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The Impact of Investment and Labor Participation on Energy Consumption: A Panel Analysis on Selected OIC Countries

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A country's economy cannot be separated from economic activity and energy consumption. A country's economic activity increases in proportion to its income. Furthermore, countries will respond to increased economic activity by changing their energy use. This research aims to assess how much extra energy is being utilized by economic activity to maintain the current environment. The results of the analysis show that the gross fixed capital creation variable has a major impact on the energy consumption of OIC countries. The labor force participation of individuals aged 15 to 24 also has a significant effect on energy use. Energy consumption can therefore be increased by raising investment and labor force participation. An annual data series (2010–2015) is used in this investigation. Panel data is the term for the sort of data that is utilized. Further research subjects can do dynamic panel data (countries) analysis by including factors not included in the research mode.

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INTRODUCTION

There are 57 member countries in the Organization of Islamic Cooperation (OIC), which is the organization with the second-highest membership count after the United Nations. This organization, established in 1969, was founded with the goal of strengthening ties between its Muslim-majority member nations, promoting international peace and security, and easing the coordination of cross-border cooperation. (Choiriyah & Auwalin, 2020).

Figure 1 shows top 10 countries energy consumers, which 5 of them are OIC countries. Dependence on energy in OIC countries needs to be studied further as evaluation material for these countries. Massive energy use can cause environmental damage and climate change. International attention to the earth's climate has only emerged in the last decade when it was felt that the earth's temperature had increased significantly. Climate change is a real challenge in the 21st century, as global temperatures increase as a trigger for climate change. Rising temperatures because of high concentrations of greenhouse gases in the earth's atmosphere are the cause of global warming. Human development in all fields covering various aspects, including economic, social, cultural and technological, is closely related to the increase in the concentration of greenhouse gases in the atmosphere (Fauzi, 2018).

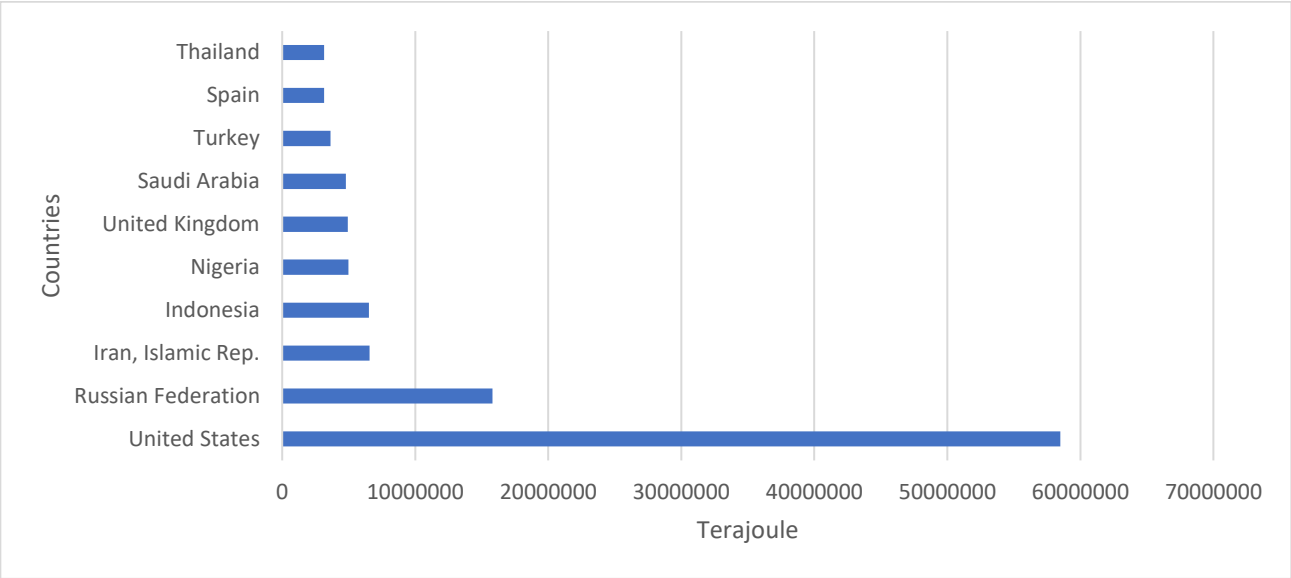

Figure 1. Top Ten Countries by Energy Consumption

Economic development that pursues economic profits often ignores its impact on the surrounding environment. Development which was originally aimed at improving human welfare damaged life-supporting elements (environmental quality). Economic development that is underway to improve the quality and sustainability of humanity grows in inverse proportion to the quality of the environment. This quality degradation is closely related to the use of energy that is not environmentally friendly in the economic development process (Fauzi, 2018).

Greenhouse gas emissions have increased as a result of industrial development and energy consumption employing ecologically unfriendly technology, particularly in emerging nations. Fossil energy use will result in a higher concentration of greenhouse gasses, particularly carbon dioxide. With a 56% contribution, CO2 gas is the main cause of global warming, followed by 18% from CH4 and 6% from NO2. Global warming is caused by high atmospheric CO2 gas concentrations (Fauzi, 2018).

A nation's economic growth is fueled in part by investment. One type of investment that helps a country's economy grow is the gross fixed capital formation. From the perspective of expenditure, gross fixed capital is also a part of GDP encompasses the production, acquisition, or manufacturing of capital goods both domestically and internationally. This element contributes to better economic growth, higher national income, and employment creation. An extension of the economy's scale will result from an increase in gross fixed capital (Pradhan, 2018).

Labor force participation, which measures how actively the working-age population engages in economic activities, including those who are actively seeking employment or are employed, is a crucial

indication of a nation's economy. The labor force participation rate is a crucial factor in assessing a nation's potential for economic growth since higher labor force participation rates translate into higher production potential and economic contributions. Ludvigsson et al. (2019) state that analyzing labor force participation is also essential for creating social and fiscal measures that encourage social inclusion and efficient workforce scheduling.

The use of energy is essential to a country's daily activities and economic growth. One of its uses is energy consumption across a range of industries, such as transportation, industry, residential, and commercial. When examining economic growth, energy consumption must be considered as it is often classified as a social and productive activity. In addition, many countries are looking for greener ways to meet their energy needs as people grow more aware of how energy use impacts the environment (Shahbaz et al., 2018).

The OIC countries are interested in conducting research on their energy use because, up until now, very few academics have looked at the connection between energy consumption and climate change in these countries. This article examines the relationship between labor force participation and investment capital and energy consumption levels in a subset of Organization of Islamic Cooperation (OIC) member nations. A nation's income is composed of various elements, including its labor force and capital stock. An increase in income is correlated with robust economic activity in that nation. This increase in economic activity is expected to have an effect on the country's energy usage. This study aims to evaluate the extent to which the use of ever-increasingly-massive energy consumption from economic activity maintains the global climate.

LITERATURE REVIEW

Growing nations are under immense pressure to lower the increasing need for goods and services with minimal environmental impact (Chung, 2020). Sustainable development, which is closely tied to the financial well-being and prosperity of humanity, has become a top priority globally. Businesses impacting natural sustainability should prioritize environmentally friendly practices. Early adoption of green business plans is especially crucial for low-income nations like India to participate in global sustainability efforts and assess their competitive advantages (Zhang et al., 2021). The global apprehension about the severe impacts arising from climate change has spurred collective endeavors and heightened attention directed towards fostering a resilient and sustainable Architecture, Engineering, and Construction industry (C. Debrah, 2022).

Tang (2009) employed cointegration and causality analysis to investigate the role of electricity consumption in Malaysia from 1970 to 2005. The research underscores the significance of energy-saving measures, emphasizing the impact on economic growth in Malaysia, given its status as an energy-dependent nation, as revealed by Granger causality research. Shifting focus to the relationship between energy use and foreign direct investment (FDI), another study titled "Multivariate Granger Causality between CO2 emissions, energy consumption, FDI, and GDP: Evidence from the BRIC panel (Brazil, Russian Federation, India, and China)" by Pao and Tsai (2011) reveals a two-way causal relationship between energy consumption and foreign investment. The findings suggest that increased energy use positively influences a country's production, demonstrating the interconnected dynamics of energy consumption, economic growth, and foreign direct investment.

Research by Wahyudi & Palupi (2023) demonstrates this. The findings demonstrated the two-way causal links between energy consumption and foreign direct investment, energy consumption and labor force participation rate, and foreign direct investment and labor force participation rate. Lee (2013) investigated the relationship among carbon emissions, economic growth, environmentally friendly energy use, and foreign direct investment. A cointegration test is used in this study to examine the long-term balance relationship between variables and a fixed effects model. The results of the study show that there is a correlation between foreign direct investment and carbon emissions even though there isn't a direct one.

Polat (2018) examined the impact of foreign direct investment (FDI) on the mix of non-renewable and renewable energy use in 85 industrialized and developing nations from 2002 to 2024. According to this study, foreign direct investment (FDI) lowers but does not change energy consumption in developed nations. Energy in underdeveloped nations. This study also clarifies how foreign direct investment (FDI) has two distinct effects on energy consumption: the establishment of foreign companies in the host country and the uptake of energy-saving technology by businesses if the investing nation allocates funds to meet strict environmental regulations. Some studies (Tiwari, 2014; Hasanov et al.,2017; Tiwari et al., 2020) are of the

opinion that the consumption of energy drives growth, a few (Tiwari, 2014; Ajmi et al., 2013; Magazzino, 2014; Tiwari et al., 2020) support the conservation hypothesis (growth drives energy consumption). Based on the reality in their respective countries, policymakers across the world are taking a call on shifting toward clean and renewable energy. Similarly, investors are bearing in mind the nexus between NREC and economic growth in different countries while deciding the investment destinations for clean and renewable energy (Khan et al., 2020).

Energy use is among the most important economic metrics, according to research by Aidarova et al. (2023). This study examines Kazakhstan's energy consumption, foreign direct investment, and labor force participation rates from 1991 to 2021 as a result. Findings foreign direct investment affect on Kazakhstan's energy usage. In addition, the labor force participation rate influences energy consumption immediately but cannot be sustained over time. Other study From (Alnabulsi, 2023) aimed to assess the impact of renewable energy consumption on economic growth in Jordan from 1990 to 2020 using time series analysis. The research results indicate a positive and significant influence of renewable energy consumption, gross fixed capital formation, carbon dioxide emissions, and total population on real Gross Domestic Product (GDP).

Jebli and Youssef (2015) looked at foreign commerce, the economic expansion of Tunisia between 1980 and 2009, the use of renewable and nonrenewable energy sources, and the nation's CO2 emissions per person. The estimation results of the test show that employing renewable energy has a negative long-term effect on greenhouse gas emissions. Another research involved comparing different biomass processing methods to evaluate the economic viability of alternative management approaches. The analysis anticipated a Total Annual Revenue (TAR) close to EUR 7.9 million for an initial investment of EUR 9.8 million, achieving an Internal Rate of Return (IRR) of 9% for a subsidized processing facility located in the Greek region (Manthos 2023).

DATA AND METHODOLOGY

This is a quantitative study focused on the impact of gross fixed capital formation and labour force participation on energy consumption in selected OIC countries. The sample in this study comprises data collected from 36 OIC countries, for period 2010 to 2015. The secondary data collected from various sources were processed using statistical software. Data processing activities, including the creation of tables and analysis, were performed using software tools appropriate for panel data regression. The research model employed to analyze the data is as follows:

$$E_{it} = \alpha + \beta_1 GFCF_{it} + \beta_2 LFP_{it} + \varepsilon_{it} \quad (1)$$

Where Eq. (1) describe the effect of various independent variables on dependent variables in this study. The dependent variable of this study is energy consumption ($\mathbf{E_{it}}$). Other explanatory variables are $\mathbf{GFCF_{it}}$ is gross fixed capital formation, $\mathbf{LFP_{it}}$ is labour force participation, and $\boldsymbol{\varepsilon_{it}}$ is the error term. The variables considered in this study are detailed in Table 3, and the overall characteristics of the data are summarized in Table 1.

Panel Data Model Selection Test

The Chow test is used to determine the best model between the fixed effect model (FEM) and the common effect model (CEM). The probability value of the F statistic is used to determine whether to reject H_0. H_0 is rejected if the probability value is less than the genuine level (α). Next, a Hausman test is carried out to determine whether there is a correlation between each individual element and the regressor, which is used to establish which model is superior, assuming that H_0 is REM and H_1 is FEM. Based on a comparison between Hausman statistics and probability values, H_0 is rejected if the probability value is smaller than the real level (α), which also serves as the foundation for rejecting H_0.

Classic assumption test

The classical assumption test is a statistical requirement that must be met in multiple linear regression analysis based on ordinary least squares (OLS). To ensure that the regression model obtained is the best model, multicollinearity tests, normality tests, heteroscedasticity tests and autocorrelation tests are carried out. The multicollinearity test is a test that shows whether there is a correlation between independent variables. To ensure whether the data used has a normal distribution, a normality test is carried out. In the normality test, the assumption of the Central Limit Theorem states that if there are more than thirty observations then the normality test is not needed and can be ignored, it can be applied if the data tends to be abnormal (Ajija et al., 2011). Then a heteroscedasticity test is carried out to avoid heteroscedasticity problems which cause inefficient estimation results using the

Glejser Test method. Next, the autocorrelation test can be determined using the Durbin-Watson test. To ascertain whether there is a positive or negative correlation, the Durbin-Watson test result is compared to the Durbin-Watson Table value (Ghozali, 2013).

Table 1 Research variable

Variable	Notation	Definition	Unit
Total Energy Consumption	EC	The total energy consumed by a system or environment.	kWh/kJ
Gross fixed capital formation (%)	GFCF	The percentage of GDP or national income used throughout time to purchase and maintain tangible assets like infrastructure and machinery for output.	Percent
Labour force participation rate, total (% of 15-24 year olds)	LFP	A statistic that expresses as a percentage of the overall population between the ages of 15 and 24 the number of persons in that age range who are actively participating in the labor force, including those who are employed or seeking employment.	Percent

RESULTS AND DISCUSSION

Panel Data Regression Result

This study uses panel data analysis to investigate the effects of labor force participation and gross fixed capital on energy consumption. Arellano (2004) defines panel data as data that is utilized in econometrics in a variety of contexts. This is a collection of data that has been tracked over time for the same person. Between the PLS and FEM models with the H_0 and H_1 hypothesis, the Chow test was successful in identifying the optimal panel data regression model. Additionally, a Hausman test is also required to establish whether there is a correlation between each individual element and the regressor, which is used to establish which model is superior, assuming that H_0 is REM and H_1 is FEM. Table 3 Chow test findings indicate that the probability value is 0.0000, which is less than the real level of 5%. Therefore, the Fix Effect Model (FEM) is used in the temporary model estimation. The model utilized is FEM since the Hausman test indicates that the probability value is 0.0000, which is less than the real level value of 5%.

Based on the results of data processing using the Eviews 9 software obtained the results of the estimation are in table 2 below.

Table 2. Estimation result

Variables	Common Effect Model (CEM)	Fix Effect Model (FEM)	Random Effect Model (REM)
Constant	121536.4	-51494.54	175436.3
	0.0977	0.5957	0.2819
CAP	1.75E-05***	1.10E-06***	1.65E-06***
	0	0.013	0.0001
LFP	0.022817	0.078494	0.061114
	0	0	0
R-Squared	0.739109	0.99814	0.484742
Adjusted R-Squared	0.736659	0.997754	0.479904

Parentheses and prob. indicates the value of the significance level or probability value in each variable.
*significant at 10%, **significant at 5%, ***significant at 1%.
Source: Own estimation, 2023

The best FEM model produced model estimates, which were tested, led to the selection of the model for the classical assumption test. The traditional assumption test yields the Best Linear Unbiased estimate (BLUE) estimate results. The autocorrelation, heteroscedasticity, multicollinearity, and normality tests were among those that were performed.

Table 3 Model selection result

Test	Hypothesis	Const	Prob.	Details
Chow test	H0=CEM (prob. >0.05)	708.410**	0.000	Prob. <0.05
	H1=FEM (prob. <0.05)			FEM best model
Hausman test	H0=REM (prob. >0.05)	37.202**	0.000	Prob. <0.05
	H1=FEM (prob. <0.05)			FEM best model

Source: Own estimation, 2023

The Jarque Bera test was used in the normality test to ascertain whether the data was normally distributed. The Jarque-Bera test has a probability value of 0.076511 and a value of 5.1401639. This demonstrates that the distribution of the data is not normal. The Central Limit Theorem assumption can be applied if the data tends to be abnormal; that is, if the number of observations is greater than 30, a normality test is not necessary and can be disregarded (Ajija et al., 2011:42).

The study employed a series of classical assumptions and diagnostic tests to ensure the robustness of the regression model. Firstly, a multicollinearity test was performed to assess the correlation between independent variables. According to Gujarati (2006), an r-value less than 0.8 indicates no multicollinearity. In Table 4, the correlation coefficient between fixed gross capital (CAP) and labor force participation (LFP) was found to be 0.646315, below the threshold, indicating the absence of multicollinearity.

Table 4. Multicollinearity Test looking at independent inter-variable correlation values (r)

Relationship	**Independent Inter-variable**	
	CAP	LFP
CAP	1.000000	0.646315
LFP	0.646315	1.000000

Source: Own Estimation 2023

Secondly, a heteroscedasticity test using the Glejser Test was carried out to address efficiency issues in the estimation results. Regressing the independent variables on their absolute residual values is how this test is executed. Based on Table 4 the probability values for labor force participation and fixed gross capital are 0.0816 and 0.5137, respectively, according to the table. The estimate passes the heteroscedasticity test since the probability value for these two variables is higher than 5%.

Table 5. Hetesroscedasticity Test by Glejser Teest

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
CAP	1.40E-07	2.14E-07	0.654358	0.5137
LFP	-0.006055	0.003457	-1.751616	0.0816
C	121600.8	47168.65	2.578000	0.0107

Source: Own estimation

The third classical assumption examined was autocorrelation, identified through the Durbin-Watson test. To determine whether there is a positive or negative correlation, the Durbin-Watson test result is compared to the values listed in the Durbin-Watson table (Ghozali, 2013). The Durbin Watson value of 0.944630 indicated positive autocorrelation (Table 6). To address this,

robust standard errors were employed, ensuring more consistent and accurate parameter estimation.

Table 6 Autocorrelation test result by Durbin Watson test

Indicator	Stats.
Durbin Watson stat	0.944630

Source: Own estimation 2023

In panel data analysis, the robust method is an estimation technique used to address issues with heteroskedasticity, autocorrelation, and outlier data. When employing robust regression techniques, autocorrelation in static panel data can be eliminated in various ways. If autocorrelation is detected, estimates can be generated using the first or second difference approaches of Cochrane-Orcutt or Newey-West. Robust regression techniques can be utilized to estimate parameters more consistently and accurately while preventing autocorrelation (Arellano, 2004).

Table 7. Robust Standar Error

Variable	Coefficient	Std.Error	t-Statistic
CAP	1.10E-06	4.39E-07	2.508587
LFP	0.079494	0.007099	11.05659
C	-5149454	96867.09	-0.531600
Indicator	**Stats**	**Indicator**	**Stats**
R-squared	0.654381	Adjusted R-squared	0.651136
Rw-squared	0.992757	Adjust Rw-squared	0.992757
Akaike info criterion	527.4544	Schwarz criterion	540.8685
Deviance	5.01E+12	Scale	97695.33
Rn-squared statistic	86807.76	Prob (Rn-squared stat.)	0.000000

Source: Own estimation 2023

Hypothesis test

The Robusted FEM model equation is shown below, and it is based on the estimation results in Table 7.

$$E_{it} = \alpha + 1.10GFCF_{it} + 0.079LFP_{it} + \varepsilon_{it} \qquad (2)$$

T-test results revealed that both GFCF and LFP have a significant impact on energy consumption in the selected OIC countries. For GFCF, the computed t-statistic (t = 2.508587) exceeded the critical value (t table 1.971111258), leading to the rejection of H_0 and acceptance of H_1. This implies that GFCF affects energy consumption. A positive coefficient (1.10E-06) suggests a positive relationship with energy consumption. This means that an increase in GFCF, which represents investments in physical capital like machinery and buildings, leads to a higher demand for energy. This is likely due to increased production activities and the use of energy-intensive equipment. Similarly, for LFP, the calculated t-statistic (t = 11.05659) surpassed the critical value, resulting in the rejection of H_0 and acceptance of H_1, indicating that LFP affects energy consumption. A positive coefficient (0.079) indicates a positive relationship between labor force participation and energy consumption. This means that as more people participate in the workforce, energy consumption increases.

Next, the F-test was conducted to assess the combined model impact of GFCF and LFP on energy consumption. The calculated F value (2582.204) exceeded the critical value (F table 3.88527959), with a significance value of 0.000000 < 0.05. This led to the rejection of H_0 and acceptance of H_1, suggesting that both variables jointly influence energy consumption. Following the T-test and F-test, the Coefficient of Determination (R^2) test was performed, yielding an Adjusted R-squared value of 65.1136%. This indicates that GFCF and LFP can collectively explain 65.1136% of the variation in energy consumption in the selected OIC countries. It is important to note that 34.8864% of the variation is attributed to factors not considered in the research model.

Discussion

The fixed gross capital variable significantly influences energy consumption in OIC countries. This indicates that increasing investment in gross fixed capital can contribute positively to increasing energy consumption. Gross fixed capital formation often involves the construction of infrastructure and projects that require energy resources. In the labour force participation variable, labour force participation in the 15-24-year age group significantly influences energy consumption. A large workforce in this age group contributes to increased energy consumption, as more production and economic activities involve energy use.

The acquisition of resultant assets, including the production of such assets by producers for their use, less write-offs is known as gross fixed capital formation, or GFCF. Assets meant to generate additional goods and services for a longer period of time are considered relevant assets. GFCF is a crucial measure of economic investment and is frequently employed as a stand-in for GDP growth. Economic growth is positively connected with fixed capital formation, non-renewable and renewable energy, and carbon emissions, but negatively with the former (Abbas 2020). The transition to renewable energy sources can be facilitated by raising capital intensity.

A study by Niczyporuk (2022) found that an increase in labour force participation impacts increasing output may result in a rise in the demand for energy use. The government and the private sector must implement a policy to improve the quality of production inputs that use renewable energy sources in order to increase energy efficiency and solve this issue. (Ula 2019) Found that using the OLS approach model shows that renewable energy consumption positively contributes to economic growth in ASEAN countries, and (GCM) also positively contributes to economic growth in ASEAN countries. GFCF is an important economic indicator related to investment and can be related to energy consumption and economic growth. Apart from that, work participation also represents energy consumption, a shift towards renewable energy sources and a reduction in carbon emissions that may be facilitated by improving the economy, especially in capital.

Discussion of these two variables is critical because they have a relationship that can prove that many things influence energy consumption. The variables used can explain the scope of the OIC with reasonably good data. Using data series that are complete and countries that adequately represent the OIC countries makes the research valid in describing the relationship between these variables.

CONCLUSION

Energy consumption is one of the most important economic indicators. Therefore, it is essential to understand the factors that influence energy consumption, especially for the economic activities. Energy usage is also among the most significant economic metrics. Hence, it is crucial to comprehend the variables that affect energy consumption, particularly for a nation's economy. This study aims to examine the impact of both the labor force participation rate and gross fixed capital formation on the overall energy consumption. Our analysis's findings indicate that the Gross Fixed Capital Formation variable significantly affects how much energy is consumed in OIC nations. This implies that larger investments in gross fixed capital can contribute to higher energy consumption because gross fixed capital formation frequently entails the development of infrastructure and projects requiring energy resources. Additionally, because greater production and economic activities demand energy, the 15- to 24-year-old age group's labor force involvement also has a substantial impact on energy consumption. Energy consumption may therefore rise in tandem with rising investment and labor force participation. This analysis uses annual data sets from 2010 to 2015. Utilized data types include panel data. Researchers with advanced training can perform dynamic panel data analysis by including factors not found in the study model.

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