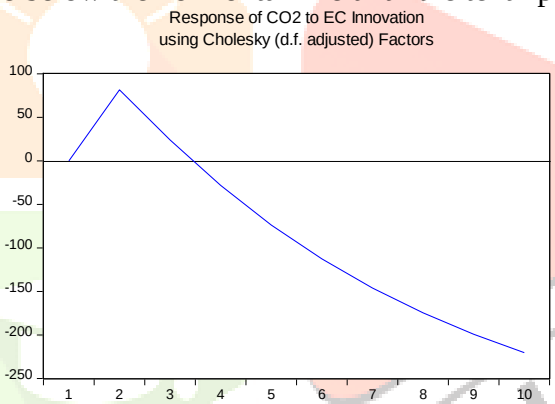

Figure 4.2 Results of Carbon Dioxide IRF Analysis on Energy Consumption Shock

From Figure 4.2 above, it can be explained that the response of carbon dioxide to energy consumption shocks in the first period to the second period has increased with a positive trend because the IRF line is above the horizontal line. The energy consumption response to energy consumption shocks decreased with a negative trend in the second to tenth period.

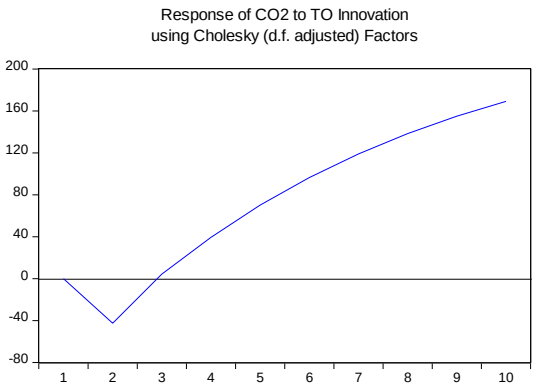

Figure 4.3 Results of Carbon Dioxide IRF Analysis on Trade Openness Shock

From Figure 4.3 above, it can be explained that the response of carbon dioxide to the shock of trade openness from the first period to the second period has decreased and shows a negative trend. But in the second to the tenth period, the response of carbon dioxide to the shock of trade openness has increased showing a positive trend. This is shown from the IRF line which tends to rise above the horizontal line until the tenth period.

4.7 Variance Decomposition Test

Table 4.6 Variance Decomposition Analysis Results

Variance Decomposition of Karbon Dioksida:					
Period	S.E.	CO2	GDP	EC	TO
1	762.2617	100.0000	0.000000	0.000000	0.000000
2	983.3455	98.37139	1.313067	0.206839	0.108706
3	1116.407	94.67334	4.355535	0.621840	0.349283
4	1214.017	89.27755	8.883816	1.149650	0.688988
5	1296.656	82.80326	14.42758	1.689320	1.079833
6	1373.298	75.92366	20.44200	2.161096	1.473243
7	1447.601	69.19960	26.44931	2.519583	1.831506
8	1520.621	63.00283	32.11301	2.752008	2.132151
9	1592.221	57.52112	37.24412	2.868284	2.366476
10	1661.805	52.80500	41.76946	2.890059	2.535478

Source: Eviews 10 (processed)

From table 4.6 above, it can be explained that in the first period, carbon dioxide was greatly affected by the carbon dioxide shock itself by 100 percent. Meanwhile, in the first period, the variables GDP, energy consumption, and trade openness did not have an effect on carbon dioxide. So on, starting from the first period to the tenth period, the proportion of carbon dioxide shock itself is still large. However, the carbon dioxide shock provides a gradually decreasing proportion of the effect on the carbon dioxide itself from the first to the tenth period.

In the second period, the GDP variable contributed 1.313 percent and so on, it increased until the tenth period with a shock of 41.76 percent. The results of the Variance Decomposition analysis in the fourth period, the energy consumption variable contributed 1.14 percent to carbon dioxide. The contribution of energy consumption to carbon dioxide increased in the fifth to tenth period with a shock of 2.89 percent. The results of the Variance Decomposition analysis in the fifth period of the trade openness variable contributed 1.07 percent to carbon dioxide and increased until the tenth period with a shock of 2.53 percent.

V. CONCLUSION

Based on the results of the analysis and discussion, the following conclusions can be obtained:

The probability value on the Granger causality test results shows that there is one-way causality, namely carbon dioxide affects economic growth with a probability value of 0.0123 which is smaller than the significance level of (a) 0.05. The probability value on the Granger causality test results shows that there is a two-way causality, namely energy consumption affects carbon dioxide with a probability value of 0.0004. And the carbon dioxide variable statistically significantly affects energy consumption as evidenced by the Prob value which is less than 0.05, namely 0.0007. So, it was concluded that there is a two-way causality between energy consumption and carbon dioxide. The probability value on the Granger causality test results shows that there is no causality. Trade openness does not affect carbon dioxide with a probability value of more than 0.05, namely 0.9739. And the carbon dioxide variable statistically does not significantly affect trade openness as evidenced by the Prob value greater than 0.05, namely 0.7087. So, it can be concluded that there is no one-way or two-way causality between trade openness and carbon dioxide

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