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Energy Consumption, Company Size, and Age on the Carbon Footprint Produced by Non-Financial Companies in Indonesia

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Abstract
This research investigates the correlation and effect Energy Consumption, Company Size, and Age on Carbon Emission among non-financial companies in Indonesia. Regression model was used in analyzing research data in the form of annual and sustainability reports of 121 Indonesian companies from 2018-2022. Findings reveal a significant positive relationship between Energy Consumption, Size, and Company Maturity with Carbon Emissions. However, Profitability, Solvency, and GCG do not have significant impact on Carbon Emissions. These results underscore the necessity for companies to implement appropriate policies and strategies to mitigate environmental pollution and enhance environmental performance. This research also highlights the ambiguity in the relationship between corporate environmental performance and company size, age, and financial indicators which can be addressed in future research.

Keywords: Carbon Footprint, Energy Consumption, Company Age, and Company Size

1. Introduction

Global warming refers to the increase in the Earth's temperature due to the release of gases that trap heat, a phenomenon often called the greenhouse gas effect or climate change (*What Is Global Warming?* | National Geographic, 2019). This results in several environmental impacts, such as melting glaciers, rising sea levels, diminishing tropical rainforests, and wildlife struggling for habitat.

Data from the UN for 2011-2020 indicates that the primary driver of climate change is the increased use of fossil fuels (oil, coal, and gas), which has led to a 75% rise in global greenhouse gas emissions and a 90% increase in CO_2 emissions (*Causes and Effects of Climate Change | United Nations*, 2023).

In 2015, 196 UN member states met and agreed on a binding legal agreement related to climate change called The Paris Agreement (*The Paris Agreement | UNFCCC*, 2016.). The main goal of this agreement is to keep the rise in the Earth's average temperature below 2°C and to strive to limit the temperature increase to 1.5°C.

Vol. 8, No.07; 2024

ISSN: 2456-7760

The Paris Agreement forms the foundation for Indonesia, along with other countries, to commit to preserving the Earth through joint climate change action. This commitment is outlined in Act No. 16 of 2016 concerning the Ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change (*UU No. 16 Tahun 2016 Tentang Pengesahan Paris Agreement To The United Nations Framework Convention On Climate Change (Persetujuan Paris Atas Konvensi Kerangka Kerja Perserikatan Bangsa-Bangsa Mengenai Perubahan Iklim)*, 2016). Indonesia has set a target to reduce greenhouse gas (GHG) emissions by 29% and aims to reach peak national emissions by 2030 (*Indonesia Submits New 2030 Climate Targets | WRI*, 2021) and achieve net zero emissions by 2060 (*G20 Indonesia 2022 | Net Zero Carbon 2060*, 2022).

Research on pollution, such as the book "Industrial Pollution Control" (Sell, 1992), indicates that companies and business entities have been significant contributors to pollution since the industrial revolution, necessitating serious control measures to mitigate the resulting impact. A research performed by Wang *et al*. (2016) found a long-term relationship between economic growth, energy consumption, and CO_2 emissions. Their analysis suggests that the impact of CO_2 emissions on economic growth and energy consumption is only marginally significant. Additionally, a Granger causal relationship exists between economic growth, energy consumption, and CO_2 emissions, with a unidirectional causal relationship from energy consumption to CO_2 emissions.

Besides the relationship between carbon footprint and energy consumption, other indicators also influence a company's environmental performance. For example, research by Berchicci *et al*., (2017) on 3,130 companies in the USA concluded that increasing company valuation through asset acquisition positively impacts environmental performance targets, provided there is an effective strategy for asset utilization. Conversely, when assets are sold, companies must strategize appropriately to maintain the expected environmental performance targets based on the existing asset condition.

In addition to company size, other research highlights additional indicators that can influence environmental performance. One significant factor is company age, measured through company age. For example Orazalin and Mahmood (2018) conducted a research on 50 oil and gas companies in Russia during the 2012-2016 period found that older and more established companies tend to disclose more transparent economic and environmental information, supporting legitimacy theory.

The author includes additional measurement variables to examine their relationship with the carbon footprint as an indicator of a company's environmental performance. This research utilizes independent variables such as energy consumption, company size, and company age.
The author limits the research scope to companies in specific groups based on their characteristics. The selected groups include non-financial sector companies such as those in manufacturing, mining and energy, infrastructure, property, and other similar industries.

While there has been extensive research on the relationship between energy consumption, company size, company age, and a company's carbon footprint, most research have examined

Vol. 8, No.07; 2024

ISSN: 2456-7760

these variables separately. However, to the best of the author's knowledge, no research has simultaneously observed these variables in companies with similar characteristics, particularly in Indonesia.

In regards to the aforementioned analysis, several research questions were proposed as follows.

a. How does energy consumption affect the company's Carbon Footprint?
b. How does company size affect the company's Carbon Footprint?
c. How does company age affect the company's Carbon Footprint?

1.1 The Relationship between Energy Consumption and Carbon Footprint

The use of energy resources to conduct business activities inevitably produces pollution (Le *et al*., 2017). The input used will always generate the expected output, meaning that the more energy an entity uses, the greater its contribution to pollution, which in turn degrades the quality of the surrounding environment. To address this, a business entity can implement two policies to mitigate and control the impacts on its environmental stakeholders (Sun *et al*., 2019); increasing the use of renewable energy through conservation and efficiency or energy savings, and using the combination between renewable and non-renewable energy.

Previous research by Hu and Kao (2007) indicated that the intensity of energy use will decrease steadily yet slowly because energy use is replaced by labor, which is more effective than solely aiming for energy use efficiency. This research aligns with the Kuznets Environmental Curve Theory, which posits that in the early stages of economic development, there is a linear relationship between economic benefits and environmental degradation due to pollution. However, over time, as economic benefits increase, entities can better mitigate and control pollution, ultimately improving environmental quality (*Environmental Kuznets Curve - an Overview | ScienceDirect Topics*, 2018).

1.2 Company Size on Carbon Footprint

This relationship is grounded in the Theory of the Impact of Asset Markets on Stakeholders (Jensen, 1988**).** According to this theory, changes in a company's structure and size result from the release and acquisition of asset values. While these changes can yield positive benefits for certain stakeholders, they may also negatively impact others.

1.3 Company Age on Carbon Footprint

The concept of company age varies depending on the context of the research. Morgan, *et al.* (2004). defined company age as the number of years a company has managed its business operations. Additionally, company age can be categorized into different groups: young companies (less than 5 years), medium-sized companies (6-10 years), and mature/old companies (more than 10 years) (Julienti & Bakar, 2011) (Ayyagari, *et al.* 2011).

Various theories explore how companies grow and develop with age. The Growth Rate Model (Greiner, 1998) posits that a company's structure evolves over time, particularly in terms of size measured through assets. The Choice Effect Model (Jovanovic, 1982) suggests that companies unable to compete and generate profits will naturally be eliminated, leaving only highly productive companies to endure. This model also states that newly established companies start with a fixed level of productivity, which improves over time.

Vol. 8, No.07; 2024

ISSN: 2456-7760

1.4 The Agency Theory and Stakeholders

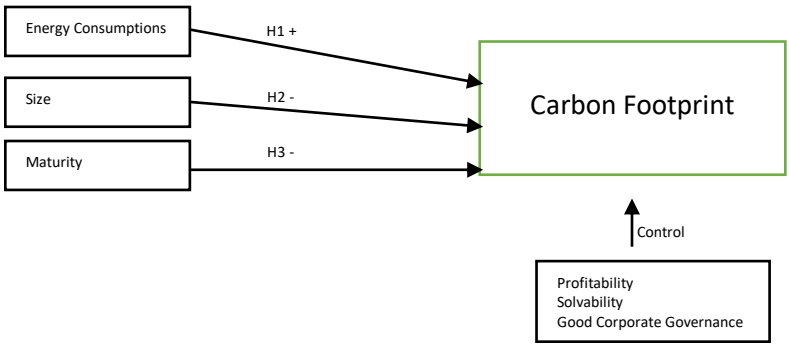
Agency theory (Jensen and Meckling, 1976) explains the relationship between the agent (manager) and the owner (principal). This relationship involves the owner granting the agent authority to make technical decisions in conducting the company's business activities. The theory also highlights the potential conflict of interest that arises when the owner's goal of increasing wealth through dividends or share value conflicts with the agent's desire to enhance personal prosperity.

Beyond the agency-owner relationship, companies are generally required to fulfill the interests of stakeholders. According to Stakeholder Theory (Freeman, 1984), the primary goal of establishing a company is to satisfy stakeholder needs. The greater the influence of a company's stakeholders, the more the company must comply and adapt to their demands. One key stakeholder, as considered in this research, is the environment in which the company operates.

1.5 Research Framework

Based on the theoretical framework and research problem formulation, four variables were identified: the independent variables (Energy Consumption, Company Size, and Company Age), the dependent variable (Carbon footprint), and the control variables (Profitability, Solvency, and Good Corporate Governance). This framework develops a hypothesis suggesting that the independent variables are predicted to have a direct and significant influence on the dependent variable.

The framework of this research is illustrated in the following figure:



a. The relationship between companies' energy consumption on environmental performance

The relationship between increasing energy consumption and the amount of pollution emissions released has been established by prior researchers. Mesagan and Chidi (2020) examined three African countries over the period 1981-2017, and Khan *et al.* (2022) analyzed 21 APEC countries from 1990-2016. Both research concluded that there is a significant relationship between the intensity of energy use, economic development, and growth, all of which positively correlate with environmental carbon emissions. However, Khan also noted that, according to the Kuznets Environmental Curve Theory, a non-linear condition emerges where sufficient economic development and growth eventually reduce carbon emissions and improve environmental performance.

Vol. 8, No.07; 2024

ISSN: 2456-7760

The author believes that the level of energy consumption among companies in Indonesia does not vary significantly. However, given the government's plans to promote energy savings and the use of alternative energy, it is hoped that all companies will conduct business activities while maintaining energy efficiency, particularly during the transition to renewable energy. These savings efforts are expected to influence the company's environmental performance, particularly in terms of the carbon emissions released.
Based on the insights from previous research, the first hypothesis for this research is formulated as:

H_1 = Energy Consumption positively affects Resulting Carbon Footprint

b. The relationship between company size on environmental performance
Previous researchers have examined the relationship between increasing company size and the amount of carbon footprint released has been established. Woo *et al.* (2014) examined 1,656 South Korean companies from 2007-2009, and Berchicci et al., (2017) involved 3,130 companies in the USA. These research showed the presence of a positive relationship between increasing company size, measured by asset value, and environmental performance.

Increasing the company's asset value through asset acquisition decisions can benefit environmental performance targets, provided these decisions are well-prepared and implemented with effective strategies for efficient asset utilization. Conversely, when there is a divestment of assets, the company must adopt appropriate strategies to protect stakeholder interests while ensuring the sustainable management of remaining assets.

The author is certain that companies in Indonesia possess substantial asset values. The utilization of these assets is expected to serve as a significant indicator for companies in formulating sustainable environmental management policies and strategies.
The second hypothesis of this research is developed in regards to the aforementioned insights.
H_2 = Company Size negatively affects the Resulting Carbon Footprint.

c. The influence of company age on environmental performance

Based on previous research, there exists a relationship between company age and the amount of carbon footprint released. Orazalin and Mahmood (2018) analyzed 50 Oil and Gas Companies in Russia from 2012-2016, indicating that older and more established companies tend to disclose more transparent economic and environmental information, supporting legitimacy theory. Additionally, foreign ownership has a positive impact on sustainability reporting. This finding is consistent with Orazalin and Mah

mood (2018)’s research on 114 company data observations in Kazakhstan, which revealed that older companies tend to disclose information consistently at a higher level.

The author posits that most companies in Indonesia exhibit a high level of age, as evidenced by the fact that the average reporting company has been established for over 10 years. Older companies are expected to possess more experience in formulating company performance

Vol. 8, No.07; 2024

ISSN: 2456-7760

strategies, particularly in disclosing environmental performance, which is still relatively novel in Indonesia.
Therefore, the third hypothesis of this research is formulated as follows:
H_3 = Company Age negatively affects the resulting Carbon Footprint

2. Research Method

This research utilized secondary data obtained from annual reports and sustainability reports published by both state-owned enterprises (BUMN) and private companies. Secondary data comprise of information collected indirectly by researchers through other sources such as documents.

The research population included non-financial companies in Indonesia. The sample selection process involved identifying companies that had published both annual reports and sustainability reports between 2018 and 2022. A total of 121 companies were purposively selected as samples based on the completeness of data available in the annual and sustainability reports of each company to ascertain the data validity and reliability.

2.1 Dependent Variable; Environmental Performance as measured by Carbon Gas Emissions generated.

2.2 Independent Variables; Energy Consumption, Company Size, and Company Age
2.3 Control Variables; Profitability, Solvency, and GCG

Panel regression analysis was conducted to assess the influence of financial ratios, governance, and energy consumption on corporate carbon emissions in Indonesia from 2018 to 2022. Panel data, comprising both cross-sectional and time-series data were analyzed using the following panel regression model:

$$Y = \alpha + \beta_1 \chi_1(CE) + \beta_2\chi_2(Size) + \beta_3\chi_3(Age) + \beta_4\chi_4(Prof) + \beta_5\chi_5(Solv) + \beta_6\chi_6(GCG) + \varepsilon\ldots$$

Where Y is Carbon Emissions, α is the constant value, Energy Consumption (CE), Company Size (Size), Company Age (Age), Profitability (Prof), Solvency (Solv), and Corporate Governance (GCG)..

3. Results and Discussion

3.1 Descriptive Statistical Analysis
The results of the descriptive statistical analysis are presented in Table 1 as follows.

Vol. 8, No.07; 2024

ISSN: 2456-7760

Table 3.1. Descriptive Statistic

Variable	Obs	Mean	Std. dev.	Min	Max
Carbon Emissions	537	4.90041	3.24238	-7.42	14.76
Energy Cons	537	5.31892	3.50110	-4.96	13.06
Size	537	16.99669	1.24235	14.14	21.22
Age	537	39.25885	18.77225	3	109
Prof	537	0.05384	0.11835	-0.87	0.7605
Solv	537	0.51228	0.24034	-0.213	2.058
GCG	537	82.65017	7.11585	60	99.01

The table specifies that the average value of the Carbon Emissions variable was 4.90, indicating that the average carbon emissions footprint produced by non-financial companies in Indonesia was 4.90. This value is significantly distant from the minimum range of -7.42, representing the company with the smallest carbon emissions footprint, and the maximum of 14.76, depicting the company with the largest carbon emissions footprint. This highlights the diverse characteristics of the companies in this research concerning their environmental performance.

3.2 Multicollinearity

The correlational matrix is presented in Table 2 as follows.

Table 3.2. Correlation Matrix and VIF

	CE	EC	Size	Age	Prof	Solv	GCG
CE	1						
EC	0.6055	1					
Size	0.4533	0.4465	1				
Age	0.1610	0.1081	0.1712	1			
Prof	0.0276	0.0937	0.0030	0.0706	1		
Solv	-0.1282	-0.2087	-0.1097	-0.0186	-0.3782	1	
GCG	0.1224	0.1577	0.3701	0.1292	0.0209	0.0232	1

The table illustrates the utilization of VIF (variance inflation factor) to assess multicollinearity. According to the table findings, the average VIF value remains below 0.7 (Ghozali, I., 2016), indicating the absence of multicollinearity issues among the study variables.

3.3 Regression Analysis

The results of the Panel Regression Test performed in this research are shown in Table 3.

Vol. 8, No.07; 2024

ISSN: 2456-7760

Table 3.3. Panel Regression Test

Variable	Carbon Emissions	
	Coefficient	P > [t]
Energy Consumptions	0.465	0000***
Size	0.614	0.000***
Age	0.013	0.027**
Prof	-0.719	0.467
Solv	-0.066	0.893
GCG	-0.024	0.142
Observation	537	
Number of Firm	121	
R-Square	0.4162	
Prob > F	0.000	

*=p<0.05; **=p<0.01; ***=p<0.001

In the first hypothesis, the results of the regression test on the relationship between the Energy Consumption variable and the Carbon Emission variable revealed a positive coefficient of 0.465, with a significance level of 0.000 (below 1%). These findings indicate a significant positive relationship between the Energy Consumption variable and the Carbon Emission variable, thereby H_1 is accepted.

In the second hypothesis, the results of the regression test on the relationship between the Company Size variable and the Carbon Emission variable showed a positive coefficient of 0.614, with a significance level of 0.000 (below 1%). These findings indicate a significant positive relationship between the Company Size variable and the Carbon Emission variable, thus H2 is rejected.

Regarding the third hypothesis, the results of the regression test on the relationship between the Company Age variable and the Carbon Emission variable yielded a positive coefficient of 0.013, with a significance level of 0.027 (below 5%). These findings indicate a significant positive relationship between the Company Age variable and the Carbon Emission variable, thereby not supporting H3.

4. Discussion

On the first hypothesis, Those results align with previous research (Mesagan and Chidi, 2020) (Khan *et al.*, 2022), which concluded that there is a significant relationship between energy use intensity, economic development, and growth, all of which positively influence environmental carbon emissions. Additionally, Khan added that, according to the Kuznets Environmental Curve Theory, a non-linear condition may emerge where sufficient economic development and growth could eventually reduce carbon emissions and improve environmental performance.

On the second hypothesis, The results obtained are indeed contradictory to various previous research (Woo et al., 2014) (Deng et al., 2019) (Berchicci et al., 2017), which assert a positive relationship between increasing company size, measured through asset value, and environmental

Vol. 8, No.07; 2024

ISSN: 2456-7760

performance. These research suggest that companies with greater asset value, especially if there is investment in sustainable environmental practices, tend to exhibit higher environmental performance, such as lower carbon emissions. Essentially, companies with greater asset value possess more capabilities and resources not only for profit-generating business activities but also for meeting the needs of other priority stakeholders, including environmental concerns.

However, the findings of this research are consistent with other research lain (Bowen 2000; Darnall *et al.*, 2010), which suggest that relatively smaller companies may be better equipped to address the demands of special stakeholders, such as environmental groups, due to pressure from powerful stakeholders, particularly government entities. Larger companies may resist such pressure through lobbying or political means, potentially resulting in environmental performance that is not superior to that of smaller companies.

On the third hypothesis, Those results are inconsistent with various previous research (Orazalin and Mahmood, 2018) (Mahmood and Orzalin, 2017), which suggested that older and more established companies tend to disclose more transparent economic and environmental information, supporting legitimacy theory. The research also indicated that older companies have a tendency to maintain high levels of information disclosure over time.

This result of this research aligns with findings from Trencansky and Tsaparlidis (2014), suggesting that older companies face greater challenges in adapting to change, such as adopting CSR systems, due to stakeholder pressure against change, which often takes time to implement. Similarly, Barron *et al*., (1994) noted that older companies tend to struggle with embracing new challenges compared to newer counterparts.

Regarding control variables, such as Profitability, Solvency Ratio, and Good Corporate Governance, they were found to have no significant influence on Carbon Emission. Profitability variables do not have a significant effect on the Carbon Emissions. These results support research conducted by Mesagan *et al*., (2022) which states that company performance has a negative but insignificant effect on pollution generated in both the long and short term. The study also states that the results obtained do not match theoretical expectations because company performance is expected to increase economic productivity and consequently increase pollution.
Meanwhile, Solvency Ratio does not have a significant effect on the Carbon Emissions variable. These results are supported by the research of Hang *et al*. (2018) which states that there is a relationship between financial performance and the corporate environment provides uncertain results. In developed countries, there is a positive relationship, but the relationship disappears in developing countries.

Lastly, Good Corporate Governance do not have a significant effect on the Carbon Emissions variable. These results are supported by Nurvita dan Priambodo (2022) research, which states that there is no relationship between GCG quality and environmental performance. The study also states that environmental performance is significantly influenced by company size.
The authors argue that there are several additional reasons why profitability, solvency and governance have no effect on environmental performance. First, the trends in financial and environmental performance of companies are not consistent with Kuznets' environmental curve

Vol. 8, No.07; 2024

ISSN: 2456-7760

theory, with some companies experiencing a decrease in profitability but a decrease in reported carbon emissions, and vice versa. And not a few companies that experienced an increase in profitability but also experienced an increase in the number of carbon emission reports produced, and vice versa.

Second, the financing structure of companies funded by third parties (such as banks) has not specifically required, on the terms of lending, the environmental performance of the company. This is based on the rules and commitments on sustainability that only started in Indonesia in 2018.

Third, good corporate governance cannot directly target the company's environmental performance. Corporate governance in Indonesia is regulated through OJK regulations for private companies and BUMN regulations for state-owned companies, both of which do not explicitly regulate corporate governance to manage environmental stakeholder

The author posits that several factors contribute to increased carbon emissions intensity with larger and more mature companies. The relationship between company size, age, and carbon emissions remains linear, indicating that Indonesian non-financial firms have not yet reached a point of change in the Kuznets Environmental Curve. This delay may stem from the novelty of carbon emission disclosure and control practices in Indonesia, with regulations like Law number 16 of 2016 on the Paris Agreement and Presidential Regulation Number 59 of 2017 on Sustainable Development Goals implementation only becoming applicable to businesses in 2018. Consequently, both large and old companies in Indonesia require time to adjust to these regulatory changes.

This research examined the correlation and impact of Carbon footprints on Energy Consumption, as well as the Size and Age of Companies, particularly within the non-Financial sector in Indonesia. The dataset comprised information from 121 non-financial companies' annual and sustainability reports, documenting carbon emissions produced during the period from 2018 to 2022. Findings indicate that energy consumption, company size, and age positively influence carbon emissions, while factors like Profitability, Solvency, and GCG do not directly affect emissions. These results underline the necessity for companies to formulate appropriate policies and strategies to mitigate the environmental impact, thus enhancing environmental performance.
Seeing the results that state that carbon emissions are more influenced by energy use and company size and maturity of the company itself, the author can provide several recommendations. Recommendations especially for policy makers or in this case the government, to immediately develop technical rules as an implementation of the commitment to implement Act no. 16 of 2016. These technical rules are made with the aim of giving confidence to industry players in conducting business in a sustainable business climate. The rules can refer to practices that have been implemented in other countries such as The Clean Air Act, which regulates the emission of air pollutants into the atmosphere, The Clean Water Act, which establishes standards for water quality and pollution control, or Waste management laws, which govern the disposal and treatment of solid and hazardous wastes.

Vol. 8, No.07; 2024

ISSN: 2456-7760

While the government develops appropriate regulations, businesses companies can continue to control their environmental performance through sustainable business practices, such as energy efficiency and the use of energy from renewable sources.

The limitation of this research is on the single-country focus and restriction to non-financial companies. This decision was made to directly observe the environmental performance trends of non-financial firms, particularly those with high emission levels such as manufacturing and mining companies, in fulfilling governmental environmental management expectations. Future researchers are encouraged to enhance environmental performance evaluation by employing more robust indicators such as ESG scores and expanding the research scope to include financial institutions and similar entities across both developed and developing countries.

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