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Do Trade Openness, Human Capital, and Good Governance Affect Green Energy Consumption: New Evidence from (G7)

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Abstract : *Green energies are more adapted to the environment, and their production and production are less polluted. Moreover, since there is no end to this energy category, green energies are taking on an ever-increasing share of the world's energy supply system, even in countries with fossil fuels. The current study aims to examine the factors affecting green energy consumption in Group 7 countries using a table-based data approach (Panel data quantile regression) from 1996-2022. The study examined how financial impacts such as the Good Governance Index (GGI), Human Capital (MYS), Trade Openness (TO), Income (GDP), Inflation (INFL) and Non-Financial Fixed Capital Formation (GFCF) are affected. Thus, assuming the stability of other factors, by an increase of one unit in GGI, MYS, TO, GDP, INFL, and GFCF, green energy consumption (GEC) increases between 0.24 and 0.59%, 2.46 to 7.12%, 0.98 to 1.53%, 0.73 to 1.03%, 0.42 to 0.62% and 1.07 to 1.73%. Given the positive and meaningful impact of the Good Governance Index and Human Capital on green energy consumption, it is proposed to double attention to the quality of laws and regulations, the rule of law, and the design and enforcement of laws in protecting the environment and developing more clean energies. The results can be an outstanding lesson for creating and developing countries.*

Keywords: *Green energy transition, Trade openness, Governance, Renewable Energy Consumption, Panel Data Techniques*

1. INTRODUCTION

Air pollution has significantly increased due to the Industrial Revolution, and climate change, in a more general sense, is a highly complex problem involving several Energy, environmental, and economic elements (Huang et al., 2022). Energy production contributes significantly to greenhouse gas (GHG) emissions even though it is necessary for economic development (Acheampong et al., 2022). Therefore, most global societies have stressed the need for the green energy transition (GET), which entails substituting green energy sources (GES) for conventional fossil fuels to lessen the negative impacts of such greenhouse gases. (Rehman and colleagues, 2023; Zhang et al., 2021) This gradual shift to trade openness for green Energy (GE) may help decrease carbon emissions, diversify energy sources, lessen dependency on fossil fuels, and foster economic development and jobs in manufacturing and services (Wang et al., 2023; Qing et al., 2024). Figure (1) presents information indicating that CO2 emissions in 2022 are expected to reach 37.15 billion tons annually. This underscores the need to address environmental concerns and minimize fossil fuel use.

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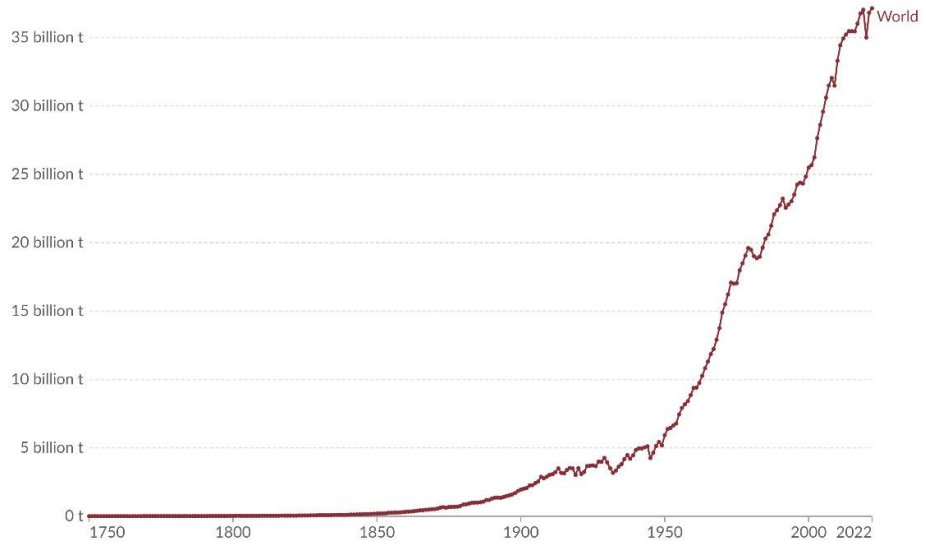

Figure (1): Annual CO_2 emissions. **Source:** ourworldindata.org

Nevertheless, implementing GET necessitates substantial expenditures and changes in current policies. One policy that might facilitate this shift is trade openness (TO). It can foster unrestricted commerce, incentivize investments in environmentally friendly energy initiatives, and decrease the expenses associated with green energy technology by reducing tariffs and non-tariff trade barriers. (Mohamed Yusoff and Ridzuan, 2023; Shabbir et al., 2019; Nawaz et al., 2021). Conversely, implementing TO might foster rivalry between the green Energy and fossil fuel sectors, hence impeding the mainstream adoption of green energy technology (Lin et al., 2023).

Furthermore, the presence of TO can impact the enforcement of environmental norms and laws, leading to less efficient methods of promoting green energy technology. Hence, it is crucial to examine the impact of TO on GET to formulate efficient strategies. The following references were cited: Lee et al., 2022; Zhang et al., 2023; Wei et al., 2023; Nawaz et al., 2021; Hayat et al., 2022.

Hence, attaining energy security is a paramount objective for the economy of any nation. Energy self-sufficiency refers to the market economy's capacity to meet consumers' present and future energy demands. Energy security in a nation relates to the ability of the country to control the quantity of Energy available at a cost that is affordable to consumers while also adhering to environmental conservation standards. The significance of the energy security category is growing due to the focus on environmental sustainability, energy efficiency, and sustainable development (Karacan et al., 2021). Researchers and experts have been making significant efforts to find alternative sources of fossil fuels due to population growth, increased

energy demand, depletion of fossil resources, and rising environmental pollution. These alternative sources are more accessible and can help mitigate the ecological damage caused by fossil fuels (Qing et al., 2024).

Energy consumption, environmental degradation, and climatic emergencies are significant challenges inherent in the global economy. Simultaneously, the government actively supports measures to foster a low-carbon economy and advance energy efficiency. Energy efficiency benefits customers as it helps lower energy expenses and mitigate environmental deterioration. The primary factors contributing to energy consumption are globalization and industrialization. Decreasing energy consumption and fostering economic development presents a difficulty since economic expansion often leads to rising CO2 emissions (as seen in Figure (2), demonstrating a positive correlation between GDP per capita and environmental carbon emissions). Increased. The notable surge in carbon emissions is directly linked to the rise in energy usage. Nonrenewable energy usage exacerbates environmental standards by releasing CO2 emissions. Hence, governments prioritize using clean energy sources as a substitute for polluting energy sources. Therefore, current research has focused on investigating the correlation between Energy and the environment, as shown by studies done by Huang et al. (2021), Taskin et al. (2022), Shaohua et al. (2023), and Qing et al. (2024).

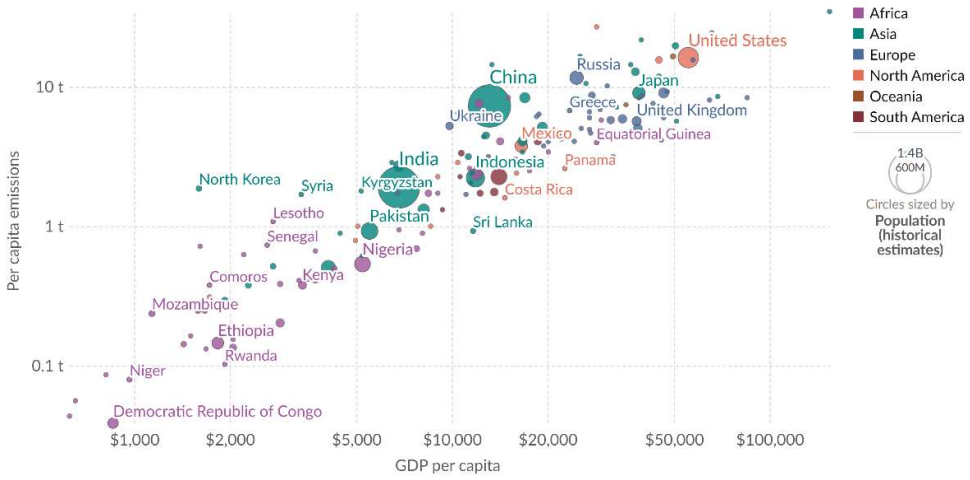

Figure (2): CO_2 emissions per capita vs. GDP per capita, 2018. **Source:** ourworldindata.org

Furthermore, addressing issues about climate change and the quality of institutions (good governance) are crucial priorities to achieve the Sustainable Development Goals (SDGs). The governance index, primarily assessed via government openness by Openness International, is also attributed to other economic, social, political, institutional, health, and environmental

benchmarks. Hence, emphasizing checks and balances and good governance in nations is crucial in influencing several significant economic factors (Huang et al., 2022). The present study aims to examine the factors that affect the consumption of green Energy in Group 7 countries. The research utilizes the panel data approach and quantile panel regression, covering 1996 to 2022. The study specifically focuses on investigating the magnitude and nature of the impact of economic-social factors (income - Gross Domestic Product and gross stability capital formation), political factors (good governance index), and country-specific factors (human capital). This research is motivated by the rising concerns regarding energy security, climate change, and heat-related issues. The presence of the Earth is quite significant. This is particularly crucial in Group 7 nations that possess considerable potential for renewable Energy and must consider factors such as solid governance criteria and human capital.

Therefore, despite the many studies on the variables influencing renewable energy usage in various nations, the current research focuses on the following distinctive aspects: The current study examines the impact of the Good Governance Index, calculated as the mean of six different metrics. The effect of good governance, specifically factors such as Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption, on the adoption of green Energy in the G7 countries has been examined, attracting significant attention thus far. Negation positioned Furthermore, other studies have used diverse variables to incorporate human capital into economic discourse and econometric models. However, in recent times, there has been a growing emphasis on using the average number of years of schooling among those aged 25 and above. Furthermore, the present study focuses specifically on the impact of commercial openness on the use of environmentally friendly energy sources. This particular combination of factors has not yet been explored in previous studies. Hence, the present study exhibits significant novelty, with its primary inquiry being: Does the level of economic openness, human capital, and quality of governance substantially impact the use of environmentally friendly energy sources?

This study is structured as follows: the second section explores the theoretical underpinnings and provides an overview of the research conducted in the area relevant to the present investigation. The third section is devoted to precisely defining the model. The fourth section describes the model estimate and analysis of the findings. The fifth section presents the conclusions and policy proposals.

2) LITERATURE REVIEW

This section will provide a comprehensive assessment of the literature about the issue. In this part, to accomplish our objective, we will independently analyze the theoretical and experimental underpinnings of each significant variable that has had a notable impact on our study.

2-1) Trade Openness and Green Energy Consumption

Trade openness (TO) has been linked to various advantages for the transition to green Energy, including enhanced investment and innovation in renewable energy technologies, improved availability of affordable energy sources, and increased efficiency in the global distribution of renewable energy products (Lee et al., 2022; Zhou et al., 2022). According to Kolcava et al. (2022), trade liberalization might decrease obstacles to accepting and spreading environmentally friendly energy technology, such as tariffs, non-tariff barriers, and discriminatory legislation. Trade liberalization promotes the movement of commodities, services, and information across countries, which may increase the availability of advanced and affordable technology. This, in turn, speeds up the shift towards a low-carbon economy; as to the findings of Akbar et al. (2020), the success of green Energy relies on several aspects, such as the structure of trade agreements, the extent of environmental goals, the accessibility of financial and technical assistance, and the alignment of energy policies with trade openness. In addition, several scholars, including Akbar et al. (2020) and Hayat et al. (2022), have constructed a theoretical framework to demonstrate that trade liberalization may promote the spread of green energy technology. This is achieved by diminishing the expenses of importing and exporting renewable energy-related products and services. Sluggish: The first premise of this study posits that "increased commercial openness has a favorable and substantial impact on the consumption of green energy".

2-2) Good Governance and Green Energy Consumption

Three researchers from the World Bank, namely Daniel Kaufmann, Art Kraay, and Pablo Zoido Lobaton, aggregated data from surveys conducted by multiple international institutions such as the Economist Intelligence Unit, the International Country Risk Group, the Heritage Foundation, and the House of Freedom. They analyzed the economic, social, and political conditions of different countries and introduced a set of governance indicators. These three researchers began their study with the notion that the customs and institutions by which governance is implemented in a nation have a causal influence on the growth and development

of that country, particularly in terms of economic growth. Kaufmann et al. referred to these establishments and traditions as governance and analyzed its many aspects by evaluating and introducing six new metrics (World Bank). The second hypothesis of this study posits that the "Good Governance Index has a positive and significant impact on the consumption of green energy." This study will analyze the measures of good governance and their impact on the channels of influence regarding green energy usage.

2-2-1) Regulatory Quality

The efficacy of rules and regulations indicates the government's competence in devising and executing accurate policies and legislation. The private sector can enhance and advance its operations and development due to its capacity to formulate and implement policies and legislation (World Bank). The index benefits from using various forms of Energy and stimulates private-sector endeavors by enhancing government policies. Therefore, the quality of the laws may enhance renewable and nonrenewable energy consumption by leveraging scale effects. Regarding the use of renewable Energy, scholarly research has shown that a nation's governance indices, political systems, and institutional quality have a crucial role (Sarkodie and Adams, 2020; Cabeca et al., 2021). Enhanced regulatory procedures and government policies that promote sustainable energy systems may improve the overall energy profile and guide energy usage toward environmental preservation. Regulatory bodies have the authority to enforce antitrust rules in the energy industry, ensuring fair competition and high-quality consumer services. This may lead to an overall improvement in the quality of the energy sector. According to Abid (2017), robust institutions facilitate foreign investment by encouraging the use of ecologically sustainable technology, which in turn may effectively increase the use of renewable Energy.

Consequently, the favorable impact of the quality of laws and regulations on the adoption of green Energy suggests that enhancing the quality of laws leads to heightened knowledge and use of these sustainable energy sources. Nevertheless, it may need significant time for this consciousness to disseminate enough and for the populace to begin embracing it. One illustrative option is the installation of solar panels on residential rooftops. However, enhanced regulatory frameworks and improved organizational quality may effectively enhance energy consumption habits and expedite the transition process (Mahmood et al., 2021).

2-2-2) Rule of Law

The rule of law encompasses the public's opinion of how law enforcement agents comply with and uphold societal rules. It mainly pertains to the effectiveness with which contracts are executed; property rights are protected, the police force operates, the courts function, and the likelihood of crime and violence occurring (World Bank). But, the rule of law may facilitate the implementation of environmental policy. In addition, robust law and order guarantees the implementation of environmental legislation by instilling a sense of responsibility and the threat of legal consequences for failing to comply (Welsch, 2004). The rule of law has a detrimental impact on the use of nonrenewable resources, as anticipated by theoretical projections. It facilitates the enforcement of environmental regulations and diminishes the consumption of nonrenewable fuels, sometimes called "dirty energies" (Mahmood et al., 2021). Existing work has shown that the rule of law positively alters energy consumption patterns (Bellakhal et al., 2019; Oberthur et al., 2021).

Furthermore, Lu et al. (2021) said that the presence of effective governance contributes to the enhancement of energy efficiency. Hence, it might potentially contribute to mitigating the total energy consumption in any given nation. Enforcing stricter rules and upholding the rule of law is essential in ensuring that governments, producers, big polluters, and regulatory agencies adhere to international treaties and actively contribute to attaining global climate objectives. By implementing more stringent laws, nations can enforce pollution fees and other restrictions on the energy industry, leading to increased adoption of renewable energy sources and reduced greenhouse gas emissions. Salman et al. (2019) found that implementing a stringent rule decreases pollution levels.

Conversely, several studies have shown that the rule of law has had a detrimental impact on the development of Renewable Energy. According to Mahmood et al. (2021), South Asian nations have little commitment to incorporating Renewable Energy into their legislative systems. This conclusion aligns with Obeid's (2016) research, which determined that the rule of law facilitates the rapid dissemination of pollution and may be linked to the significant reliance of these economies on nonrenewable energy sources since the fossil fuel industry generates a substantial number of employment opportunities. Hence, implementing more stringent legislation and regulations pertaining to Energy in these nations might impede their operations and hinder their economic progress. Consequently, they now prioritize economic

development and adopt less strict energy regulations. Enhancing regulations may lead to decreased economic activity, reducing demand for all energy sources (Huang et al., 2022).

2-2-3) Government Effectiveness

The government's efficiency and effectiveness index measures how well public services are seen to be and the quality of national services. It also considers the competency and independence of government agents without being influenced by political influences. This index represents the government's efficacy in carrying out designated responsibilities, as determined by the World Bank. Therefore, the efficiency of the government may enhance the use of various forms of Energy. Moreover, the research has shown the impact of governmental inefficiency on using renewable energy sources. Galinato and Galinato (2012) contended that a feeble government is vulnerable to the influence of interest groups, which might impede the execution of environmentally friendly energy policy. As a result, public services cannot promote renewable energy sources effectively. An adept and streamlined administration, by facilitating human development and promoting a greater level of GDP, also contributes to the augmentation of renewable energy consumption (Huang et al., 2022).

2-2-4) Political Stability

This index quantifies the views of the probability of government instability or overthrow using unlawful or violent methods, as defined by the World Bank. An established and well-established government can provide the required duration to implement and attain renewable energy production capability. Conversely, political instability hampers the government's capacity to enforce environmentally friendly policies since an unstable administration faces pressure from local and international economic interest groups, preventing the implementation of stringent environmental regulations (Purcel, 2019). The efficacy and dependability of government policies are critical determinants of innovation and the uptake of novel technology. An unpredictable political climate is anticipated to adversely affect the acceptance of innovation, including implementing novel technology in the energy industry and using new and environmentally friendly energy sources (Johnstone et al. 2010). Political instability is likely to adversely impact the usage of Renewable Energy by limiting investment possibilities and lowering income (Marks et al., 2010).

2-2-5) Control of Corruption

Corruption control encompasses the endeavors of governmental authorities to advance personal interests, as well as the capacity of influential individuals and their interests to influence policies and regulations (World Bank). Mahmoud et al.'s research (2021) has shown that enhancing corruption control only hastens the adoption of nonrenewable energy sources. Arminen and Menegaki (2019) contended that corruption hinders the enforcement of environmental legislation. Therefore, enhancing measures to combat corruption should result in a decrease in the usage of nonrenewable Energy. However, according to Hassan et al. (2020), corruption is the primary factor behind environmental deterioration in Pakistan.

Furthermore, many studies have contended that countries with feeble institutions are more inclined to welcome foreign investment due to the potential for foreign investors to engage in bribery with the bureaucracy to circumvent environmental regulations (Larraín and Tavares, 2004). In their study, Oberthür et al. (2021) have discussed the influence of corruption control on energy usage. Efficiently managing corruption may lead to a boost in economic activity, resulting in overall economic development. Additionally, it can increase the use of Renewable Energy by raising income levels (Mehrara et al., 2015; Mahmoud et al., 2021). There are two perspectives on the impact of corruption on economic growth: the efficiency and inefficiency schools of corruption:

A) School of Corruption Efficiency: Leff, Bayley, and Huntington argue that laws and institutions in developing nations are ineffectual, and they propose that corruption in the public sector is a means to address this inefficiency. According to Mehrara et al. (2015), corruption is seen as a lubricant for developing nations' stagnant economic and administrative systems. This facilitates internal investment innovations and ultimately leads to economic progress in these countries.

B) According to Bardhan's perspective (1997), corruption hampers economic progress via many means. Engaging in rent-seeking activities is more lucrative in corrupt situations than engaging in constructive employment. Consequently, financial incentives are directed towards rent-seeking activities rather than engaging in productive labor. Furthermore, in corrupt settings, it is well understood by businesspeople that they must pay a sum of money, known as a bribe, before taking any action. However, due to the clandestine nature of bribery, the recipient of the bribe may not fulfill their commitments as expected. Corruption not only leads to disrespect and mistrust towards the government system of a country but also hinders

innovations and inventions. Consequently, under these circumstances, a decline in economic growth is inevitable (Mehrara et al., 2015).

2-2-6) Voice and Accountability

This index pertains to the level of autonomy that individuals have in influencing the government selection process and the level of independence that mass media has, as stated by the World Bank. This statistic is sometimes known as the democracy index. A democratic administration is characterized by its attentiveness to its population's demands and responsiveness in delivering services. A government of this kind will ultimately serve as a foundation for fostering comprehensive economic progress and advancing human well-being. Chen et al. (2021) found that nations with a greater level of democracy outperform countries with a lower level of democracy in the realm of green Energy. In nations with precarious freedom of speech, this measure will have limited efficacy in influencing energy use across all categories. Implementing this index will enhance the incentive for economic activities, leading to a subsequent rise in revenue and use of renewable energy resources (Mahmoud et al., 2021).

2-3) Human Capital and Green Energy Consumption

Human capital has the potential to influence green energy usage via three distinct mechanisms. Enhancing human capital and knowledge within a country would foster a greater inclination towards a green economy. But, the presence of human capital leads to heightened environmental concerns, including issues like air pollution and global warming. Furthermore, similar to how the accumulation of personal human capital leads to individual economic development and a rise in personal income, at the national level, human capital may be seen as a production component compatible with physical capital. The comprehensive production performance framework demonstrates that expanding human capital is both a prerequisite and a result of economic development. Human capital can impact the use of environmentally friendly Energy through economic expansion.

Furthermore, the augmentation of human capital allows the industrial sector to implement and use novel technology. Given the use of sophisticated equipment in the renewable energy sector, there is a need for highly experienced workers who can both install innovative green energy technology and provide maintenance and repair services. Based on the three indicated pathways, it can be inferred that human capital growth would positively impact green Energy use (Mehrara et al., 2015). This study's third hypothesis posits a positive and substantial correlation between human capital and the usage of green Energy.

2-4) Income and Green Energy Consumption

Energy consumption has long been a critical driver of wealth and economic progress. Within the realm of economic studies and ideas, there often exists a direct correlation between Gross Domestic Product (GDP) and renewable and nonrenewable energy sources. Greater energy consumption is anticipated to correlate with elevated levels of economic development, thus leading to an upsurge in income. This gain in money will likely overshadow the use of environmentally friendly energy sources. According to Marques et al. (2010), an anticipated correlation exists between increasing income levels and increased use of green Energy. Given the significant cost associated with building enterprises and technology for extracting green Energy, those with higher income levels will have the financial capacity to cover these expenses.

Conversely, a more significant income level leads to an increase in investment in Renewable Energy. Additionally, a higher income provides a greater capacity to shoulder the financial burdens associated with regulatory expenses and laws about the advancement of renewable Energy. Based on the information provided, it has been determined that an increase in wealth has a beneficial and substantial impact on using environmentally friendly energy sources (Marques et al., 2010; Sadorsky, 2009).

3) METHODOLOGY

The present study seeks to examine the factors that impact the utilization of green Energy, with a particular focus on analyzing the degree and nature of influential factors such as good governance index, income (gross domestic product), gross fixed capital formation, inflation, human capital, and trade openness within the group of seven countries. The analysis used panel data and the quantile panel regression econometric technique. Quantile panel regression, first proposed by Koenker and Bassett (1978), offers an alternative to ordinary least squares (OLS) regression and similar techniques that usually presume a consistent connection between the independent and dependent variables across all levels. Quantile regression is a kind of regression analysis that is not based on estimating the relationship between variables using a specific amount or subset of data. In ordinary least squares (OLS) regression, the goal is to minimize the discrepancy between the projected values generated by the regression line and the actual observed values. Panel data quantile regression, in contrast, assigns varying weights to the disparity between the projected values from the regression line and the actual observed values, intending to minimize these weighted discrepancies. The primary benefit of the quantile

panel regression approach is its ability to analyze the correlations between factors beyond the average of the data. This makes it valuable for interpreting findings that deviate from a normal distribution and have non-linear associations with predictor variables. Quantile regression has two benefits over regular least squares regression. Firstly, it does not rely on any assumptions about the distribution of the target variable. Secondly, this approach is less affected by outliers and non-normality of data, as stated by Cook and Manning (2013).

Therefore, the complete definition of quantile panel regression is defined as equation:(1)

$$Y_i = X_i \beta_\tau + U_{\tau i} \quad , \quad 0 < \tau < 1 \qquad \textbf{Equation (1)}$$

Equation (2) shows the conditional quantile function of the dependent variable (target) conditional on the explanatory variables (x).

$$Quant_\tau (Y_i \mid X_i) = X_i \beta_\tau \qquad \textbf{Equation (2)}$$

Also, according to equation (3), the following condition holds for the mentioned conditional quantile function.

$$Quant_\tau (U_i \mid X_i) = 0 \qquad \textbf{Equation (3)}$$

Quantile panel regression estimates the impact of observable variables on the conditional distribution (Equation 2) by minimizing the absolute value of the errors (u). Therefore, according to equation (4), the model's coefficients are estimated by minimizing the absolute value of the errors using suitable weighting.

$$\text{Min} \sum \tau \, |y_i - x'_i\beta| + \sum (1 - \tau) \, |y_i - x'_i\beta|]$$
$$Y_i > x'_i \beta \quad Y_i < x'_i\beta \qquad \textbf{Equation (4)}$$

Therefore, equation (4) calculates the model's output using linear programming. Hence, in line with the objective of the present study, the E-Views12 econometrics program was used to analyze the data and estimate the research model. The significance of the results was determined based on probability at a confidence level of 95%. Initially, this study examines the research variables in terms of their stationarity. The Levin, Lin, and Chu (LLC) unit root test was used to investigate the stationarity of the variables. Subsequently, after the execution of the diagnostic tests, the estimation technique for the model is established, ultimately resulting in the estimation of the coefficients. Based on the test findings, including the normality test, it was determined that the most suitable approach for estimating the model in this study is the quantile panel regression econometric methodology. The statistical population of the current research consists of the nations belonging to the Group of Seven, as previously stated. The

study period from 1996 to 2022 was chosen because of the abundance of statistics and data about the factors studied. Based on the above situations, the data investigated in this study is of the panel data type.

The current research model investigates the factors that influence the consumption of green Energy in the Group of Seven countries. It is based on previous studies by Qing et al. (2024) and Huang et al. (2022) and is represented by equation (5):

$$\ln REC_{it}=\alpha+\beta_1 GGI_{it}+\beta_2 \ln GDP_{it}+\beta_3 \ln GFCF_{it}-\beta_4 \ln INFL_{it}+\beta_5 \ln MYS_{it}+\beta_6 \ln TO_{it}+\varepsilon_{it} \quad \textbf{Equation (5)}$$

Table (1) describes the variables utilized and the source of each data in relation (5). The following discussion provides a more comprehensive explanation of each of the factors that have been used.

Table (1): Description of variables and data sources

Variable	Description	Source	Expected Sign (s)
REC	Renewable Energy Consumption (Measured in kilowatt-hours of primary Energy per person)	Our world in data	/
GGI	Good Governance Index	The Worldwide Governance Indicators (WGI)	+
GDP	Gross Domestic Product	World Development Indicators	+
GFCF	Gross Fixed Capital Formation (% of GDP)	World Development Indicators	+
INFL	Inflation, Consumer Prices (annual %)	World Development Indicators	-
MYS	The years of education of the adult population of 25 years and more	The UNESCO Institute for Statistics	+
TO	Trade (% of GDP)	World Development Indicators	+

Source: Research Findings

It is essential to mention that because the variables in this study were measured using various units, it is necessary to normalize the data before doing the experimental analysis to standardize it. Thus, the natural logarithm has been used to circumvent issues associated with data distribution. However, the decision to use the logarithmic form for the variables (excluding the Good Governance Index variable, for which the natural logarithm is not applied) has resulted in estimated coefficients that represent the elasticity of the variables about the consumption of green Energy. This makes it easier to interpret the coefficients. The Good Governance Index variable (GGI) was derived as an index based on the research conducted by Akhtaruzzaman (2021) and is calculated as a simple average of six indicators of good governance: Voice and Accountability, Political Stability, and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. Suppose the logarithmic version of this variable is not utilized in the model estimate. In that case, estimating the model will not be an issue since the variable is derived as an average of

six indicators. The study has focused on the dependent variable, the natural logarithm of green energy consumption (lnREC). The data related to lnREC has been acquired from the Our World in Data database. One of the independent variables in this study is the natural logarithm of real GDP, denoted by the notation lnGDP. Income is identified as a significant factor influencing the usage of renewable Energy, as per the stated theoretical grounds. This study used the real GDP at the constant price of 2010 in US dollars to measure income in the calculation. The data about this variable has been gathered from the World Bank website. Another factor being studied is the logarithm of gross fixed capital formation, denoted as lnGFCF. The data for this variable is obtained from the World Bank website. The variable LnINFL, representing the natural logarithm of inflation, is included as an independent variable in the research model. Information on this variable is obtained from the World Bank website. The variable used in this research, LnMYS, represents the average natural logarithm of the years of education of the adult population aged 25 and over. It measures the average number of years of education completed by individuals in this age group in a country, excluding any time that has passed. To reiterate individual ratings. This study used the average educational attainment of individuals aged 25 and above to assess human capital's influence on adopting renewable energy sources. The relevant data was obtained from The UNESCO Institute for Statistics (UIS). Additionally, the study model incorporates the natural logarithm of trade openness as an independent variable, denoted as InTO. The relevant data for this variable is acquired from the World Bank website.

4) EMPIRICAL RESULTS

This section will provide and analyze the study results. Initially, the descriptive statistics will be examined, followed by the examination of inferential statistics derived from the pertinent estimations in the present study using E-views software.

4.1) Descriptive Statistics

According to the data in Table (2), due to the limited number of nations being examined, it has been determined that the graphs representing each variable will not be included in this report. Only the descriptive statistics for each variable will be published.

Table (2): Descriptive statistics of research variables

	REC	TO	GGI	MYS	GDP	GFCF	INFL
Average	7913/333	55/094	3	12/112	4/46e+12	21/330	1/729
Median	3946/261	54/959	3/150	12/585	2/69e+12	21/320	1/663
maximum	36249/360	99/880	4/258	14/255	2.54e+13	31/575	8/201
minimum	296/933	18/125	0/560	8/224	6.31e+11	15/711	- 1/352

Deviation from the norm	10320/550	18/779	1	1/546	4/88e+12	2/870	1/453
Number of observations	189	189	189	189	189	189	189

Source: Research findings

According to the data in Table (2), the mean of all variables is greater than the standard deviation. This suggests a lack of spread and variability in the variables. Avoiding distinct plots for each variable was necessary due to the many nations and years investigated. However, just a concise overview of descriptive statistics is given for each variable.

4.2) Inferential Statistics

Before doing any estimate, it is crucial to verify that the study variables are stable to avoid spurious regression, as the econometric literature recommends. When the study variables remain constant, the resulting estimates will not be affected by the issue of spurious regression, which refers to erroneous relationships. Firstly, the stationarity of the variables was examined using the Levin, Lin, and Chu (LLC) test. This test determined the importance of the variables based on the likelihood at a 95% confidence level. If the estimated P-value is less than 5%, the null hypothesis (H0) indicating the presence of a single root for the variables is rejected, implying that the variable is not significant. It was. The measured variables are stated individually in Table (3), and for certain variables, the mean is calculated by taking the first-order difference. This calculation was performed, and the Table includes the probability and t-statistic values.

Table (3): Unit root test

Variables	t-Test	probability value	degree of stationary
LnREC	- 2/932	0/001	(1)
LnTO	- 1/685	0/046	(0)
GGI	- 2/362	0/009	(0)
LnMYS	- 4/892	0/000	(0)
LnGDP	- 5/691	0/000	(1)
LnGFCF	- 1/940	0/026	(1)
LnINFL	- 5/717	0/000	(1)

Source: Research findings

Now, the Chow Test is used to identify the kind of study data, whether Pooled or Panel. Subsequently, suppose the data is in panel format. In that case, the appropriateness of using either fixed effects or random effects approaches for model estimation is assessed by the use of the Hausman test. The null hypothesis (H0) in the Chow Test posits that all the widths of

the origins are equal, indicating no statistically significant difference between the individual effects. The data reported in Table (4) shows that the null hypothesis (H0) is rejected. This is because the probability value is less than the crucial value (0.05), indicating that the pooled regression (H0) hypothesis is not supported.

Table (4): The estimation results of Limer's F test

Test statistics	The value of the statistic	Probability value
The value of the F statistic	165/277	*0/000
The value of the chi-square statistic	357/640	*0/000

Source: Research findings. * Significance at the 5% level.

On the other hand, based on table (5), the results of the Hausman test are reported. The Hausman test checks whether the equation should be estimated with fixed or random effects, and the test results show that the model is with fixed effects. Because the probability value is less than the critical value (0.05), hypothesis H0 (random effects) is rejected.

Table (5): The estimation results of the Hausman test

Test statistics	The value of the statistic	Probability value
Cross-section random	991/665	*0/000

Source: Research findings

* Significance at the 5% level.

Following the test completion, as mentioned earlier, assessing the dependent variable's normalcy is necessary. Based on Table (6) findings, the Jarque-Bera Test indicates that the dependent variable (green energy consumption) is not normally distributed. This is supported by the probability value being lower than the critical value (0.05), leading to the rejection of the hypothesis H0 (normality). Therefore, when the traditional linear assumption is violated, such as when the dependent variable is not normally distributed, the quantile panel technique provides more dependable outcomes. Furthermore, Figure (3) illustrates the procedure for assessing the normality of the dependent variable.

Table (6): The results of the normality test of the dependent variable (Green Energy Consumption)

Description	Value
Jarek-bra statistics	147/292
Probability value	*0/000

Source: Research findings

* Significance at the 5% level.

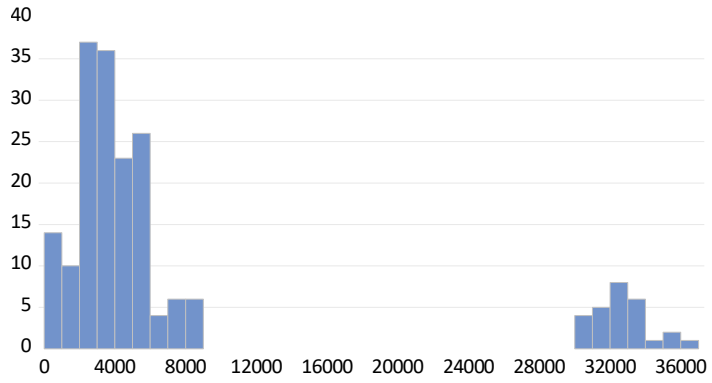

Fig (3): Showing the results of the normality test of the dependent variable (green energy consumption). **Source:** Research findings

Furthermore, according to the findings presented in Table (7), Pagan's test reveals the presence of autocorrelation in the disturbance components. This conclusion is drawn based on the probability value being lower than the critical value of 0.05, leading to the rejection of the H0 hypothesis that suggests the absence of autocorrelation.

Table (7): Checking the correlation between the disturbance components

Description	Value
Brosh Pagan test	176/536
Probability value	*0/000

Source: Research findings
* Significance at the 5% level.

The diagnostic test findings (co-accumulation) have been presented based on the information in Table (8). Cointegration is a statistical method used to determine the enduring connections between variables over a prolonged period. The study used Johansen's collocation test for analysis. According to the data in Table (8), because the probability value is higher than the critical value (0.05), we may conclude that the H0 hypothesis, which suggests the lack of a long-term connection between the study variables, is supported. Consequently, it can be inferred that the variables do not exhibit a long-term relationship.

Table (8): Checking the correlation between the disturbance components

Description	Value	probability level
ADF test statistic	- 0/490	0/312

Source: Research findings

Based on the completed tests, it can be inferred that the quantile panel regression in this section is accurate. Therefore, after the specified tests have been reviewed, the quantile model is computed in the last phase. The outcomes of estimating this model are shown in Table (9).

Table (9): Estimation of the Quantile model

Variable	Quantile	Coefficient	T statistic value	probability level
GGI	10	0/590	9/356	0/000
	20	0/571	8/761	0/000
	30	0/538	7/810	0/000
	40	0/246	2/356	0/019
	50	0/183	1/828	0/069
	60	0/156	1/163	0/246
	70	0/055	0/434	0/664
	80	0/085	0/535	0/592
	90	0/022	0/185	0/853
LnGDP	10	0/756	4/346	0/000
	20	0/736	3/880	0/000
	30	0/780	4/021	0/000
	40	0/368	1/240	0/216
	50	0/088	0/231	0/817
	60	0/949	5/754	0/000
	70	0/959	4/193	0/000
	80	1/016	2/813	0/005
	90	1/032	4/452	0/000
LnGFCF	10	1/071	2/673	0/008
	20	1/402	3/808	0/000
	30	1/737	4/826	0/000
	40	0/933	1/676	0/095
	50	0/474	0/842	0/400
	60	- 0/193	- 0/160	0/873
	70	- 0/961	- 0/829	0/407
	80	- 0/664	- 0/361	0/718
	90	- 0/907	- 0/627	0/531
LnINFL	10	- 0/131	- 0/981	0/327
	20	- 0/060	- 0/414	0/679
	30	- 0/050	- 0/331	9/741
	40	- 0/142	- 0/910	0/364
	50	- 0/242	- 1/229	0/220
	60	- 0/627	- 3/308	0/001

Variable	Quantile	Coefficient	T statistic value	probability level
	70	- 0/478	- 2/740	0/006
	80	- 0/423	- 1/688	0/092
	90	- 0/423	- 2/225	0/027
LnMYS	10	2/986	2/586	0/010
	20	2/460	2/011	0/045
	30	1/853	1/605	0/110
	40	1/477	1/460	0/145
	50	2/157	1/688	0/093
	60	6/256	6/811	0/000
	70	6/416	7/486	0/000
	80	7/129	5/898	0/000
	90	6/538	7/476	0/000
LnTO	10	1/271	4/776	0/000
	20	1/358	5/587	0/000
	30	1/533	7/002	0/000
	40	0/987	3/059	0/002
	50	0/694	1/918	0/056
	60	- 0/309	- 1/163	0/246
	70	- 0/444	- 0/887	0/376
	80	- 0/861	- 0/857	0/392
	90	- 1/189	- 1/845	0/066

Source: Research findings

In the following, the results obtained from table (9) are interpreted:

The Good Governance Index (GGI) significantly impacts the logarithm of green energy consumption in all deciles, except for the fifth to ninth deciles. The remaining deciles show statistical significance. Therefore, if all other parameters remain stable, a one-unit rise in GGI results in a logarithmic increase in green energy consumption ranging from 0.24 to 0.59 percent. The rise in the Good Governance Index leads to an increase in economic growth and GDP, which in turn gives the rationale for the increased use of green Energy. This outcome aligns with the investigation's findings conducted by Akhtaruzzaman (2021).

The logarithm of gross domestic product (LnGDP) positively affects the logarithm of green energy consumption in all deciles except for the fourth and fifth deciles. The other deciles show

statistical significance. Therefore, if all other parameters remain stable, a one percent rise in the natural logarithm of GDP (LnGDP) leads to a corresponding increase in the logarithm of green energy consumption ranging from 0.73 to 1.03 percent. Consequently, a direct correlation exists between GDP and green energy consumption since more energy consumption is anticipated to drive economic development and raise income levels, which in turn may overshadow the importance of green energy consumption. Higher-income levels are predicted to correlate with increased use of green Energy (Marques et al., 2010).

The logarithm of gross fixed capital formation (LnGFCF) positively impacts the logarithm of green energy consumption for deciles up to the fifth, and the first, second, and third deciles show statistical significance. Assuming all other parameters remain stable, a one percent rise in LnGFCF leads to a logarithmic increase in green energy consumption ranging from 1.07 to 1.73 percent. Consequently, the rise in Gross Fixed Capital Formation (GFCF) enhances productivity and economic expansion, perhaps prompting the implementation of regulations for advancing renewable energy sources.

The logarithm of inflation (LnINFL) negatively impacts the logarithm of green energy consumption across all deciles. Specifically, the sixth, seventh, and ninth deciles show statistically significant effects. Assuming all other parameters remain stable, a one percent rise in LnINFL results in a drop in the logarithm of green energy consumption by around 0.42 to 0.62 percent. The analyzed nations exhibit an inverse correlation between the inflation rate and green energy use.

The logarithm of human capital (LnMYS) positively influences the natural logarithm of green energy consumption in all deciles except for the third, fourth, and fifth deciles. The remaining deciles have statistical significance. Assuming all other parameters remain stable, a one percent increase in the natural logarithm of MYS results in a logarithmic rise in green energy consumption ranging from 2.46 to 7.12 percent. Consequently, when the level of human resources grows, there is a corresponding rise in environmental issues such as air pollution and global warming. This, in turn, presents a chance to implement and use innovative technology. Consequently, it can be inferred that enhancing human capital would positively impact the use of green Energy (Mehrara et al., 2015).

The logarithm of trade openness (LnTO) positively impacts the logarithm of green energy consumption for deciles up to the fifth, and there is statistical significance for deciles ranging from the first to the fourth. Therefore, if all other parameters remain stable, a one percent rise

in the natural logarithm of green energy consumption (LnTO) results in a logarithmic increase in green energy consumption between 0.98 and 1.53 percent. Trade liberalization enables the smooth movement of products, services, and information across countries. This may enhance the availability of breakthrough technologies and speed up the shift towards a low-carbon economy. Hence, trade liberalization may promote the spread of environmentally friendly energy technology by decreasing the expenses associated with importing and exporting renewable energy-related products and services (Akbar et al., 2020; Hayat et al., 2022).

Based on the results mentioned, it can be inferred that several factors contribute to the lack of significant effects on the consumption of green Energy in different quantities. These factors include the insufficient observations in various deciles, the limited influence of variables on distribution points, and the inherent variations in the distribution of the dependent variable in this study. Furthermore, based on the data in Table (10), the quantile analysis has identified the specific nations assigned to each quantile.

Table (10): Distribution of countries based on different quantiles

Quantile	Country
Max	Canada, United States
75 th percentile	France
50 th percentile	Germany, Italy
25 th percentile	Japan
Min	United Kingdom

Source: Research findings

5) CONCLUSION AND POLICY SUGGESTIONS

The present study seeks to examine the factors that influence the adoption of green Energy, with a specific focus on analyzing the magnitude and nature of the impact of the Good Governance Index, human capital, trade openness, gross domestic product income, inflation, and gross fixed capital formation within the Group of Seven (G7) countries. The analysis used panel data and the quantile panel regression econometric technique. The investigated sample spans from 1996 to 2022. The estimate of the regression model revealed that all the variables examined were statistically significant in most of the quantiles tested, and their signs were compatible with the theoretical underpinnings.

One additional finding from this study is that gross domestic product (income) significantly influences the utilization of green Energy in G7 nations. Hence, to create an effective energy policy, it is crucial to comprehend the correlation between income and the use of

environmentally friendly energy sources. Additionally, accurate income elasticities for green energies play a significant role in formulating an efficient energy policy. Upon analyzing the acquired findings, it can be concluded that adopting price policies, such as raising the cost of fossil fuel resources to encourage the usage of Renewable Energy, may not effectively accomplish the intended objective of boosting the consumption of green Energy in the specified nations. Hence, it is advisable to devise and execute non-monetary measures, such as legal assistance and economic support in the form of financial aid and subsidy disbursements, establishment of institutions, adoption of innovative technologies, and promotion and provision of resources in renewable Energy.

Furthermore, given the favorable and substantial impact of the Good Governance Index and human capital on the utilization of environmentally friendly Energy, it is recommended to prioritize the enhancement of legislation and regulations, the enforcement of legal principles, and the formulation and execution of laws aimed at safeguarding the environment and advancing the growth of sustainable energy sources. Furthermore, this research suggests that society plays a crucial role in the advancements of the energy sector. It is recommended that the focus be on establishing political and economic stability and enhancing the training and development of specialized human resources. This can be achieved by expanding and improving educational programs in terms of quantity and quality, with the active involvement of universities. Additionally, making the most of available opportunities for technical and academic cooperation with countries that possess advanced technologies is advised. Lastly, raising awareness and promoting the adoption of new energy sources should be prioritized.

One suggestion for future research is to examine the individual impact of each sub-index of good governance on the adoption of green Energy in the G7 nations. Furthermore, the coefficients obtained in this study may lack reliability owing to the use of diverse primary energy sources and various oil products for power production and the subsidies provided by OPEC member nations to these products. Hence, it is advisable to incorporate the cost of alternative energy sources and petroleum products into the model to enhance the elucidation of the acquired coefficients and outcomes. This would necessitate conducting a separate and supplementary investigation. Consequently, including these factors in future research can be recommended.

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