Original Research Article

Analyzing Factors that Influence Energy Intensity in G20 Countries

Comment [YA1]: This title is suiteable, attactive, quite clear and very interesting. If I may suggest an alternative title: ***Analysis of factors influencing energy intensity in G20 countries***

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ABSTRACT

Comment [YA2]: This abstract is good, clear, comprehensive and correct.

Aims: The purpose of this study is to analyze the impact of Gross Domestic Product (GDP), Industry Value Added (IVA), Urban Population (UP), Trade, and Foreign Direct Investment (FDI) on Energy Intensity in G20 countries.
Study design: This research used a quantitative descriptive method using panel data analysis.
Place and Duration of Study: The scope of this research extends to G20 member countries such as Argentina, Brazil, Canada, China, Germany, European Union, France, United Kingdom, Indonesia, India, Italy, Japan, Korea, Mexico, Rusia, Saudi Arabia, Turki, United States, and South Africa, between 1990-2021.
Methodology: This research uses descriptive method combined with panel data analysis, analyze determine of GDP, IVA, UP, Trade, and FDI on Energy Intensity in G20 countries.Furthermore, the data uses is secondary data that has a regression model on panel data from 1990-2021.
Results: The result of this research show that IVA has a positive relationship and has a significant effect on increasing energy intensity in G20 countries. GDP, Trade and UPvariables have a negative relationship and have a significant effect on Energy Intensity in G20 countries. Meanwhile, the FDI variable has no significant effect on Energy Intensity in G20 countries.
Conclusion: Based on research result, Energy Intensity in G20 countries is influenced by various factors, The IVA factor has a positive and significant relationship with energy intensity, can be utilized to increase productivity and economic growth, but need to be balanced with effort to increase energy efficiency.
While the GDP, Trade and Urban Population factors have a negative and significant relationship to energy intensity. However, FDI does not have a significant effect on energy intensity in G20 countries. The government should consider policies to reduce dependence on intensive energy, especially in sector that have a negative relation with energy intensity such as GDP, trade and urban population.

Keywords: Energy Intensity, GDP, Industry Value Added, Urban Population, Trade, Foreign Direct Investment, Panel data analyst

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1. INTRODUCTION

G20 countries account for approximately 75 percent of global energy demand, 80% of global greenhouse gas emissions and 60% of the world's population. Therefore, G20 countries hold a big responsibility and strategic role in encouraging the use of clean energy(OECD)

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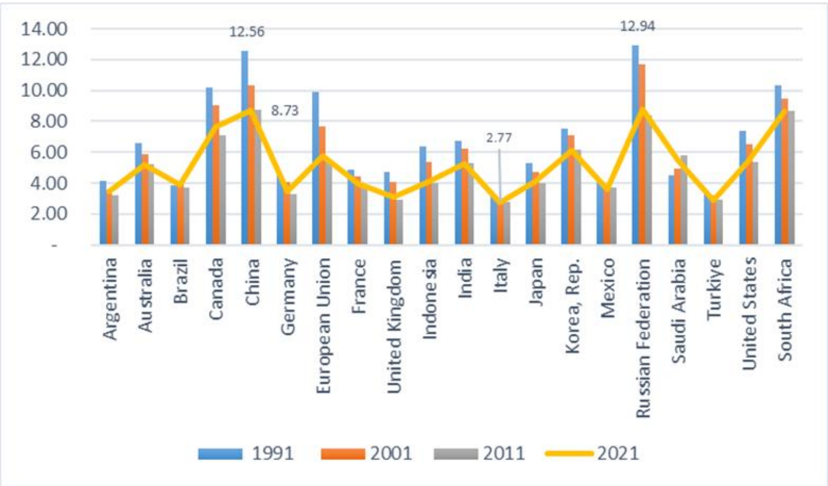
Stimulate economic growth and development by using natural resources sustainably and efficiently, using clean resources, minimizing pollution and environmental impact, and fighting natural disasters. Based on energy intensity data from 2000 to 2019, energy intensity conditions in G20 countries showed a decreasing trend during 2000-2019.



Source: World Bank, 2023

Fig.1. Energy Intensity from G20 Countries

The relationship between energy and sustainable growth is closely linked to energy efficiency. The more effectively a country manages its energy, the more efficient it is. Energy efficiency is also an indicator of the Sustainable Development Goals (SDG) (Azaliah and Hartono). Improving energy efficiency is an important task in development. A relevant solution that can be implemented due to limited resources and increasing needs is energy use efficiency(Kurmanov et al.).

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The trend of urbanization and increasing living standards will lead to very high energy demand in cities. By 2050, 55% of the world's population is expected to live in urban areas (OECD). Cities account for nearly two-thirds of global energy demand, generate up to 50% of solid waste and are responsible for 70% of greenhouse gas emissions. Globally, at the urban level, material consumption is expected to increase from 40 billion tons in 2010 to 90 billion tons in 2050, mainly driven by demand for construction materials in developing countries. development. Thus, cities will play a key role in the transition from a linear economy to a circular economy.

Environmental problems that were previously ignored due to factors such as increasing economic growth, industrialization and trade, are now having an impact that can threaten the world's environmental conditions. Trade policies can be designed to adapt to changes in environmentally friendly energy policies (Aydin and Turan).

The study(Gallastegui et al.)discusses energy economics and climate policy as well as the complexities of regulation the energy sector. The development and progress of a country depends on energy, every country needs energy as development capital. Investment and energy efficiency are needed if a country wants to produce a sustainable energy supply.

Studies on the determinants of energy intensity, both in Indonesia and other countries, have been conducted using a variety of methods, but no one has yet measured the determinants using panel data in G20 countries. G20 countries are currently focusing on the clean energy transition and playing a strategic role. Therefore, the influence of energy intensity on economic growth, industrial value added, population, trade and investment must be studied in G20 countries. This study contributes to measuring the variables that influence energy intensity in G20 countries.

Table 1. Variables, symbols, units, and data sources

Variables	Symbols	Units	Data Sources
Energy Intensity	EI	Mega Joules Per Kapita	World Bank Data
Gross Domestic Product	GDP	Trillion (Constant US$)	World Bank Data

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Industry Value Added	IVA	Persentase (%)	World Bank Data
Urban Population	UP	Persentase (%)	World Bank Data
Trade	TRD	Persentase (%)	World Bank Data
Foreign Direct Investment	FDI	Persentase (%)	World Bank Data

2. METHODOLOGY

This research uses quantitative method for analysis using panel data regression, to see how Gross Domestic Product (GDP), industrial added value, urban population, trade and foreign direct investment influence energy intensity in G20 countries. The scope of this research is G20 member countries such as Argentina, Brazil, Canada, China, Germany, European Union, France, United Kingdom, Indonesia, India, Italy, Japan, Korea, Mexico, Russia, Saudi Arabia, Turkey, United States, and South Africa, using the 2000-2019 period. The data used is combined data between cross-sectional and time series data is also known as panel data. This research uses secondary data sourced from World Bank data.

This study uses the following research model:

$$EI_{it} = \beta_0 + \beta_1 LogGDP + \beta_2 IVA_{it} + \beta_3 UP_{it} + \beta_4 TRD_{it} + \beta_5 FDI_{it} + \varepsilon_{it}$$

Explanation

β_0 = Constant
β_1 = Coefficients
EI_{it} = Energy Intensity
GDP_{it} = Gross Domestic Product
IVA_{it} = Industry Value Added
UP_{it} = Urban Population
TRD_{it} = Trade
FDI_{it} = Foreign Direct Investment
E = Residual (error term)
i = Member of G20 Countries
t = Time
Log = Logarithmic transformation

When estimating panel data, there are three approaches to selecting the best model, specifically the common effects model, fixed effects model, and random effects model. To determine the best model of the three, Chow test, hausman test and lagrange multiplier test was executed.

3. RESULTS AND DISCUSSION

3.1. RESULT

a) Chow Test

The Chow test in panel data is a statistical method used to test for significant differences between linear regression models and panel data in two different groups. In the Chow test, a comparison is made between the Common Effect Model and the Fixed Effect Model by looking at the probability (p-value). Following are the results of the chow test.

Table 2. Chow Test

Effect Test	Statistic	d.f.	Prob
Cross Section F	400.508238	(19,615)	0.0000

Based on the results of the Chow test, the p-value between the Common Effect Model and the Fixed Effect Model at the 5% real level (0.05) is 0.0000. The p-value results are smaller than the 5% real level (0.05), so it can be concluded that the Fixed Effect Model is more appropriate to use than the Common Effect Model from data in G-20 countries based on the Chow test.

b) Hausman Test

Based on the results of the Hausman test, the p-value between the Random Effect Model and the Fixed Effect Model at the 5% real level (0.05) is 0.0091. The p-value results are smaller than the 5%

real level (0.05), so it can be concluded that the Fixed Effect Model is more appropriate to use to analyze research models than the Random Effect Model from data in G-20 countries based on the Hausman test.

Table 3. Hausman Test

Effect Test	Statistic	d.f.	Prob
Cross section random	15.303654	5	0.0091

c) Lagrange Multiplier Test

Based on the results of the Lagrange multiplier test, the Breusch-Pagan probability between the Common Effect Model and the Randon Effect Model at the 5% real level (0.05) is 0.0000. The results of the p-value are smaller than the 5% real level (0.05), it can be concluded that the Random Effect Model is more appropriate to use to analyze research models than the Common Effect Model from data in G-20 countries based on the Lagrange multiplier test.

Table 4. Langrange Multiplier Test

Effect Test	Cross-section	Time	Both
Breusch-Pagan	6881.424 (0.0000)	4.653474 (0.0310)	6886.078 (0.0000)

Based on the test results, it was found that the Fixed Effect Model was the best model used in this research and had passed classical assumption testing. The estimation results are as follows:

Table 5. Panel data estimation results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Log_PDB	-1.971.111	0.102230	-1.928.118	0.0000
IVA	0.078264	0.008618	9.081.384	0.0000
TRD	-0.006117	0.002650	-2.308.317	0.0213
UPOP	-0.274241	0.055034	-4.983.124	0.0000
FDI	-0.001632	0.016081	-0.101508	0.9192
C	60.13155	2.983686	20.15344	0.0000
R-squared	0.933231	Mean dependent var		5.557597
Adjusted R-squared	0.930625	S.D. dependent var		2.383.479
S.E. of regression	0.627787	Akaike info criterion		1.945.049
F-statistic	3.581.593	Durbin-Watson stat		0.192076
Prob(F-statistic)	0.000000			

Based on the estimation result in Tabel, the regression equation can be written as follows:

$$\boldsymbol{EI_{it} = 60.13 - 1.971(LogGDP) + 0.078(IVA_{it}) - 0.274\,(UP_{it}) - 0.06(TRD_{it}) - 0.001\,(FDI_{it}) + \varepsilon_{it}}$$

3.2. DISCUSSION

Based on the regression results, it was found that Gross Domestic Product (GDP), urban population and trade in G20 member countries have a negative and significant influence on energy intensity. Meanwhile, Industrial Value Added has a significant positive impact on energy intensity. In this case, if there is an increase in GDP of 1%, it will cause a decrease in energy intensity in G20 countries of – 1,971 with ceteris paribus assumptions.

Based on research (Fitriyanto and Iskandar)stating that GDP has a negative relationship with energy intensity according to the Kuznets curve hypothesis, there is a non-linear relation (quadratic) between energy intensity and GDP per capita.

The regression results for the urban population variable give significant negative results, if there is an increase in urban population of 1% it will cause a decrease in energy intensity in G20 countries of -0.274 with ceteris paribus assumptions.

The results of research (Zhu, et al.) show that the population migration situation to urban areas has a negative impact on energy intensity.The impact of urbanization is U-shaped on energy intensity, due to gradual differences in energy intensity demand in urbanization. The intensity of energy requirements varies according to the stages of urbanization, and the main stages of urbanization requirements rely on large amounts of energy as support. When urbanization develops to a certain level, energy requirements decrease. Suggestions for implementing policies that consider energy efficiency in urbanization and development processes.

The trade variable shows significant negative results, when there is an increase in trade of 1%, it will cause a decrease in energy intensity in G20 countries by –0.006 with ceteris paribus assumptions. This result is also in accordance with research (Samargandi)that trade as a driving factor for entry into countries reduces energy intensity, encourages local companies and industries to be more energy efficient.

Industrial value added has a positive influence on increasing energy intensity in G20 countries. If there is an increase in industrial value added by 1%, it will cause an increase in energy intensity in G20 countries by 0.078 with ceteris paribus assumptions. Based on (Azaliah and Hartono) industry has a positive impact on energy intensity, so this can be an indication that the country is focusing on developing the industrial sector so that it is still intensive in energy use.

The regression coefficient on Foreign Direct Investment (FDI) is negative but not significant. Anothet finding from research (Fitriyanto and Iskandar)is an increase energy efficiency in developing countries through FDI does not happen automatically occur and without climate or energy policy.

4. CONCLUSION

Based on research result, Energy Intensity in G20 countries is influenced by various factors, The IVA factor has a positive and significant relationship with energy intensity, can be utilized to increase productivity and economic growth, but need to be balanced with effort to increase energy efficiency.

While the GDP, Trade and Urban Population factors have a negative and significant relationship to energy intensity. However, FDI does not have a significant effect on energy intensity in G20 countries. The government should consider policies to reduce dependence on intensive energy, especially in sector that have a negative relation with energy intensity such as GDP, trade and urban population.

REFERENCES

Comment [YA7]: I found that not all references were cited in the body of your manuscript.

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SPECIAL COMMENT

This **manuscript** has been **well written** following the way of writing a **Original Research Article**. Research **objectives**, **Hypotheses, Justification** of the Study, **Place and Duration** of the Study, **Methodology**, have all been well and clearly stated. **The methods** used in solving the problem, the **significance** and **urgency** of the problem under study, but the **significant findings** have not been ***explained explicitly*** and ***clearly***. I think this manuscript is***scientifically correct***. Analysis and discussion are also presented sequentially and well structured. In the Results and Discussion section*should* ***not only mention***about the***results obtained*****,** but also***discuss key findings, claims, limitations of the study***, etc**.** ***Your key findings should be written in this section***and***discussed in depth***and*comprehensively based on* ***reputable*** and***sufficient*** *references*.I found that not all references **have beencited properly** and **correctly**, and these **references** are **dominated** by**Textbooks, Journals** and **Proceedings** ***(Conference Article),*** and***Websites***and**.** The number is **very poor(only 8 references).**I suggest that you increase the number of references based on reputable references and adequate number. I believe that the author has ***adequate understanding*** **and** ***knowledge***of the issues covered in this manuscript.