Journal of Economic Cooperation and Development, **46**, 4 (2025), 27-54

Human Capital Development and its Impact on Environmental Sustainability in OIC Nations: A Panel Data Approach

Noorazeela Zainol Abidin[1], Mohd Shahidan Shaari[2],
Ahmad Nizam Che Kasim[3], Abdul Rahim Ridzuan[4] and David Forgenie[5]

ABSTRACT

Education plays a vital role in reducing a country's carbon dioxide emissions and other environmental problems by fostering a sense of social responsibility. However, in some developing countries, increasing education levels may lead to a slight rise in carbon emissions due to greater economic expansion and productivity. Twenty countries from the Organization of Islamic Cooperation (OIC) were studied to determine the impact of human capital on carbon dioxide emissions between 1990 and 2019. The study was conducted using a panel static approach. The findings reveal a significantly positive correlation between CO_2 emissions, gross domestic product, and trade openness. At the same time, education, foreign direct investment, and the interaction between the country dummy and year of schooling are negatively related to CO_2 emissions in OIC countries. Policymakers can leverage these results to devise strategies that incorporate environmental education to reduce CO2 emissions. As carbon taxes and renewable energy subsidies are two policy changes that aim to reduce CO_2 emissions, educating more people about them can help these policies to be better understood. Supporting these adjustments will help persuade governments and businesses to combat climate change.

ملخص

تلعب التربية والتعليم دورا محوريا في الحد من انبعاثات ثاني أكسيد الكربون وغيرها من المشكلات البيئية من خلال تعزيز الشعور بالمسؤولية الاجتماعية. ومع ذلك، قد يؤدي ارتفاع مستويات التعليم في بعض الدول النامية إلى زيادة طفيفة في الانبعاثات الكربونية نتيجة التوسع الاقتصادي وزيادة الإنتاجية. وقد تناولت هذه الدراسة 20 بلدا من بلدان

[1] Faculty of Business and Communication, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia. E-mail: noorazeela@unimap.edu.my
[2] Faculty of Economics and Business, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail: smshahidan@unimas.my
[3] Faculty of Business and Communication, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia. E-mail: ahmadnizam@unimap.edu.my
[4] Institute for Big Data Analytics and Artificial Intelligence, Universiti Teknologi MARA, Malaysia. E-mail: Rahim670@uitm.edu.my
[5] Department of Agricultural Economics and Extension, Faculty of Food and Agriculture, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago. E-mail: anthonyforgenie@gmail.com

منظمة التعاون الإسلامي (OIC) لدراسة أثر رأس المال البشري على انبعاثات ثاني أكسيد الكربون خلال الفترة من 1990 إلى 2019، باستخدام أسلوب التحليل الساكن للبيانات اللوحية. أظهرت النتائج وجود علاقة إيجابية ذات دلالة إحصائية بين انبعاثات CO_2 والناتج المحلي الإجمالي وانفتاح التجارة، في حين كان للتعليم، والاستثمار الأجنبي المباشر، والتفاعل بين المتغير الصنعي للبلد وعدد سنوات الدراسة، تأثير سلبي على الانبعاثات. يمكن لصنّاع السياسات الاستفادة من هذه النتائج لوضع استراتيجيات تدمج التعليم البيئي بهدف خفض الانبعاثات، حيث يعد التثقيف حول ضرائب الكربون ودعم الطاقة المتجددة عاملا مهما لفهم أفضل لتلك السياسات ودعم تنفيذها، مما يعزز من دور الحكومات والشركات في مواجهة تغير المناخ.

RÉSUMÉ

L'éducation joue un rôle essentiel dans la réduction des émissions de dioxyde de carbone et d'autres problèmes environnementaux d'un pays en renforçant le sens des responsabilités sociales. Cependant, dans certains pays en développement, l'augmentation du niveau d'éducation peut entraîner une légère augmentation d'émissions de carbone en raison de l'expansion économique et de la productivité croissante. Vingt pays de l'Organisation de la coopération islamique (OCI) ont fait l'objet d'une étude visant à déterminer l'impact du capital humain sur les émissions de dioxyde de carbone entre 1990 et 2019. L'étude a été réalisée grâce à une approche fixe. Les résultats révèlent une corrélation positive significative entre les émissions de dioxyde de carbone, le produit intérieur brut et l'ouverture commerciale. Dans le même temps, il existe une relation négative entre l'éducation, les investissements directs étrangers et l'interaction entre la variable fictive du pays, l'année d'études et les émissions de dioxyde de carbone dans les pays de l'OCI. Les décideurs politiques peuvent mettre à profit ces résultats pour élaborer des stratégies intégrant l'éducation à l'environnement afin de réduire les émissions de dioxyde de carbone. La taxe carbone et les subventions aux énergies renouvelables étant deux changements politiques visant à réduire les émissions de dioxyde de carbone, sensibiliser davantage de personnes à ces questions pourrait contribuer à une meilleure compréhension de ces politiques. Soutenir ces changements aidera à convaincre les gouvernements et les entreprises de lutter contre le changement climatique.

Keywords: CO_2 emission, education, GDP, FDI, trade openness, OIC countries

JEL Classification: F4, O5, Q5, Q54, Q56, I2

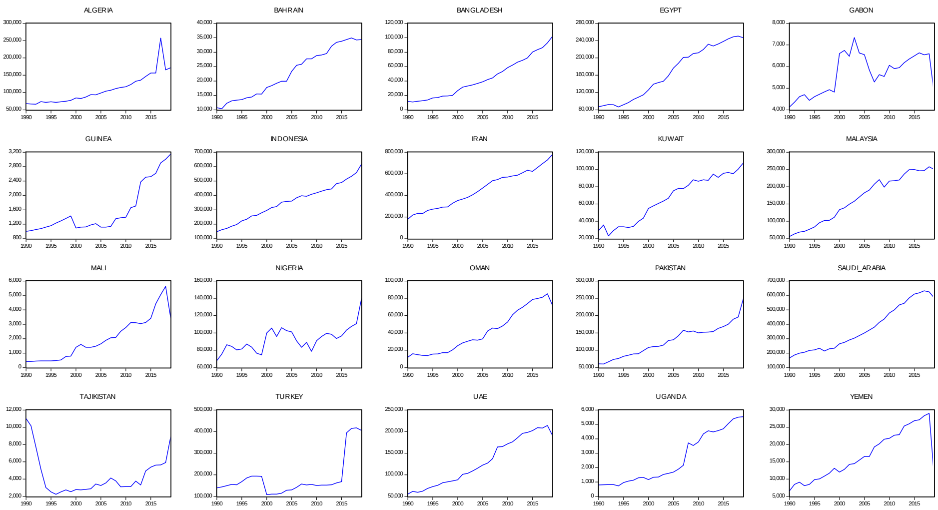
1. Introduction

Carbon dioxide (CO_2) is not just a byproduct of modern industrialization and technology. It is a major atmospheric pollutant that is pushing this planet to the brink. The nuclear industry, fossil fuel combustion, and turbines used to generate electricity are all significant sources of carbon dioxide. This greenhouse gas acts like a blanket in the atmosphere, trapping heat that warms the planet (Dhayal et al. 2024). The accumulation of carbon dioxide is a stark indicator of a planet in distress. Increases in atmospheric carbon dioxide contribute to global warming, rising sea levels, and more frequent and severe weather events. Wildfires, floods, extreme heat, and drought are some of the devastating consequences that are worsening due to carbon emissions. The urgency of the climate crisis cannot be overstated, and our research aims to provide insights that can help mitigate this global threat.

It is expected that in 2024, worldwide CO_2 emissions, mostly produced by the combustion of fossil fuels, will rise to levels last seen before the COVID-19 pandemic began. Moreover, human activities, especially energy use, are the primary driver of current climate change, as stated by Raihan et al. (2023) and Kurniawati et al. (2023). A growing concern is brewing concerning finite energy sources and a new green economic paradigm as a result of the alarming phenomenon of global warming (Abdollahbeigi, 2020 & Majekodunmi et al., 2023). The relationship between increased economic activity, energy use, and environmental degradation has been debated for decades (Pujiati et al., 2023; Ridzuan et al., 2023). Rising energy use and economic activity have led to increased carbon dioxide emissions and environmental degradation (Shaari et al., 2023). Before, improving energy efficiency was one of the most cost-effective ways to lessen pollution and boost the economy, but this is no longer the case. Saving money on utilities means more money for other purchases that boost happiness and health, which in turn boosts productivity at home and business. It has been stated that the rate of economic expansion is directly related to energy consumption (Adhikari & Chen, 2012). Energy is just as critical as labor and capital for a flourishing economy. Yet, there has been some discussion about this issue because wasteful energy consumption is bad for the planet. This is because increased energy use may affect air quality due to increased emissions of carbon dioxide.

Figure 1 depicts the trend in CO_2 emissions across OIC countries. The trend demonstrates a consistent rise in regional emissions, prompting our decision to concentrate on these nations. Notably, between 1990 and 2019, greenhouse gas emissions among OIC countries surged by 91%. Some OIC members are among the 100 countries that ratified both the Kyoto and Montréal Protocols. Even as they make progress in environmental protection, many nations still face environmental problems at home (Shaari et al., 2020). According to the OIC Environment Report (2019), between 2000-2017, 38 of the 54 OIC countries with available data saw increased CO_2 emissions per capita. The biggest rise in CO_2 emissions per capita was in Saudi Arabia, at 6.7 metric tonnes. Next, Kazakhstan was seen at 5.9 metric tonnes, Oman at 5.8 metric tonnes, Turkmenistan at 3.9 metric tonnes, and finally, Iran at 3.0 metric tonnes. Nonetheless, CO_2 emissions fell the most per person in Qatar at 16.5 tonnes, followed by the UAE at 6.4 tonnes, Kuwait at 3.3 tonnes, and Bahrain at 2.8 tonnes. Countries that export fuel, such as Qatar, Bahrain, Kuwait, the United Arab Emirates, and Saudi Arabia, have persistently high per capita emissions. Carbon dioxide emissions per person in the 16 member countries, most of which are in Sub-Saharan Africa, stayed well below half a metric tonne.

Figure 1: Total CO_2 Emissions in OIC Countries



Source: World Bank

Rising atmospheric amounts of carbon dioxide are mostly attributed to human activities like the burning of oil, coal, and gas and the destruction of forests. Information on the labor force and the average level of education in OIC member nations is necessary for a human capital analysis. The lifelong effects of education in broadening people's horizons are undeniable. The amount of time spent in postsecondary education affects a person's learning potential. Education is critical in the fight against climate change, as stated by the United Nations (2021). Education has the power to change people's minds and behaviors. Customers are able to make better decisions as a result of education. The effects of global warming and how to adapt to them can be taught to children as early as five. Education benefits everyone, but it has a particularly beneficial influence on encouraging initiative in young people.

Previous research has explored the link between education and CO_2 emissions. For instance, Xin et al. (2023) emphasized the role of education in reducing emissions within China, while Lee et al. (2024) conducted research on the effect that tertiary education has on carbon dioxide emissions in 151 different nations. However, these studies overlooked a crucial aspect: the interaction between country classification dummy variables and years of schooling. Addressing this gap provides the impetus for the current study to contribute to the existing literature. Specifically, considering the distinction between upper-middle-income and lower-middle-income OIC countries is crucial in this context. Upper-middle-income and lower-middle-income countries within the OIC group often exhibit significant economic disparities. These differences can influence the availability of resources, technological capabilities, and policy priorities related to environmental conservation and emission reduction efforts. Understanding how education interacts with these economic gaps might help determine how well educational interventions reduce CO_2 emissions across economic contexts.

Given this background, the contributions of this study can be explained in two main aspects. First, this study can help policymakers to reduce CO_2 emissions by several factors, especially in human capital. The reason is through education, the rise in human capital can decrease CO_2 emissions in a country. Policies to mitigate CO_2 emissions in OIC countries include enhancing the quality of education, increasing FDI, ensuring the efficiency of trade openness, and raising the GDP. Second, this research adds to previous research on the impact of human capital on CO_2 emissions. Previous studies did not delve deeply into the subject. Furthermore, this is the first study using the static panel method to examine the linkage between human capital and CO_2 emissions in OIC countries. The linkage between the nation dummy and the year of schooling is also shown in the study. As a result, CO_2 emissions are a critical issue that must be tackled, particularly in OIC countries. Based on the preceding debate, the future appears bright. This study is expected to produce new findings that will serve as a valuable reference for all parties involved. To the extent of our knowledge, the number of studies that have been carried out in nations that are members of the OIC is also quite low.

This paper focuses on two key Sustainable Development Goals (SDGs): SDG 4, which emphasizes quality education, and SDG 13, which addresses climate action. SDG 4 recognizes education as a critical driver of sustainable development, improving economic outcomes, and promoting environmental awareness and responsible behavior. By exploring the linkage between human capital development and environmental sustainability, the paper highlights how education can empower individuals in OIC countries to adopt sustainable consumption patterns and support eco-friendly policies, contributing to reducing carbon emissions. Education equips people with the knowledge to understand the implications of environmental degradation, fostering a more environmentally conscious society. Simultaneously, this study aligns with SDG 13, which calls for urgent action to combat climate change and its effects. Human activities, particularly in OIC nations with high industrial output, significantly contribute to rising CO_2 emissions. This paper posits that by enhancing education and building human capital, OIC countries can reduce emissions and promote sustainability, as educated populations are more likely to support cleaner technologies, renewable energy adoption, and effective climate policies. Overall, the paper contributes to SDG 4 and SDG 13 by demonstrating how education can be a powerful tool for achieving environmental sustainability and mitigating climate change in OIC countries.

2. Literature Review

2.1. Human Capital and CO_2 Emissions

The interplay between human capital and environmental sustainability is increasingly capturing attention, especially given the escalating worries surrounding carbon emissions. Human capital has served as a proxy for higher education in numerous studies examining the impacts of development on ecosystems. The team utilized both panel data and data gathered at the national level to examine this correlation. Khan (2020) indicated that for every additional year of education, there is a correlation with a decrease in CO_2 emissions between 50.1% and 65.8%. Higher education serves as an indicator of advanced human capital. The study indicates that elevated human capital correlates with lower emissions, attributed to factors such as heightened environmental awareness and the adoption of eco-friendly technologies. Lutz et al. (2014) reported that increased levels of education might correlate with a slight increase in emissions that contribute to global warming. Lower emissions have been associated with a decelerated population growth in additional studies (O'Neill et al., 2010).

Sapkota and Bastola (2017) proposed that an increase in human capital, particularly through a better-educated workforce, can enhance the adoption of greener industrial technology and reduce pollution. A recent investigation conducted by Afshan et al. (2023) analyzed China's ecological footprint to assess the influence of eco-innovation, green finance, and stringent environmental regulations. This investigation employed data between 2000 and 2017 and applied a distinctive quantile autoregressive distributed lag (QARDL) method to identify numerous relationships among the variables. The estimation results from QARDL indicate that eco-innovation, green finance, and stringent environmental policies have positively influenced China's ecological footprint, with the quantile affecting the intensity of this relationship. The Wald test of parameter constancy, which showed bi-directional causality among all variables across multiple quantiles, was employed to further validate the findings.

Yao et al. (2020) indicated that the previously robust positive relationship between human capital and CO_2 emissions in OECD countries has transitioned to a more pronounced negative correlation. This is essential because the human capital acquired through primary education may not influence the environment in the same way as human capital obtained through higher education, as demonstrated by Li and Wang (2018). Wang and Xu (2021) highlighted the significance of internet utilization and human capital in the context of low-carbon economic growth, indicating that human capital mitigates the negative impact of internet use on CO_2 emissions. Additionally, Alkhateeb et al. (2020) found that although primary and secondary education had no impact on CO_2 emissions, the level of energy consumption was significant.

Uddin (2014) identified a causal relationship between pollution, education expenditure, and economic growth. The findings of this study may assist authorities in managing pollution and enhancing their understanding of the impacts of economic growth on environmental quality. Short-term increases in CO_2 emissions can be linked to rises in human capital, energy consumption, and economic growth, as demonstrated in a study conducted in Indonesia by Bashir et al. (2018). Mahmood et al. (2019) indicated that the human capital of Pakistan has a detrimental impact on the nation's CO_2 emissions. Lim et al. (2021) found that China's creative people capital slows environmental degradation. This study shows that investing in innovative human resources may help China achieve economic growth and environmental sustainability. However, energy use, population density, and economic structure all increase CO_2 emissions. Research reveals that FDI reduces CO_2 emissions, but environmental sustainability requires more innovative human capital.

2.2. Foreign Direct Investment and Trade Openness on CO_2 Emission

The effects of globalization and FDI on OIC environmental quality were also examined. Farooq et al. (2020) used GMM panel data to examine how globalization and gender inequality affect economic development in the Organisation of Islamic Cooperation (OIC). They found that globalization boosts growth in high-income states but slows growth in low-income states. Shahbaz et al. (2016) found that Globalization's effects on environmental quality vary by country, although CO_2 emissions are falling overall. One study examined globalization through the tourism industry in 15 major tourist destinations and concluded that it considerably and positively boosts CO_2 emissions (Akadiri et al., 2019). Koengkan et al. (2020) showed that economic, social, and political globalization negatively affected Latin America and digital nations' natural worlds in their study of the symmetric effects of globalization on CO_2 emissions. Shahbaz et al. (2019) found that globalization, energy use, and commerce all raise CO_2 emissions in Pakistan, even while foreign direct investment cuts them in the near run. Globalization and pollution caused a severe decline in 25 developing countries' environmental quality between 1970 and 2014. Despite environmental quality being a variable, several studies using environmental pathways as an environmental criterion and investigating how FDI, trade liberalization, and internal efficiency affect OIC countries' environmental quality support this claim.

Pazienza (2019) found that more FDI could help the environment. Wang et al. (2013) found that foreign direct investment (FDI) has both good and negative effects on economic growth, labor productivity, and development in the receiving country. Despite scholarly claims that reducing CO2 emissions can benefit the environment, Liu et al. (2018) showed that FDI reduces carbon emissions and improves environmental quality. Ali et al. (2021) found that trade liberalization, human capital, and public investment benefit higher-income and overall OIC countries. Trade liberalization hurts low-income OIC states' economies, while human capital has little effect. Trade liberalization and human capital growth are essential for economic success, and OIC countries all have strong institutional performance and economic growth. Hassan et al. (2020) explained that natural resource extraction and consumption harm the ecosystem. Increased emissions may cost more than FDI in Pakistan.

Demena and Afesorgbor (2020) stated that FDI reduces pollution. Huang et al. (2018) stressed that the environmental Kuznets curve (EKC) only applies to the most polluted areas. FDI and trade positively affect CO2 emissions despite negative direct effects (Kaya et al., 2017). Bakhsh et al. (2020) found that FDI reduces Asian CO_2 emissions. Paramati et al. (2017) and Lin et al. (2021) discovered an inverse relationship between FDI and CO_2 emissions. FDI increases CO_2 emissions, although Shahbaz et al. (2015) observed that emissions can be reduced after a certain level. Chimbo (2020) proposed the growth theory, maintenance hypothesis, feedback hypothesis, and neutrality hypothesis to explain energy use and economic growth. Both the growth theory and the conservation hypothesis emphasize that economic growth increases energy use. The feedback hypothesis states that energy use and economic growth are interdependent, while the neutrality hypothesis does not. Kolawole (2017) used multiple approaches to study how CO_2 emissions and technical efficiency affect Ghana, Senegal, and Morocco's industrial structure and economic growth. The study found that Senegal and Morocco need economic growth, whereas Ghana needs technical efficiency to cut CO_2 emissions.

Zhang et al. (2020) reported that 45-55% of all energy consumption comes from the transportation, service, and residential sectors. Marbuah et al. (2021) defined the green consumer pattern to reduce energy demand and CO_2 emissions using a microscopic simulation model. Bin and Dowlatabadi (2005) used the consumer lifestyle approach to study how individual actions relate to energy use and greenhouse gas emissions. According to research by Girod and de Haan (2009), changing one's behavior can reduce carbon dioxide emissions by as much as 30 percent. Rahmani et al. (2020) explained that lifestyle choices made in the home can have a sizable effect on household energy use and carbon dioxide emissions.

2.3. The Role of Economic Growth on CO_2 Emission

Hassan et al.'s (2020) environmental quality study focused on globalization and energy usage intensity. They used panel ARDL data from 64 nations from 1970 to 2015 to examine CO_2 emissions and GDP. Results showed that global integration and energy use intensity increased CO_2 emissions, but GDP showed an inverted U-shaped connection that implied green growth. The study also found a global environmental Kuznets curve, implying that emerging nations may move towards green growth faster than developed economies despite polluting more with GDP.

Padhan et al. (2020) used cointegration analysis to examine the relationship between CO_2 emissions and economic activity in 31 countries, 28 of which are OECD members and three others—China, Brazil, and India. Different countries' air pollution-economic activity links must be evaluated to avoid inaccurate estimations and findings, as seen in the data. Pincheira (2019) used the vector error correction model to empirically analyze energy usage underestimation as a control variable and the carbon-Kuznets curve linkage. Similar to earlier studies, economic expansion controls emission intensity rather than absolute emissions. Kasperowicz (2015) found a short-term positive correlation between GDP and CO_2 emissions because the more intense energy consumption of existing technologies increases capacity and CO_2 emissions. Khan et al. (2020) noted that Pakistan's increased energy consumption and economic growth increase CO_2 emissions.

Li et al. (2022) used 1986–2020 data and the nonlinear ARDL (NARDL) approach to study the complex effects of institutional quality and other control variables on environmental sustainability in G7 nations. Institutional quality, foreign direct investment, trade openness, economic development, and environmental sustainability in G7 countries were asymmetric. The study stressed the importance of accounting for data nonlinearities to avoid misleading results and recommended country-specific policy methods to solve environmental sustainability issues. Using monthly data from 1992 to 2017, Fatima et al. (2021) examined the asymmetric and time-varying effect of international energy prices on China's CO_2 emissions using a non-linear ARDL model and wavelet analysis. Their findings showed that world energy prices affect CO_2 emissions differently across time and sectors. The study stressed the relevance of temporal and sectoral dynamics in energy policy development and warned against missing fundamental nonlinearities, which could miss the link between energy costs and CO_2 emissions.

Variations in CO_2 emissions measurements can yield diverse outcomes across countries, influenced by factors such as growth rates, environmental conditions, and pollution levels. This study employed a static panel approach to address a knowledge gap regarding human capital and carbon dioxide emissions in OIC countries, including Bahrain, Tajikistan, Uganda, Saudi Arabia, UAE, Algeria, Kuwait, Oman, Gabon, Iran, Malaysia, Turkey, Bangladesh, Egypt, Indonesia, Nigeria, Pakistan, Mali, Guinea, and Yemen. Previous studies examined human capital through enrolment metrics in K-12 and higher education. Utilizing years of education as an indicator of human capital enables this examination to focus on the connections between nations.

3. Data and Methodology

This study used the panel static methodology, which consists of three models: pooled ordinary least squares (POLS), fixed effect (FE), and random effect (RE), to investigate the relationship between human capital and carbon dioxide emissions in a selection of OIC nations (Bahrain, Kuwait, Oman, Saudi Arabia, UAE, Algeria, Gabon, Iran, Malaysia, Turkey, Bangladesh, Egypt, Indonesia, Nigeria, Pakistan, Mali, Guinea, Tajikistan, Uganda, and Yemen) from 1990 to 2019. In contrast to the complicated instrument variables the panel dynamics method requires, the panel static approach mixes time series data with cross-sectional data where T> N. The World Bank, the United Nations Development Programme, and Our World in Data all contributed data for this analysis. To verify that the panel data is stationary for either I(0) or I(1), we employed the unit root test developed by Levin et al. (2002) and Im et al. (2003) to evaluate the panel's data stationarity. For the data to be regarded as stationary, all variables must take on the value of I(1). In addition, IPAT, a fundamental model for gauging the combined effects of population (P), wealth (A), technology (T), and the natural environment (I), is outlined as follows:

$$I = f(P, A, T) \quad (1)$$

Population (P) is the size of the population that directly affects the overall environmental impact because more people generally result in higher consumption of resources and greater waste production. Affluence (A) refers to the level of economic wealth or consumption per person. In wealthier societies, the demand for goods and services tends to be higher, which can lead to greater use of resources and more emissions. The impact of technology (T) refers to the efficiency of production processes and the environmental impact of the goods and services produced. More advanced technologies can reduce environmental impacts. The IPAT model suggests that environmental impact (I) is a function of population (P), affluence (A), and technology (T). This means that the environmental impact is determined by these three factors.

CO_2 emissions were used as a surrogate for the impact on environmental degradation. Education may be used as a proxy for population, GDP per capita can be used as a proxy for prosperity, and foreign direct investment and trade openness can be used as a proxy for technology. In this research, two estimating models were used. The first estimation model was created to distinguish between human capital and CO_2 emissions. Meanwhile, in model two, the second estimation used a dummy variable to capture the interaction term between the country and education variables. The model is written as follows:

Model 1:

$$lnCO2_{it} = \beta_0 + B_1 YOS_{it} + \beta_2 lnGDP_{it} + \beta_3 lnFDI_{it} + \beta_4 lnTO_{it} + \varepsilon_{it}$$

$$i = 1, 2, \dots\dots, N \quad t = 1, 2, \dots\dots, T \quad (2)$$

Model 2:

$$lnCO2_{it} = \beta_0 + B_1 YOS_{it} + \beta_2 DM * YOS_{it} + \beta_3 lnGDP_{it} + \beta_4 lnFDI_{it} + \beta_5 lnTO_{it} + \mu_{it}$$
$$i = 1, 2, \dots\dots, N \qquad t = 1, 2, \dots\dots, T \qquad (3)$$

Based on equations 2 and 3, $lnCO_2$ is the dependent variable in this study, which refers to carbon dioxide emission, whereas independent variables such as YOS refer to the average year of schooling, and DM * YOS is the interaction between country dummy and year of schooling. DM refers to the dummy variable, which is D=2 if upper middle OIC country and D=1 if lower middle OIC country. Besides, lnGDP refers to the gross domestic product, lnFDI refers to foreign direct investment, and lnTO refers to trade openness, ln is the natural logarithm and is the error while i refers to the country and t for the year.

The coefficient of the constant budgeting model is a budgeting that uses the Ordinary Least Squares (OLS) approach. The assumption in the constant coefficient is homogeneity i.e., Var (u) = 0 or the intercept for the state is constant. The POLS model ignores the panel structure of the data and simply estimates. Meanwhile, the FE model is the differences across cross-sectional units that can be captured in differences in the constant term. An F-test was conducted to determine whether POLS or FE is the best model for this study.

If the results show that it is not a constant coefficient, then the null hypothesis will be rejected ($p < 0.05$), or in other words, a P value is smaller than the significant value of 5 percent. It indirectly indicates that the fixed effect estimation model is preferable and vice versa.

The individual-specific impact is a random variable in the random effects model unrelated to the explanatory factors. Individual effects are also randomly distributed among cross-sectional units in order to capture individual effects in the RE, according to Seddighi (2000). The Hausman test can determine which of the two models, RE or FE, is the best. If the estimated results show that the model is significant, that is, if the P value is less than 5 percent, the null hypothesis is rejected ($p<0.05$). As a result, fixed effect estimation is favored over variable effect estimation and vice versa.

4. Empirical Results

In Table 1, we observed significant variation across the variables, with each showcasing unique characteristics. A comparative analysis of the variables with the highest maximum and minimum values sheds light on their extremes and distributional properties. Based on the descriptive statistics provided in Table 1, the distribution and characteristics of the variables are as follows. For example, lnGDP has the highest maximum value at 36.9321, indicating a significant range in the data compared to other variables. In contrast, YOS has the smallest maximum value of 12.1000. Additionally, $lnCO_2$ has a moderate maximum value of 13.5665, while lnFDI and DM*YOS both have higher maximum values at 24.3985 and 24.2000, respectively. In terms of distribution, $lnCO_2$ and lnFDI have negative skewness, suggesting that their distributions are left-skewed, while lnTO shows a slight positive skew. The kurtosis values indicate that lnGDP and lnFDI have leptokurtic distributions (heavy tails), while the other variables, such as YOS and lnTO, have distributions closer to normal.

Table 1: Descriptive Statistics

	$lnCO_2$	YOS	DM*YOS	lnGDP	lnFDI	lnTO
Mean	10.5631	5.7672	9.4345	27.9099	20.0330	4.1494
Median	11.2199	5.9500	10.0000	28.5642	20.3152	4.0792
Maximum	13.5665	12.1000	24.2000	36.9321	24.3985	5.3955
Minimum	6.0403	0.3000	0.3000	10.6230	6.9078	2.9386
Std. Dev.	1.8741	2.8552	6.1398	5.1377	2.4017	0.5203
Skewness	-0.5848	-0.0648	0.1925	-1.2044	-1.2666	0.3586
Kurtosis	2.2433	2.0949	1.8201	5.6097	6.8537	2.5099

The results of the Breusch-Pagan LM and Pesaran CD tests reported in Table 2 provide no evidence of cross-sectional dependence in both Model 1 and Model 2. This result indicates that the observations across different units are not interrelated.

Table 2: Cross-Section Dependence Results

Test	Model 1		Model 2	
	Statistic	Prob.	Statistic	Prob.
Breusch-Pagan LM	77.9786	1.0000	63.7127	1.0000
Pesaran scaled LM	-5.7466	0.0000	-6.4784	0.0000
Pesaran CD	-0.3817	0.7027	-0.8786	0.3796

Table 3 displays the results of the unit root tests. For the LLC unit root test, the variables lnCO_2 and lnGDP are not significant at the level. Thus, the null hypothesis of a unit root is not rejected, indicating these variables are non-stationary at this stage. However, at the first difference, all variables (YOS, DM*YOS, lnGDP, lnFDI, and lnTO) are significant, and thus the null hypothesis is rejected, confirming stationarity. For the IPS unit root test, the results show that lnCO_2, lnGDP, YOS, and DM*YOS are not significant at the level, meaning the null hypothesis of a unit root is not rejected. However, all variables (YOS, DMYOS, lnGDP, lnFDI, and lnTO) are significant at the first difference, indicating stationarity as the null hypothesis is rejected. These findings suggest that POLS, fixed effects, and random effects analyses are suitable for this study.

Table 3: Unit root test

Variable	**LLC**		**IPS**	
	I(0)	I(1)	I(0)	I(1)
lnCO_2	-3.8806	-3.5099**	1.0913	-11.5385**
YOS	-2.4138**	-6.4380**	3.0336	-11.4135**
DM*YOS	-2.4138**	-6.4380**	3.0336	-11.4135**
lnGDP	0.6710	-6.1053**	6.4774	-9.8934**
lnFDI	-5.9907**	-12.5740**	-4.3012**	-15.5914**
lnTO	-2.3844**	-10.9425**	-1.7885**	-13.2455**

Note: ** show the significance levels of 5 %

Table 4 presents the estimated relationship between human capital and CO_2 emissions in OIC nations using two different model specifications. The first model was estimated without the interaction term between the dummy country variable and education in relation to CO_2 emissions in upper- and lower-middle-income OIC nations, while the second model includes this interaction term. To classify the results, three estimation techniques were used: Pooled Ordinary Least Squares (POLS), Fixed Effects (FE), and Random Effects (RE).

The selection between POLS and FE models was first made using the F-test. The F-test assesses whether the fixed-effects model is a better fit for the data than the pooled OLS model. The null hypothesis of the F-test is that the fixed effects are not necessary, implying that the pooled OLS model is sufficient. However, the test results showed that the probability of the null hypothesis being true is less than 5 percent, which led to the rejection of the null hypothesis. This rejection indicates that the FE model is preferred over the POLS model for both Model 1 and Model 2, as it accounts for individual heterogeneity across countries.

To refine the model selection, the Hausman test was performed to differentiate between the FE and RE models. The Hausman test helps determine whether the RE model is consistent and efficient or if the FE model is more appropriate. At the 5 percent significance level, the Hausman test favored the FE model, suggesting that fixed effects should be used instead of random effects in both models. Finally, to confirm the appropriateness of using RE over POLS, the Breusch-Pagan test was conducted. The Breusch-Pagan test assesses whether the RE model provides a significant improvement over the POLS model by testing the null hypothesis that the random effects are not needed. The test results indicated that the null hypothesis was rejected at the 5 percent significance level, further supporting the choice of fixed effects over random effects.

Table 4: CO_2 Emission Model Estimation Result

Variable	**Model 1**			**Model 2**		
	POLS	**Fixed Effect**	**Random Effect**	**POLS**	**Fixed Effect**	**Random Effect**
YOS	0.2653 (0.0265)**	-0.0955 (0.0127)**	0.1637 (0.0128)**	-0.0751 (0.0395)**	-0.1999 (0.0340)**	0.3290 (0.0352)**
DM*YOS	-	-	-	0.2168 (0.0199)**	-0.550 (0.0167)**	-0.0873 (0.0181)**
lnGDP	0.0036 (0.0137)	0.8614 (0.0404)**	0.5592 (0.0356)**	0.0027 (0.0125)	0.8114 (0.0428)**	0.4802 (0.0358)**
lnFDI	0.3574 (0.0273)**	-0.0163 (0.0062)**	-0.0031 (0.0069)	0.3269 (0.0251)**	-0.0143 (0.0062)**	0.0002 (0.0069)
lnTO	-1.0450 (0.1529)**	0.2351 (0.0465)**	0.1684 (0.0520)**	-1.6371 (0.1499)**	0.2286 (0.0461)**	0.1585 (0.0518)**
Constant	6.1077 (0.8840)**	-14.6782 (1.0983)**	-6.6250 (1.0243)**	9.1174 (0.8539)**	-13.3785 (1.1581)**	-4.5733 (1.0182)**
Observation	600	600	600	600	600	600
R^2	0.4252	0.0376	0.0577	0.5208	0.0347	0.0507
F test	1322.03 (0.0000)** Reject Null Hypothesis			1116.56 (0.0000)** Reject Null Hypothesis		
Hausman Test	248.41 (0.000)** Reject Null Hypothesis			195.05 (0.0000)** Reject Null Hypothesis		
Breush - Pagan Test	5336.44 (0.0000)** Reject Null Hypothesis			4644.45 (0.0000)** Reject Null Hypothesis		

Note: ** show the significance levels of 5%

Regarding the R^2 values, Model 1 has an R^2 value of 0.0376, which means that the independent variables account for approximately 3.76 percent of the variance in the dependent variable, CO_2 emissions. Model 2 shows a slightly lower R^2 value of 0.0347, which is equivalent to 3.47 percent. While these values are relatively low, they provide insight into the proportion of variation explained by the included variables. It is crucial to note that macroeconomic studies typically show lower R^2 values due to the complexity of the relationships being modeled and the presence of unobserved factors that influence the dependent variable. The F-test, Hausman test, and Breusch-Pagan test collectively guided the selection of the appropriate model. The FE model was found to be the most suitable choice, both in terms of accounting for individual heterogeneity across countries and offering a more accurate estimation compared to POLS or RE models. Table 4 above shows a summary of the CO_2 Emission Model Estimation analysis.

Based on the results of Model 1, shown in Table 2, it seems that all variables are critical in figuring out CO_2 emissions in OIC countries. The variables that significantly and favorably affect CO_2 emissions are education (YOS), gross domestic product (GDP), and trade openness. An increase of one year in schooling leads to a 0.10 percent reduction in CO_2 emissions, consistent with the result produced by Mahmood et al. (2019), Alkhateeb et al. (2020), and Khan (2020). This number can be attributed to education, which provides individuals with a better understanding of the environment and methods for reducing CO_2 emissions. When people have more information about how their actions affect the environment, they can make better choices about how they live and what they buy. Also, learning new skills can inspire technological breakthroughs that cut carbon dioxide output. Those with higher levels of education are more likely to pursue careers in sectors like engineering and science, where they might provide innovative solutions to environmental problems. More investment in renewable energy sources like solar and wind power, which emit less CO_2 than traditional sources like coal and oil, can also result from education.

Besides, an increase of 1 percent in GDP leads to a 0.86 percent increase in CO_2 emissions. This finding aligns with earlier studies by Kasperowics (2015) and Khan et al. (2020). A nation's GDP serves as a strong indicator of its energy consumption, which, in turn, is closely linked to its CO_2 emissions. This is largely due to fossil fuels such as coal, oil, and gas remaining the primary energy sources for the production and consumption of goods and services. Increases in industrial production and vehicle miles traveled are two major contributors to a nation's rising CO_2 levels as its economy expands. More automobiles on the road, more industries cranking out goods, and more power plants cranking out electricity to meet the increased demand are all examples of what an expanding economy might necessitate. Energy is needed for all of these things, and the most convenient source of energy is typically fossil fuels, which cause CO_2 emissions.

Similarly, trade openness benefits CO_2 emissions, with a 1 percent rise resulting in a 0.24 percent increase. Other essential variables, such as foreign direct investment (FDI) and the year of schooling, have a negative effect on CO_2 emissions. A 1 percent increase in FDI results in a 0.02 percent reduction in CO_2 emissions, in line with the findings of Wang et al. (2013), Liu et al. (2018), and Pazienza (2019). This is because FDI can help countries lacking resources acquire cutting-edge, environmentally friendly technologies. These innovations can produce cleaner manufacturing operations and more energy-efficient operations. Furthermore, foreign direct investment might encourage additional spending on carbon-free renewable energy sources, including solar, wind, and hydropower. In addition to lowering pollutants, this can also increase energy reliability. Also, FDI can lead to enhanced environmental legislation and standards in host nations, which in turn can aid in reducing emissions and advancing sustainable development.

The fixed effect results in Model 2 show that the lnGDP and lnTO variables are significant and have a positive effect in determining CO_2 emission in OIC countries. While YOS, the interaction between country dummy with a year of schooling and foreign direct investment are significant but indicating a negative sign, it can be proven that an increase of one year in schooling leads to a 0.20 percent reduction in CO_2 emissions. Other than that, when the 1 percent average years of school rises, CO_2 emissions in higher middle-income OIC nations will fall to 0.55 percent. The findings align with Yao et al. (2020). Furthermore, a 1 percent rise in foreign direct investment reduces CO_2 emissions by 0.01 percent in OIC nations. Because of technology spillover advantages, FDI can effectively reduce carbon emissions. Additionally, a 1 percent increase in GDP will lead to a 0.81 percent growth in CO_2 emissions. Fast-growing economies are experiencing significant air pollution and rapidly increasing carbon dioxide emissions. An increase of 1 percent in trade openness will result in a 0.23 percent rise in CO_2 emissions. This is because commerce aims to reduce the cost of production; it will allow businesses to create more items while neglecting environmental standards and regulations, resulting in environmental degradation.

Conducting the Generalized Linear Models (GLM) method serves as a robustness test to validate the results obtained from other modeling techniques, such as OLS regression. By comparing the results of GLM with those from traditional regression models, researchers can verify the robustness of their conclusions and identify potential limitations or biases in the initial model. Table 5 presents the results of GLM, indicating that GDP does not significantly influence CO_2 emissions. Conversely, variables such as YOS, YOS*DM, lnFDI, and lnTO demonstrate statistical significance in their impact on CO2 emissions.

Table 5: Generalized Linear Model Results

Variable	**Model 1**		**Model 2**	
	Coefficient	**Prob.**	**Coefficient**	**Prob.**
YOS	0.2653	0.0000	-0.0751	0.0577
DM*YOS	-	-	0.2168	0.0000
lnGDP	0.0036	0.7920	0.0027	0.8263
lnFDI	0.3574	0.0000	0.3269	0.0000
lnTO	-1.0449	0.0000	-1.6371	0.0000
C	6.1077	0.0000	9.1174	0.0000

5. Conclusion and Recommendation

According to the results, the FE estimator is the best model in this investigation. In OIC countries, human capital has a major impact on CO_2 emissions. The interplay between the country dummy and schooling harms CO_2 emissions in the long run. Environmental concerns such as global warming, water pollution, air pollution, and carbon dioxide emissions can be exacerbated by a lack of environmental knowledge. These studies have shed light on the environmental issue, assisting policymakers in formulating policies. The first step is to raise awareness through education. Environmental awareness can significantly enhance public understanding of the need for behavior change, adaptation, and skills to address the core causes of environmental problems, particularly those related to rising carbon dioxide emissions. If they have a better level of education and flawless knowledge of the environment, the number of people who die or are injured due to CO_2 emissions can be minimized. More knowledge should be given about the nuances and complexities of how the natural environment operates and the adjustments required in the industrialized world. Along with this, more information about how individuals affect the environment must be disseminated. These findings highlight significant progress toward achieving SDG 4 and SDG 13 in OIC countries. By showcasing the long-term positive effects of education on reducing CO_2 emissions, the research emphasizes the importance of human capital development in promoting environmental awareness and sustainable behaviors, thereby supporting both quality education and climate action objectives. Additionally, policies promoting foreign direct investment (FDI) in green technologies and integrating environmental education signal meaningful steps toward reducing emissions and advancing sustainable development across these nations.

The government should offer increased incentives to foreign investors to encourage knowledge dissemination, technology spillovers, and capital investment in environmental technologies within host countries. By attracting foreign direct investment (FDI), nations can leverage external resources to develop sustainable solutions for environmental challenges. Policymakers should implement targeted measures such as tax incentives, streamlined regulations, and investment promotion initiatives to facilitate FDI inflows into green technologies and sustainable infrastructure projects. Also, governments should prioritize environmental education initiatives for young students to cultivate a culture of environmental responsibility. By incorporating environmental sustainability into school curricula, particularly in lower-middle-income OIC nations, students can gain a deeper understanding of environmental challenges and the significance of conservation efforts. These educational programs should highlight the link between human actions and environmental impacts, equipping future generations with the knowledge and skills needed to make informed decisions and work collectively toward sustainable development.

Governments should implement policies aimed at achieving net-zero emissions, demonstrating their commitment to combating climate change and transitioning to a low-carbon economy. These policies should set ambitious goals for reducing greenhouse gas emissions across the energy, transportation, and industrial sectors, alongside initiatives to enhance carbon sequestration and removal efforts. Additionally, governments should invest in research and development to advance carbon capture and storage technologies, renewable energy infrastructure, and nature-based solutions to combat climate change effectively. Given the transboundary nature of environmental challenges, international cooperation is essential to address global issues such as climate change and biodiversity loss. Governments should prioritize diplomatic efforts to strengthen international agreements, enhance climate resilience, and mobilize financial support for developing countries' adaptation and mitigation efforts. By fostering a spirit of solidarity and shared responsibility, the international community can safeguard the planet for current and future generations, ensuring that all people inherit a cleaner and healthier environment.

References

Abdollahbeigi, M. (2020), "Non-climatic factors causing climate change," *Journal of Chemical Reviews*, 2(4), 292-308. https://doi.org/10.22034/jcr.2020.249615.1087

Adhikari, D. and Chen, Y. (2013), "Energy consumption and economic growth: a panel cointegration analysis for developing countries." *Rev. Econ. Financ*, 3, 68–80.

Afshan, S., Yaqoob, T., Meo, M. S., and Hamid, B. (2023), "Can green finance, green technologies, and environmental policy stringency leverage sustainability in China: evidence from quantile-ARDL estimation," *Environmental Science and Pollution Research*, 30(22), 61726-61740. https://doi.org/10.1007/s11356-023-26346-1

Aghion, P., Howitt, P., and Murtin, F. (2010), "The relationship between health and growth: When Lucas meets Nelson-Phelps (No. w15813). National Bureau of Economic Research.

Akadiri, S. S., Bekun, F. V., Taheri, E., and Akadiri, A. C. (2019), "Carbon Emissions, Energy Consumption and Economic Growth: Causality Evidence" *International Journal of Energy Technology and Policy*, 15(2/3), 320-336. https://doi.org/10.1504/IJETP.2019.098956

Ali, S., Yusop, Z., Kaliappan, S., Chin, L. and Nazar, R. (2021), "Impact of trade openness, human capital, and institutional performance on economic growth: evidence from organization of islamic cooperation countries." *Journal of Public Affairs*, 22(3), 1-12. 10. https://doi.org/10.1002/pa.2654

Alkhateeb, T.T.Y., Alkhateeb, T.T.Y., Mahmood, H., Altamimi, N.N. and Furqan, M. (2020), "Role of Education and Economic Growth on the CO2 Emissions In Saudi Arabia," *Entrepreneurship and Sustainability Issues, VsI Entrepreneurship and Sustainability Center*, 8(2), 195-209. https://doi.org/10.9770/jesi.2020.8.2(12)

Amponsah, E.N., Yiodam, L.B., and Agyemang, M. (2016), "The Effect of maternal education on child health: some evidence from Ghana," *International Journal of Economics and Business Research*, 11(4), 366-385.

Bin, S., and Dowlatabadi, H. (2005), "Consumer lifestyle approach to us energy use and the related co_2 emissions," *Energy policy,* 33(2), 197-208. https://doi.org/10.1016/S0301-4215(03)00210-6

Chimbo, B. (2020), "Energy consumption, information and communication technology and economic growth in an african context," *International Journal of Energy Economics and Policy,* 10(4), 486-493. Retrieved from https://www.econjournals.com/index.php/ijeep/article/view/8118

Davies, J.B. and Kuhn, P. (1992), "Social security, longevity and moral hazard," *Journal of Public Economics,* 49(1), 91-106. https://doi.org/10.1016/0047-2727(92)90065-N

Dhayal, K. S., Forgenie, D., Giri, A. K., Khoiriyah, N., and Isaac, W. A. P. (2024), "Modelling the nexus between green energy, agricultural production, forest cover, and population growth towards climate change for the transition towards a green economy," *Environment, Development and Sustainability,* 1-25.

Ehrlich, I. and F. Lui, (1991), "Intergenerational trade, longevity and the value of life extension," *Journal of Political Economy,* 99(5), 1029-1059. http://dx.doi.org/10.1086/261788

Farooq, F., Chaudhry, I. S., Yusop, Z., and Habibullah, M. S. (2020), "How do globalisation and foreign direct investment affect environmental quality in OIC member countries?," *Pakistan Journal of Commerce and Social Sciences (PJCSS),* 14(2), 551-568. Retrieved from http://hdl.handle.net/10419/222914

Fatima, T., Karim, M. Z. A., and Meo, M. S. (2021), "Sectoral CO_2 emissions in China: asymmetric and time-varying analysis," *Journal of Environmental Planning and Management,* 64(4), 581-610. https://doi.org/10.1080/09640568.2020.1776691

Girod, B., and De Haan, P. (2009) "GHG reduction potential of changes in consumption patterns and higher quality levels: evidence from swiss household consumption survey," *Energy Policy,* 37(12), 5650-5661. https://doi.org/10.1016/j.enpol.2009.08.026

Hassan, M. S., Meo, M. S., Abd Karim, M. Z., and Arshed, N. (2020), "Prospects of environmental Kuznets curve and green growth in developed and developing economies," *Studies of Applied Economics,* 38(3). http://dx.doi.org/10.25115/eea.v38i3.3367

Hassan, S., Xia, E. and Lee, C.C (2020), "Mitigation pathways impact of climate change and improving sustainable development: the roles of natural resources, income, and co_2 emission," *Energy & Environment,* 32(2), 338-363. https://doi.org/10.1177/0958305X20932550

Ismail, N. H., Nayan, S., Kadir, N., and Mat Yusoff, M. Y. (2020), "Carbon Dioxide (CO_2) emission, energy consumption and economic growth: evidence from selected southeast asia countries," *Journal of Emerging Economies & Islamic Research,* 8(2), 1-12. https://doi.org/10.24191/jeeir.v8i2.8937

Jamie, S. (2020), "Reducing Carbon Emissions Will Benefit the Global Economy. Here's How, Climate Change Policy & Economics" Retrieved on December 12, 2022 from https://earth.org/carbon-emissions-economy/

Khan, M. (2020), "CO_2 emissions and sustainable economic development: new evidence on the role of human capital," *Sustainable Development,* 28(5), 1279-1288. https://doi.org/10.1002/sd.2083

Koengkan, M., Santiago, R., Fuinhas, J. A., and Marques, A. C. (2020). "The relationship between public capital stock, private capital stock and economic growth in the latin american and Caribbean countries," *International Review of Economics,* 67(3), 293-317. https://doi.org/10.1007/s12232-019-00340-x

Kolawole, A. (2017). An Empirical Analysis of Energy Demand in Sub-Saharan Africa (Doctoral dissertation, Oxford Brookes University).

Kurniawati, T., Sofya, R., Syoyan, R., Sofia, N., Ridzuan, A.R., and Shaari, M.S. (2023), "Innovating for sustainability: The intersection of technology and environmental quality in Indonesia," *International Journal of Energy Economics and Policy,* 13(6), 170-178. https://doi.org/10.32479/ijeep.14794

Lee, H., Park, C., and Jung, H. (2024), "The role of tertiary education on CO2 emissions: Evidence from 151 countries," *Environment, Development and Sustainability,* https://doi.org/10.1007/s10668-024-04828-7

Li, D., Bai, Y., Yu, P., Meo, M. S., Anees, A., and Rahman, S. U. (2022), "Does institutional quality matter for environmental sustainability?," *Frontiers in Environmental Science,* 10, 966762. https://doi.org/10.3389/fenvs.2022.966762

Lin, X. Zhao, Y. Ahmad, M. Ahmed, Z. Rjoub, H. and Adebayo, T.S. (2021), "Linking innovative human capital, economic growth, and co2 emissions: an empirical study based on chinese provincial panel data," *Int. J. Environ. Res. Public Health*, 18, 8503. https://doi.org/10.3390/ijerph18168503

Liu, C., Wu, J., Long, C., and Kundur, D. (2018), "Reactance perturbation for detecting and identifying FDI attacks in power system state estimation," *IEEE Journal of Selected Topics in Signal Processing*, 12(4), 763-776. https://doi.org/10.1109/JSTSP.2018.2846542

Lutz, W., Muttarak, R., and Striessnig, E. (2014), "Universal education is key to enhanced climate adaptation," *Science*, 346(6213), 1061–1062. https://doi.org/10.1126/science.1257975

Majekodunmi, T.B., Shaari, M.S., Abidin, N.Z., and Ridzuan, A.R. (2023), "Green technology, exports and CO2 emissions in Malaysia," *Heliyon*, 9, e18625. http://dx.doi.org/10.1016/j.heliyon.2023.e18625

Marbuah, G., Gren, M., and Tirkaso, W. T. (2021), "Social capital, economic development and carbon emissions: empirical evidence from counties in Sweden," *Renewable and Sustainable Energy Reviews*, 152(3), 111691. https://doi.org/10.1016/j.rser.2021.111691

O'Neill, B. C., Dalton, M., Fuchs, R., Jiang, L., Pachauri, S., and Zigova, K. (2010), "Global demographic trends and future carbon emissions," *Proceedings of the National Academy of Sciences*, 107(41), 17521–17526. https://doi.org/10.1073/pnas.1004581107

Pablo-Romero, M. P., Sánchez-Braza, A., and Galyan, A. (2020), "Renewable energy use for electricity generation in transition economies: evolution, targets and promotion policies," *Renewable and Sustainable Energy Reviews*, 138(10), 110481. https://doi.org/10.1016/j.rser.2020.110481

Padhan, H., Padhang, P. C., Tiwari, A. K., Ahmed, R., and Hammoudeh, S. (2020), "Renewable energy consumption and robust globalisation (S) In OECD Countries: Do oil, carbon emissions and economic activity matter?," *Energy Strategy Reviews*, 32, 100535. https://doi.org/10.1016/j.esr.2020.100535

Pazienza, P. (2019). The Impact of FDI in the OECD Manufacturing Sector on CO2 Emission: Evidence and Policy Issues. Environmental

Impact Assessment Review, 77, 60-68. https://doi.org/10.1016/j.eiar.2019.04.002

Pincheira Lucas, R.I (2019), Economic Growth Implications For Environmental Quality Indicators: A Review And Empirical Analyses Using A Dynamic Endogenous Environmental Kuznets Curve. PhD Thesis, University of Queensland Business School, The University of Queensland. https://doi.org/10.14264/uql.2019.449

Rahmani, O., Rezania, S., Beiranvand Pour, A., Aminpour, S. M., Soltani, M., Ghaderpour, Y., and Oryani, B. (2020), "An overview of household energy consumption and carbon dioxide emissions in Iran," *Processes,* 8(8), 994. https://doi.org/10.3390/pr8080994

Raihan, A., Voumik, L.C., Mohamed Yusoff, N.Y., Ridzuan, A.R. and Esquivias, M.A. (2023), "Energetic encounters: investigating the link between tourism patterns and energy utilization in Malaysia," *Geojournal of Tourism and Geosites,* 51(4spl), 1786–1795. https://doi.org/10.30892/gtg.514spl19-1174

Ridzuan, A.R., Dash, S.K., Porwal, A., Dhayal, K.S., Rahman A.N.H., and Omran, M. (2023), "The green effect: Exploring the impact of innovation and foreign direct investment on environmental quality in Malaysia," *International Journal of Energy Economics and Policy,* 13(5), 115–125. https://doi.org/10.32479/ijeep.14530

Shaari, M.S, Karim, Z. A, and Abidin, N.Z. (2020), "The effects of energy consumption and national output on co2 emissions: new evidence from oic countries using a panel ardl analysis," *Sustainability,* 12(8), 3312. https://doi.org/10.3390/su12083312

Shaari, M.S., Majekodunmi, T.B., Zainal, N.F., Harun, N.H., and Ridzuan, A.R. (2023), "The linkage between natural gas consumption and industrial output: New evidence based on time series analysis," *Energy,* 284, 129395. https://doi.org/10.1016/j.energy.2023.129395

Shahbaz, M., Solarin, S. A., and Ozturk, I. (2016), "Environmental kuznets curve hypothesis and the role of globalisation in selected african countries," *Ecological Indicators,* 67, 623-636. https://mpra.ub.uni-muenchen.de/69859/

Ullah, S., Chishti, M. Z., and Majeed, M. T. (2020), "The asymmetric effects of oil price changes on environmental pollution: evidence from the top ten carbon emitters," *Environmental Science and Pollution*

Research, 27(3), 29623-29635. https://doi.org/10.1007/s11356-020-09264-4

Union of Concerned Scientists. Each Country's Share of CO2 Emissions. (2019). Available online: https://www.ucsusa.org/resources/each-countrys-share-co2-emissions (accessed on 27 September 2019).

United Nation. (2022). Education is key to addressing climate change. Retrieved on November 15, 2022 from https://www.un.org/en/climatechange/climate-solutions/education-key-addressing-climate-change

Vaghefi, N.; Siwar, C. and Aziz, A.A.A.G. (2015), "Green economy: issues, approach and challenges in muslim countries," *Theoretical Economics Letters,* 5(1), 28–35. https://doi.org/10.4236/tel.2015.51006

Wang, D. T., Gu, F. F., David, K. T., and Yim, C. K. B. (2013), "When does FDI matter? the roles of local institutions and ethnic origins of FDI," *International Business Review,* 22(2), 450-465. https://doi.org/10.1016/j.ibusrev.2012.06.003

Xin, Y., Yang, S., and Rasheed, M. F. (2023), "Exploring the impacts of education and unemployment on CO2 emissions," *Economic Research-Ekonomska Istraživanja,* 36(2). https://doi.org/10.1080/1331677X.2022.2110139

Xu, Y., and Li, A. (2020), "The relationship between innovative human capital and interprovincial economic growth based on panel data model and spatial econometrics, *Journal of Computational and Applied Mathematics,* 365(5), 112381. https://doi.org/10.1016/j.cam.2019.112381

Zhang, H., Shi, X., Wang, K., Xue, J., Song, L., and Sun, Y. (2020), "Intertemporal lifestyle changes and carbon emissions: evidence from a china household survey," *Energy Economics*, 86, 104655. https://doi.org/10.1016/j.eneco.2019.104655