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Crafting Pathways to Sustainable Development: Strategic Approaches of Energy Production in OIC Nations, Pitting Renewables Against Non-Renewables

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ABSTRACT

The study examines the impact of sustainable energy production on the sustainable development of Organization of Islamic Cooperation (OIC) countries from 1990 to 2020. Focusing on integrating sustainability concepts into economic and Islamic law realms, the paper investigates directional relationships among key variables, analyzing their effects on sustainable energy consumption, renewable energy, and overall sustainable development. Robust associations are identified between energy consumption (non-renewable and renewable), economic growth, gross domestic product, trade openness, greenhouse gas emissions, and foreign direct investment. Employing the panel ARDL model for OIC countries and subgroups, the findings reveal a positive and significant impact of sustainable energy consumption on sustainable development indicators. Despite positive outcomes, challenges persist, particularly in economic diversity among studied countries, with high-income nations, primarily oil producers, struggling to address environmental concerns. Low-income countries face hurdles in achieving balanced progress toward sustainable development, as indicated by the analysis.

Keywords: Renewable Energy, Sustainable Development, Energy Production, Environmental Pollution
JEL Classifications: Q01, Q40, Q42, Q43, Q53, F21, O13

1. INTRODUCTION

Energy consumption is causally related to growth, development, and sustainability. It acts as a driver for productive sectors and serves as an indicator of economic welfare and progress. Since the Industrial Revolution in the eighteenth century, advancements in industrial technology - particularly those reliant upon mechanical power - have continuously evolved. This economic system is fueled by raw materials, pushing forward the pace and development of production. In the latter half of the twentieth century, industrialized nations saw a significant increase in production across all transformative industries, utilizing energy sources, primarily fossil fuels like coal and oil, which are major contributors to the energy market. However, these sources are non-renewable and environmentally polluting, contributing to the phenomenon of global warming (Anser et al., 2021). As economic growth coincides with the consumption of non-renewable energy, it has subsequently led to escalating environmental damage. This in turn has prompted social and political movements on an international scale to discuss methods and policies that can mitigate the negative impacts of traditional economic growth, which previously did not account for environmental and social costs. Due to the direct proportionality between non-renewable energy consumption and environmental pollution, environmental degradation has been on the rise, reflecting the extent of carbon dioxide emissions.

Energy consumption has also been positively linked to trade openness, and this consumption and openness has been a significant means of supporting growth and development plans, in the traditional sense for many countries, despite directly affecting the Earth's ecosystem (Bishoge et al., 2018). Consequently, the concept of sustainable development has emerged as a new model that goes beyond merely economic aspects. This concept takes into consideration production conditions in terms of the quantity and value of the materials that are used, as well as the environmental consequences of such development.

The use of environmentally-friendly and renewable energy sources has become a global demand, supporting the goals and objectives of sustainable development through various international treaties and agreements. Achieving economic balance necessitates preserving and developing the environment without causing its future inefficiency (Christoforidis and Katrakilidis, 2021). Therefore, there is a need for global regulation and alignment to ensure a sustainable path is put forward, in order to ensure the success of these ambitions and plans. Taking into consideration the development of various indicators that serve this direction, many features are contributing to the speed and pace of transformation towards a green economy and sustainable development. These features include social, economic and geographical aspects, of which their differences vary from country to country. This poses a significant challenge for countries, particularly Islamic states, where clear disparities exist in terms of economic, geographical, social, cultural, religious, and political structures (Chua and Oh, 2011). For instance, oil-rich countries have heavily reliant economies upon oil and its derivatives, and while this does lead to high-income levels, it can also be a cause for wasteful energy consumption, which presents a major challenge due to the environmental pollution caused by oil as an energy source. Consequently, this negative impact has a more significant effect on sustainable development programs. On the other hand, some countries that have low-income levels (i.e. living below the poverty line), lack the minimum requirements for sustainable development initiatives. In addition, there are also countries with medium incomes that face challenges related to development programs (Cui et al., 2023). Therefore, this study aims to clarify and analyze the impact of non-renewable energy consumption on the process of sustainable development from the member countries of the Organization of Islamic Cooperation during the period from 1990 to 2020. The purpose is to understand the challenges faced by these countries and explore the possibilities for enhancing ways to achieve sustainable development goals across the Islamic world. The study also seeks to contribute to the economic literature concerning sustainability from the perspective of Islamic economics.

2. THEORETICAL BACKGROUND

The Industrial Revolution brought about a renaissance in all aspects of life, including economic, social and political. It led to changes in work structures, production, and consumption patterns. The growth accelerated in parallel with the development of industrial sectors, in which the concept and requirements of work, as well as the distribution of human resources, differed, thus changing the culture of consumption (Farooq et al., 2023). This development was seen as an indicator of progress and prosperity, measured by traditional growth indicators. However, these indicators did not reflect the negative aspects that emerged and significantly worsened, as evident in the increasing environmental deterioration affecting both the environment in general and human life. As a result, this degradation was associated with higher death rates and an increase in natural disasters. The international community recognized these dangers, and voices calling for action against them grew louder (Gabbasa et al., 2013). Numerous seminars and conferences were held, urging improvements in environmental quality.

On the economic front, the clear and direct causal link between growth and environmental degradation was through the industrial trajectory that consumed non-renewable energy sources and emitted polluting gases. Therefore, international societies had to reconsider traditional concepts and mechanisms of growth and development (Islam et al., 2022). The new direction and technologies that aimed to mitigate environmental deterioration led to the emergence of the concept of sustainable development. Consequently, economic concepts related to measuring productivity, quality and sustainability evolved over time. Political developments and economic systems played a crucial role in the evolution of these concepts. Both the concepts of economic growth and economic development were (and are still) used to describe the state of a country's economy through analysis centered around these two concepts. Some people do not see a distinction between them, while others study certain variables (Jamil et al., 2016). The debate is still ongoing. Some argue that the concept of development is more comprehensive compared to growth, because it encompasses moral and non-material aspects in society as well, whereas growth refers solely to the material aspect. The following is a detailed explanation of these two concepts:

(1) Economic growth: Economic growth is a quantitative measure that focuses on the increase in a country's output of goods and services over time. It is typically represented by the growth rate of the Gross Domestic Product (GDP) and is considered a fundamental indicator of a country's economic performance. Economic growth indicates the expansion of a nation's economy, the creation of more jobs, and the increase in income levels. However, it does not consider other aspects, such as income distribution, social welfare, or environmental sustainability. Economists use the term "economic growth" to refer to the increase in productivity over an extended period. However, in the medium term, it is used to indicate expansion, which contradicts the meaning of a recession. Economic growth is the rise in economic productivity in a specific country, achieved through increased production of goods and services over a defined period while excluding the effects of economic inflation (Jebli and Hakimi, 2023). Economic growth also works to increase corporate profits and demands for the workforce, leading to lower unemployment rates, higher individual income levels, and improved living standards. Consequently, individuals' increased demand for goods and services drives economic growth to higher levels (Khan et al., 2022). For economic growth to be genuine and not transitory, it must be sustainable under natural conditions and accompanied by an increase in the real income average of individuals (Majeed et al., 2021).

(2) Economic development: Economic development, on the other hand, is a broader and more qualitative concept that includes not only the increase in material wealth but also factors related to the overall well-being and advancement of society.

It encompasses social, cultural, political, and environmental aspects, in addition to the material aspects of the economy. Economic development aims to improve the quality of life, reduce poverty and inequality, promote education and healthcare, protect the environment, and ensure sustainable economic growth. The concept of economic development has evolved over time. Initially, countries focused on the idea of raising material rates, which translated into Gross Domestic Product (GDP) growth without positively impacting individuals and societies. Gradually, attention shifted towards issues of distributional justice, reducing poverty and unemployment rates (Malik et al., 2019). From the end of World War II until the 1960s, many considered the concept of growth synonymous with development (Todaro and Smith, 2020). However, over time, the concept of development evolved to indicate the extent of progress a country makes in its economic and social structures; here, we highlight several definitions for it. Mendoza-Rivera et al., (2023, p. 300) define economic development as, "the stimulation and transformation of the national economy from a state of stagnation to a state of movement and dynamism through increasing the national economic indicators, achieving tangible annual increases in Gross National Product, changing production and means, raising the level of employment, and increasing reliance on the industrial and artisan sectors, accompanied by a decline in traditional activities." Moreover, Muhammad et al., (2017, p. 21790) see it as a process resulting in "profound changes in the economic, political, and social structures of the state, and its relations in the international economic system that lead to increases and accumulations of investable real individual income over an extended period, along with several non-economic outcomes." Ultimately, the concept of development became more comprehensive, incorporating the role and effectiveness of human beings within society, including ideological, cultural, and civilizational aspects. As human beings became the central focus of modern development, there was a gradual shift towards concerns about qualitative improvements in meeting basic needs and attention to indicators, such as education, health and freedom. This differentiation allows for a clearer distinction between the concepts of economic growth and economic development. Economic growth indicators are material, focused on capital accumulation and measured quantitatively, reflecting solely economic phenomena. In contrast, economic development indicators are both material and immaterial, focusing on wealth increase, as well as other economic, social and political variables, and are measured quantitatively and qualitatively (Murshed et al., 2022). In summary, economic growth primarily focuses on the increase in material output and economic activity, while economic development takes a more holistic approach, considering both material and non-material factors in society's progress and well-being.

In this section, the general definitions and concepts related to the study's background are examined, followed by clarifying the relationships between the concepts that will be subject to subsequent empirical study. Noteworthy international conventions and experiences related to harnessing renewable energy are discussed. Moreover, the most significant indicators employed to measure environmental, social and economic factors contributing to monitoring sustainable development are delineated (Murshed et al., 2021).

2.1. Climate Change

This refers to the alterations in the Earth's temperature over time due to external geological, cosmic, or even human factors, which subsequently impact life on the planet. The impact of climate change is not limited to the environment alone but extends to various social, economic, and political aspects. Changes in temperature and associated factors are linked to fluctuations in greenhouse gas emissions and global warming, which in turn, leads to environmental degradation (Naseem et al., 2021). Numerous United Nations reports highlight the current negative effects of climate change on water resources and agriculture. Economic jurisprudence also points out the adverse effects of climate change on overall economic variables. The physical risks associated with climate change pose challenges in transitioning to low-carbon economies, which in turn affects overall financial stability. These challenges can harm financial budgets due to negative impacts on investment, economic growth, revenues, financial expenditures, and other areas (Rusydiana et al., 2021).

2.2. Environment and Environmental Degradation

The environment is the habitat in which humans live, and from which they derive the elements of economic and social life. It is influenced by the development of this life and the patterns of this development, encompassing ecological, historical, economic, and social aspects. The environment has two dimensions: A natural dimension that includes all aspects of the physical existence surrounding humans, such as land, water and space, and a social dimension that encompasses the systems and relationships that define human life patterns, whether political, economic, or legal, as well as patterns of human behavior and values (Shaari et al., 2020). Environmental degradation also refers to various factors that cause environmental pollution, including the consumption of fossil fuels, leading to greenhouse gas emissions and global warming, among others. From the perspective of traditional economic schools, economic resources were considered free of environmental costs and consequences, allowing humans to use them without incorporating them into the costs of production processes. However, this concept has changed over time, influenced by social and political movements and due to the increase in severe environmental degradation rates. Economic literature now focuses on calculating the costs of environmental degradation, incorporating the environmental aspect in cost-benefit analysis for project development (Shah et al., 2020). The extent of environmental degradation is measured by carbon dioxide emissions resulting from the burning of fossil fuels and cement production. This includes carbon dioxide emissions produced during the consumption of solid, liquid, and gaseous fuels and the burning of gases, as in the following example (Figures 1 and 2):

2.3. Sustainable Development

The emergence of a new extension of concepts related to development, later known as sustainable development, was a result of continuous societal movements concerning the criteria used for economic resources, and their direct and indirect impact on the environment. Modern manufacturing-based economies have led to various patterns of human welfare. However, they also have catastrophic effects on the environment, affecting both current and future generations. The idea of sustainable development imposes an important constraint on production and consumption patterns, aiming to preserve environmental resources and balance prosperity for successive generations. Achieving this idea requires global cooperation and collaboration between different sectors, both on a governmental and private scale. Consequently, this calls for the expansion of measurement indicators and the inclusion of environmental and societal indicators to examine the progress or commitment at the national level. Sustainable development also refers to the measures and mechanisms aimed at minimizing environmental degradation over a specific period (Sopian et al., 2011). The progress in sustainable development indicators varies depending on the economic structure, technological advancement, cultural and geographical factors, and ideological priorities underlying sustainable development. Despite the different definitions presented for sustainable development, all of them acknowledge that it is a process that continuously satisfies needs whilst considering environmental indicators, whether through preservation over time or minimizing deterioration. The World Commission on Environment and Development defines sustainable development as "all the coordinated and coherent measures and processes necessary for changing the use of resources, investment, technology, and institutions to ensure the satisfaction of human needs and activities both currently and in the future" (Shahbaz et al., 2020). Another definition describes it as "development that meets the needs of the present without compromising the ability of future generations to meet their needs," (Siddik et al., 2023). Sustainable development requires a comprehensive approach to economic, social, and environmental processes and necessitates integration between them to connect the paths of sustainable development. Consequently, sustainable development leads to a wide range of issues and requires a multi-faceted approach to managing the economy, environment, human interests, and institutional capacity. Decision-makers need to identify the necessary actions to make progress towards sustainable development based on comprehensive information concerning the current situation, trends, strengths, weaknesses, imbalances, and the impacts of interventions. This is essential to determine the extent of progress achieved towards achieving sustainable development (Simionescu et al., 2020).

2.4. Green Economy

The green economy is referred to as an economy that results in improved human welfare and social equality, whilst reducing environmental risks and ecological resource scarcity (Sopian et al., 2011; Tweneboah-Koduah et al., 2023) define the green economy as an economy based on six main sectors: renewable energy, green construction, clean transportation, water management, waste management, and land management. The green economy can be seen as a new economy that supports sustainable development, by considering the environmental dimension in development, achieving social justice, and using economic resources efficiently (Xu et al., 2022). Therefore, the green economy includes the environmental aspect within comprehensive sustainable development plans and aims to achieve one of two facets based on the targeted sector: Either developing practices and applications without harmful emissions to the environment or modernizing and developing to minimize environmental degradation to the lowest possible levels over time. As a result, the green economy is considered a branch or component of sustainable development because sustainable development requires appropriate environmental qualifications to achieve its goals.

2.5. Energy and Its Consumption

Energy is one of the characteristics of matter that can be converted into work, radiation, or heat. Heat and radiation are both important forms of energy, and their significance expanded during the Industrial Revolution in the late 18^{th} century. It was observed that heat could be utilized in various forms, such as a source of cooling in summer and warmth in winter (Yang et al., 2022). Since the first Industrial Revolution, and up until the present day, there has been an increasing interest in energy, its sources, and how to develop it in order to align and synchronize with the economy of machinery and industry. Energy sources have a direct connection with modern production and consumption, as well as with most of the relations and policies of countries and their local, international, and regional interests. In addition to this, energy often becomes the target and the cause of many international conflicts/rivalries because it is simply the measure of growth, development, and a means to exert influence and achieve stability. Energy can also be classified into two types, based on its renewability in nature: non-renewable energy and renewable energy. Energy consumption, conversely, refers to the processes of using energy to achieve direct human satisfaction or to produce final or intermediate goods and services. Energy in all its forms is the driving force of production, and its continuity and development are closely linked to the continuity of production and, consequently, growth. Since growth involves increasing production rates over time and various energy sources are used for this growth - with petroleum being a non-renewable and environmentally polluting source - the current pace of growth poses an increasing environmental dilemma (Yasmeen et al., 2022).

These figures 3-6 provide a comprehensive view of global energy consumption trends, supporting the discussion on the dominance of fossil fuels, the disparities in energy use across countries, and the transition towards renewable energy. They reinforce the analysis of sustainable energy production's role in achieving sustainable development, as examined in the empirical findings of this study.

2.6. Non-Renewable and Renewable Energy

Non-renewable energy (also known as depletable energy) can be defined as energy sources that will diminish over time due to excessive use. This category includes fossil fuels, such as oil, natural gas, coal and nuclear energy. Non-renewable energy sources are considered polluting and are major contributors to environmental degradation (Yasmeen et al., 2022). In contrast, renewable energy refers to natural and perpetual energy sources available in nature, and whether limited or unlimited, they are continuously renewable. Renewable energy is also characterized as clean energy that does not produce pollution. It includes solar energy, which is the primary source for other renewable sources like wind energy, tidal energy, wave energy, geothermal energy, hydropower, and photovoltaic energy. These forms of energy are considered environmentally friendly because their use does not lead to an increase in environmental degradation (You et al., 2022).

2.7. Gross Domestic Product (GDP)

GDP is one of the most important indicators used in the national accounts of countries. It represents the market value of final goods and services produced during a specific period. GDP is also considered a key indicator of sustainable development, which is measured through economic, social, and environmental indicators. Therefore, measuring GDP tracks the rate of economic growth, and the challenges lie in incorporating environmental and social considerations that make the components and quality of GDP vary over time. Nevertheless, it remains a significant indicator reflecting a country's strength. Although GDP measures the overall economic performance of countries, it does not properly account for the social and environmental costs and benefits. Hence, it is essential to have an alternative tool that goes beyond GDP (Younis et al., 2021).

2.8. Trade Openness

Trade openness refers to the "policies and measures that lead to the abandonment of biased policies against exports, adopting a neutral policy between imports and exports, reducing high customs tariffs and controlling them, in addition to converting quantitative restrictions into customs tariffs and moving towards a unified system for the latter" according to international institutions (Barakat et al., 2011, p. 40).

2.9. Manufacturing

In this research, manufacturing refers to the International Standard Industrial Classification (ISIC), which is a standardized classification of economic activities, allowing entities to be categorized based on their respective activities. The classification is structured in levels, containing production units based on similarities in goods and services produced, their intended uses, inputs, production processes, and technology (Yu-Ke et al., 2022).

2.10. Urbanization

According to Zeraibi et al., (2023), and based on the World Bank's definition, Urbanization refers to the people living in urban areas. Development is directly related to the levels of urbanization, as the significant growth of cities worldwide indicates the demographic shift from rural to urban areas and relates to transformations from agriculture-based economies to industry, technology, and services. Cities often generate more jobs, income, education, healthcare and other services of higher quality and quantity when compared to rural areas. However, measuring the level of urbanization at the national level lacks a consistent and globally accepted standard to distinguish between urban and rural areas. This is partly due to the diverse national characteristics that differentiate urban areas from rural ones. Therefore, distinguishing between urban and rural populations cannot be defined with a single criterion applicable to all countries.

2.11. Foreign Direct Investment (FDI)

FDI is defined as the deployment of non-domestic capital in fixed capital assets in a specific country. These foreign investments are financed through the injection of funds by individual foreign investors, corporations, or companies. This financing can take various forms (Cui et al., 2023). Theoretically, FDI is believed to contribute to the economic development of the host country by increasing productivity and competitiveness. Based on the latest theoretical and empirical research on economic development stages, FDI is confirmed to play a positive role in promoting economic development through analyzing indicators, such as per capita GDP and the FDI stock as a percentage of the GDP of 141 countries worldwide. There are also other factors related to the contribution of FDI to economic development, such as the economic conditions of the host countries and the quality of the hosted foreign capital (Mendoza-Rivera et al., 2023).

In this theoretical background section, the relevant literature and applied economic studies relating to the subject were reviewed, emphasizing the objective of this study, which is to understand the relationships between economic variables and energy consumption. Based on this, the adopted measurement model for the applied study is adhered to, in order to infer their relationships and attempt an economic analysis to arrive at results that contribute to scientific advancements in the field of sustainable development.

3. RESEARCH METHODOLOGY

To measure the research model and to test the significance between exogenous variables and sustainable development as an endogenous variable, the model estimation relied upon the Autoregressive Distributed Lag (ARDL) model, using Panel Data time series models that were applied to the countries of the OIC, and then to specific groups within (high-income, upper-middle-income, and lower-middle-income).

3.1. Measures

We will review the dependent variable and the explanatory variables as follows:

3.1.1. Dependent variable (SDG index)

The Sustainable Development Goals (SDG) Index will be utilized, which is a comprehensive indicator that assesses each country's performance in achieving the seventeen sustainable development goals. The SDG indicators are intended to be a tool used by governments and stakeholders to measure the progress made in achieving sustainable development goals and highlight gaps in both implementation and data. All indicators are aggregated into sub-themes to emphasize interconnectedness and highlight different aspects of each sustainable development goal, with equal weight given to each goal. The SDG Index result indicates the country's position on a scale ranging from 0 to 100, where a direction towards 0 reflects the country's weakness in achieving sustainable development goals, and a direction towards 100 reflects its strength in achieving sustainable development goals. The United Nations Economic and Social Commission uses two indicators to assess progress towards sustainable development goals: the status and the expected progress gap. The status indicator measures progress towards specific goals since 2000, while the expected progress gap measures the gap between the expected value of the indicator and the specific goal for the year 2030. The overall index reflects the achievement of sustainability through the achievement of 17 main goals, and each goal is measured by 6 key indicators, as previously mentioned.

3.1.2. Independent variables

- Fossil Fuels Per Capita (kWh). This indicator includes oil, coal, and natural gas products; it is synonymous with non-renewable energy. (IEA, 2023).
- Trade (% of GDP). Trade refers to the sum of exports and imports of goods and services, measured as a share of the gross domestic product (GDP).
- Urban Population (% of Total Population). This indicator refers to the percentage of the population living in urban areas, as defined by the National Statistical Offices. The United Nations Population Division collects and improves the data.
- Manufacturing, Value Added (% of GDP). Manufacturing refers to industries classified under the International Standard Industrial Classification (ISIC) 15-37. Its added value is the net output of the sector after deducting intermediate inputs. It is calculated without deducting the consumption of manufactured assets or the depletion and degradation of natural resources.
- Foreign Direct Investment, Net Inflows (% of GDP). Foreign direct investment refers to the inflows of direct investment equity in the resident economy. It includes the sum of equity capital, reinvestment of earnings, and other capital. This indicator is measured as a percentage of the Gross Domestic Product (GDP).

3.2. Statistical Sources, Study Sample, and Time Series

3.2.1. Statistical sources

Regarding the dependent variable (SDG Index), it was collected from the Sustainable Development Report (formerly known as SDG Index and Dashboards). This report is the first and most comprehensive global study currently used to assess the progress of each country towards achieving the Sustainable Development Goals (SDGs). The SDGs set standards not only for developing countries but also for industrialized nations. This report can be utilized to identify work priorities, understand key implementation challenges, monitor progress and identify gaps that need to be addressed to achieve the SDGs by 2030. The report, including the SDG Index and dashboards, complements the official indicators for the Sustainable Development Goals. It uses data from various official platforms, notably the World Bank, the World Health Organization, and the International Labor Organization, as well as research centers and non-governmental organizations. As for all the independent variables in the study, their data was collected from the World Bank's database.

3.2.2. Study sample and time series

Based on the objectives of the study, the focus was on countries that were part of the Organization of Islamic Cooperation (OIC) across various income segments, for the period between 1990 and 2020. The comprehensive Sustainable Development Goals (SDG) index was chosen because, in the researchers' opinion, it is currently the most reliable index that serves the study's purpose. However, it should be noted that the database for this index does not cover all the countries within the OIC, as the period before the year 2000 was excluded. Therefore, the time series of 1990-1999 was disregarded, and the study focused on the period of 2000-2020, which is sufficient to ensure the study still fulfils the required objectives. Additionally, several countries within the organization were excluded due to the lack of available data or missing data for some indicators of the aforementioned explanatory variables. The following are the countries in which the measurement test was conducted based on income segments:

- Low-income countries: None.
- Lower-middle-income countries: Uzbekistan, Indonesia, Iran, Algeria, Morocco, Pakistan, Bangladesh, Egypt.
- Upper-middle-income countries: Azerbaijan, Iraq, Turkmenistan, Turkey, Malaysia.
- High-income countries: United Arab Emirates, Saudi Arabia, Kuwait, Oman, Qatar.

3.3. Estimating the Model and Study Results

3.3.1. Descriptive statistics and model identification

3.3.1.1. Descriptive statistical analysis of the growth variables

Table 1 presents some descriptive statistics for the variables used in the econometric model. It is important to note that the SDG variable represents a measure of sustainable development, while the FOSSIL variable represents the logarithm of per capita fossil fuel consumption. The URBAN variable represents the percentage of the urban population out of the total population (urbanization). The remaining variables are expressed as percentages of GDP.

The results from Table 1 indicate that the standard deviation for the "OPEN" variable is the highest when compared to the other variables in the model, suggesting a significant dispersion among the member countries of the Organization of Islamic Cooperation regarding trade openness. On the other hand, the core variables of the model, which are sustainable development and fossil fuel consumption, show lower dispersion. In addition, they are the only variables that recorded a negative skewness coefficient and kurtosis values smaller than three, indicating the presence of tails in the distribution of observations for these two variables. This confirms the deviation of their distribution from the normal distribution, unlike the rest of the variables in the model. In this study, we used the Autoregressive Distributed Lag (ARDL) model, developed by Pesaran in 2001, in order to estimate the relationships between sustainable development index and explanatory variables, particularly fossil fuel consumption. To estimate this model, we utilized panel data models, and the study sample included a set of countries from the Organization of Islamic Cooperation during the period from 2000 to 2021. One of the main features of this model is its ability to test for the existence of long-run relationships between the sustainable development index and the explanatory variables,

Table 1: Descriptive statistics of model variables

Variables	Mean	Std. dev	Min	Max	Skewness	Kurtosis
SDG	63.706	4.326	53.298	73.271	−0.276	2.712
FOSSIL	9.973	1.302	6.943	12.478	−0.002	2.283
OPEN	75.68	36.38	24.701	220.406	1.3	5.083
URBAN	64.089	19.099	23.59	100	0.159	2.32
MANUF	14.737	8.542	0.908	49.879	1.364	5.807
FDI	2.908	5.265	−4.541	55.07	5.932	52.028

including fossil fuel consumption. With the model's estimators, we can investigate the long-run cointegrating relationships between the variables since the ARDL model is dynamic and considers both the lagged dependent and independent variables over several periods. Another advantage of this model, compared to traditional cointegration tests like the Perdroni 2004 test (which requires all variables to be stable in the same order of integration), is its capability to estimate the model when variables are integrated at different orders. This allows us to specify the model in levels or differences depending on the stability of the variables at the first or higher differences. The equation of the model used in this study, considering both long-run and short-run relationships, can be expressed as follows:

$$\Delta Y_{it} = a + \pi_0 Y_{it-1} + \pi_1 X_{1it-1} + \pi_2 X_{2it-1} + \ldots + \pi_j X_{mit-1} + \sum_{j=1}^{k1} \beta_0 \Delta Y_{it-1} + \sum_{j=1}^{k1} \beta_{1i} \Delta X_{1it-2} + \sum_{j=1}^{k1} \beta_{2i} \Delta X_{2it-1} + \ldots + \sum_{j=1}^{kj} \beta_{mi} \Delta X_{mit-j} + \varepsilon_{it} \quad (1)$$

Where:

- Y_{it} represents the dependent variable in the model.
- X_{it1}, X_{it2}, X_{it3},…X_{itm} represent the explanatory variables in the model.
- (a) represents the constant term, and (ε) represents the error term in the estimated model.
- The symbol (t) denotes the year of observation.
- The symbol (i) denotes the country.

The model requires determining the optimal number of lags, denoted as (K_1, K_2., K_j), which will be automatically selected using criteria such as Schwartz - SBC and Akaike - AIC, with a maximum of four lags in the model. Equation (1) consists of two parts for model estimation: one for the long-term relationship and the other for the short-term relationship. The parameters (π) represent the long-term relationship parameters, while the symbol (β) represents the short-term relationship parameters. By specifying the error correction term in (1), we can derive the Panel Error Correction Model (PECM) for the panel data.

$$Y_{it} = a_0 + \sum_{j=1}^{k1} \beta_0 \Delta Y_{it-1} + \sum_{j=1}^{k1} \beta_{1i} \Delta X_{1t-1} + \sum_{j=1}^{k1} \beta_{2i} X_{2it-1} + \ldots + \sum_{j=1}^{kj} \beta_{mi} X_{mit-j} + \theta ecm_{it-1} + \varepsilon_t \quad (2)$$

The symbol (ecm_{it-1}) represents the error correction term, while the error correction coefficient (θ) denotes the speed of adjustment from short-term mutual effects to the long-term equilibrium. The error correction coefficient is expected to be negative and significant, indicating the presence of a long-term equilibrium relationship between the dependent variable and its explanatory variables. Furthermore, Equation (1) allows us to derive the long-term relationship model between the dependent variable and the independent variables as follows:

$$Y_{it} = \alpha_i + \beta_1 X_{1it} + \ldots + \beta_{mi} X_{mit} + \eta_{it} \quad (3)$$

The symbol (η_{it}) represents the error term for the long-term relationship model, which is the same as the error correction term used in Equation (2). To further confirm the results of the test for the presence of a long-term relationship based on the statistical significance of the error correction coefficient (θ), we add the cointegration test applied to the panel data following Perdroni 2004. Finally, it is worth noting that we utilized the Pooled Mean Group (PMG) estimator used in the literature to estimate dynamic panel models. This estimator assumes homogeneity of behavior across countries in the long run, and hence, homogeneity of the error correction coefficient.

3.3.2. Results of the study on the impact of fossil energy consumption on sustainable development in OIC countries

3.3.2.1. Unit root test results

Before estimating the proposed model in this study and to avoid spurious regression, we checked the stationarity of the model variables using the IPS unit root test for Panel Data. Table 2 shows the results of the variables' stationarity test:

The results of the previous countries show that all variables used in the model (with the exception of FDI), are stationary at the first difference I(1), indicating the presence of a long-run cointegrating relationship among them. Since the FDI variable is stationary at level I(0), we need to use the Panel ARDL model if we include this variable in the model, as we have different degrees of variable stationarity in this case.

3.3.2.2. Results of the cointegration test for the variables

Except for the FDI variable, the study's variables are first-order stationary. Therefore, we conducted the Pedroni cointegration test to explore the possibility of a long-run equilibrium relationship between the dependent variable and the explanatory variables. Table 4 presents the statistical results of the Pedroni test for the core relationship between sustainable development and fossil fuel consumption (the second column of the table) for a set of relationships that include a combination of control explanatory variables (OPEN, URBAN, MANUF, FDI). The relationships are as follows (Table 3):

It is worth mentioning that the statistical tests of Pedroni are divided into two sets:

- The first set includes four individual statistical tests within the factor groups for the cross-sectional data of each country.
- The second set includes three statistical tests between the factor groups for the cross-sectional data.
- The null hypothesis for all these tests assumes the absence of

Table 2: Unit root test results

I (.)	First order difference		Level		Variables
	P-value	statistic	P-value	statistic	
I (1)	0	9.022***	0.696	0.514	SDG
I (1)	0	10.889***	0.137	2.253	FOSSIL
I (1)	0	9.762***	0.179	0.918	OPEN
I (1)	0.006	2.47***	0.992	2.452	URBAN
I (1)	0	12.379***	0.863	1.096	MANUF
I (0)			0	5.885	FDI

***P<0.01, **P<0.05, *P<0.1

cointegration among the related variables.

The results in Table 4 indicate that most of the P-value statistics for the Pedroni tests are <0.05. As a result, the null hypothesis, which states the absence of cointegration and long-run equilibrium relationship between the dependent variable and the independent variables, is rejected. Therefore, the alternative hypothesis, which suggests the presence of cointegration and long-run equilibrium relationship between sustainable development and fossil fuel consumption, is accepted, even when controlling for the specified exogenous variables.

4. ANALYSIS OF FINDINGS

4.1. Results of Panel ARDL Model Estimation

4.1.1. Results for the sample of the countries of OIC

To study the impact of fossil fuel consumption on sustainable development, we estimated the Panel ARDL model using the logarithm of the Sustainable Development Goal index (LN(SDG)) as the dependent variable and the logarithm of per capita fossil fuel consumption (LN(FOSSIL)) as the main explanatory variable. Additionally, we included a set of control independent variables (OPEN - URBAN - MANUF - FDI) in various models to examine the robustness of the results. The models are as follows:

1. LN (SDG) = f (FOSSIL)
2. LN (SDG) = F (FOSSIL, OPPEN)
3. LN (SDG) = F (FOSSIL, URBAN)
4. LN (SDG) = F (FOSSIL, MANUF)
5. LN (SDG) = F (FOSSIL, FDI)
6. LN (SDG) = F (FOSSIL, OPPEN, URBAN, MANUF, FDI)

Table 5 presents the results of the estimated parameters for the long-run relationship and the error correction term (ECT). To keep it concise, we have included only statistically significant parameters for the short-run relationship.

The results of estimating the model using the “Pooled Mean Group” (PMG) estimation method for the model parameters are as follows:

- The error correction term (ECT), which represents the speed of adjustment towards equilibrium between the variables in all models, is statistically significant and negative (except for the third model). This confirms the existence of a long-term relationship between sustainable development and fossil energy consumption. This result aligns with the findings from the Pedroni test. The speed of convergence to the long-run equilibrium ranges from 2% (third model) to 20.2% (second model). However, this speed is limited to 6.2% (first model) when we estimate the model without using control variables.
- The results of estimating the long-run relationship show that fossil energy consumption has a positive and statistically significant long-term effect on sustainable development at a 1% level in all models. This relationship can be explained in two ways: First, the integration of fossil and renewable energy consumption, where advanced countries allocate their fossil energy consumption outputs towards sustainable development goals. Second, the weak overall share of renewable energy consumption compared to total energy consumption may contribute to this positive relationship.
- The results indicate a positive and statistically significant long-term effect of urbanization on the comprehensive sustainable development index at a 1% significance level in the fourth and sixth models. On the other hand, the long-term effect of trade openness and foreign direct investment appeared to be negative and statistically significant at a 1% significance level in the second, fifth and sixth models.
- The results of estimating short-term relationships showed a negative and statistically significant effect of fossil fuel consumption on the comprehensive sustainable development index at a 5% significance level. This negative effect of fossil fuel consumption on sustainable development appeared to decelerate over the course of one to 2 years in the fifth model.

Table 3: The relationship between variables

The relationship between variables	Results of axes
(SDG, FOSSIL)	2
(SDG, FOSSIL, OPEN)	3
(SDG, FOSSIL, URBAN)	4
(SDG, FOSSIL, MANUF)	5
(SDG, FOSSIL, OPPEN, URBAN, MANUF)	6

Table 4: Cointegration test of Pedroni

Fossil- open- manuf- urban	Fossil-urban	Fossil-manuf	Fossil-open	Fossil	Test
−2.128	−0.652	−0.585	8.027***	9.501***	Panel
−0.983	−0.743	−0.72	0	0	v-Statistic
2.359	−0.686	0.925	0.614	0.873	Panel
−0.99	−0.246	−0.822	−0.73	−0.808	ρ-Statistic
−3.443***	−5.103***	−2.359***	−1.775**	−0.775	Panel
0	0	−0.009	−0.037	−0.219	t-Statistic (PP)
−3.575***	−6.159***	−3.637***	−2.25**	−1.588**	Panel
0	0	0	−0.012	−0.056	t-Statistic (adf)
4.103	1.566	2.48	1.91	1.745	Group ρ–
−1	−0.941	−0.993	−0.972	−0.959	Statistic
−6.305***	−2.831***	−1.686**	−1.35*	−0.491	Group
0	−0.002	−0.045	−0.088	−0.311	t-Statistic
−3.283***	−3.961***	−3.436***	−2.251**	−1.93**	Group
0	0	−0.003	−0.012	−0.026	t-Statistic (adf)

***P<0.01, **P<0.05, *P<0.1

Table 5: ARDL results of the OIC Countries

Fossil PARDL (1, 1)		Fossil-open PARDL (4, 4, 4)		Fossil-manuf PARDL (1, 1, 1)	
Long-run equation	2.518 (0.000)	Long-run equation	1.552*** (0.000)	Long-run equation	0.619** (0.06)
Fossil		Fossil open	−0.001*** (0.000)	Fossil manuf	0.022*** (0.000)
Short-run equation	−0.062*** (0.009)	Short-run equation	−0.202*** (0.007)	Short-run equation	−0.02 (0.184)
EC	−1.401** (0.049)	ECT	−0.439** (0.032)	ECT	
D ($FOSSIL_t$)		D ($FOSSIL_{t-1}$)			
Fossil-urban		Fossil-FDI		Fossil-open-MANUF-URBAN-FDI	
PARDL (1, 1, 1)		PARDL (4, 4, 4)		PARDL (1, 1, 1, 1, 1, 1)	
Long-run equation	1.625*** (0.000)	Long-run equation	1.565*** (0.000)	Long-run equation	0.664*** (0.002)
FOSSIL	0.008***	FOSSIL	−0.002*** (0.000)	FOSSIL	−0.0005*** (0.000)
URBAN	(0.000)	FDI		OPEN	−0.01*** (0.000
				MANUF	0.005*** (0.000)
				URBAN	0.0005 (0.204)
				FDI	
Short-run equation	−0.16*** (0.001)	Short-run equation	−0.167** (0.048)	Short-run equation	−0.134*** (0.032)
ECT	−0.304*** (0.001)	ECT	−0.246** (0.017)	ECT	
D ($FOSSIL_t$)		D (SG_{t-2})	−0.56** (0.036)		
		D ($FOSSIL_{t-1}$)	−0.464* (0.081)		
		D ($FOSSIL_{t-2}$)			

***P<0.01, **P<0.05, *P<0.1

Table 6: ARDL results of the high-income country group

Fossil PARDL (3, 3)		Fossil-OPEN PARDL (4, 4, 4)		Fossil-MANUF PARDL (3, 4, 4)	
Long-run equation	6.138*** (0.007)	Long-run equation	4.483*** (0.000)	Long-run equation	4.752*** (0.000)
FOSSIL		FOSSIL	−0.002*** (0.000)	FOSSIL	−0.001 (0.317)
		OPEN		MANUF	
Short-run equation	−0.040 (0.11)	Short-run equation	−0.147 (0.205)	Short-run equation	−0.09 (0.204)
ECT	−0.282*** (0.013)	ECT	−0.812*** (0.000)	ECT	−0.0343* (0.064)
D (SDG_{t-2})	−0.793*** (0.01)	D (SDG_{t-1})	−0.654*** (0.000)	D (SDG_{t-1})	−0.470* (0.027)
D ($FOSSIL_t$)		D (SDG_{t-2})	−0.321* (0.088)	D (SDG_{t-2})	−1.032* (0.045)
		D (SDG_{t-3})	−1.425** (0.021)	D ($FOSSIL_{t-1}$)	
		D ($FOSSIL_{t-1}$)			
FOSSIL-URBAN		FOSSIL-FDI		FOSSIL- OPEN- MANUF- URBAN-FDI	
PARDL (2, 2, 2)		PARDL (4, 4, 4)		PARDL (2, 2, 2, 2, 2, 2)	
Long-run equation	1.429*** (0.000)	Long-run equation	3.919*** (0.000)	Long-run equation	1.173*** (0.002)
FOSSIL URBAN	0.005*** (0.002)	FOSSIL FDI	−0.011*** (0.000)	FOSSIL OPEN MANUF	−0.0007*** (0.000)
				URBAN FDI	−0.001** (0.03)
					0.005*** (0.000)
					−0.001 (0.001)
Short-run equation	−0.307 (0.121)	Short-run equation	−0.063 (0.643)	Short-run equation	−0.559* (0.088)
ECT	−0.599** (0.013)	ECT	−0.736** (0.013)	ECT	−1.137** (0.015)
D ($FOSSIL_t$)	−0.902*** (0.000)	D (SDG_{t-2})		D ($FOSSIL_t$)	−1.133*** (0.003)
D ($FOSSIL_{t-1}$)				D ($FOSSIL_{t-1}$)	0.001* (0.094)
				D (MANUFt)	

***P<0.01, **P<0.05, *P<0.1

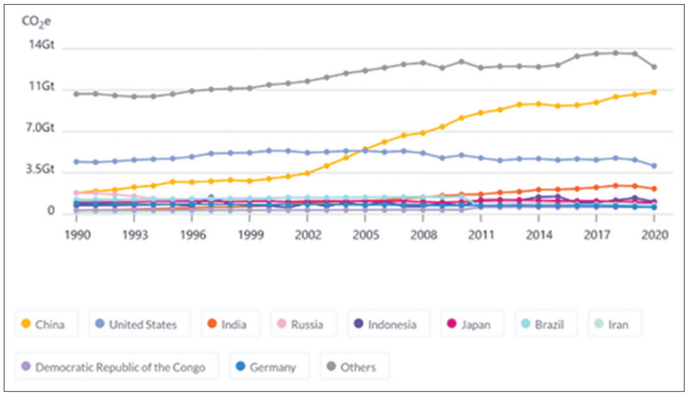
4.1.2. Results of estimations by group

4.1.2.1. High-income country group

Table 6 presents the results of estimating the models' using data from the high-income country group as follows:

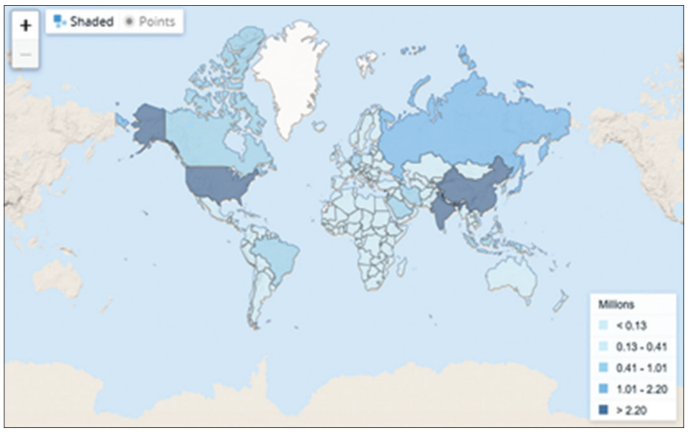
- The error correction parameters ECT were found to be statistically significant and negative only in the sixth model, where all control variables were included. This confirms the existence of a long-term relationship between sustainable development on the one hand, and energy consumption, trade openness, manufacturing, urbanization, and foreign direct investment on the other hand. The speed of adjustment towards the equilibrium in the long run was approximately 56%, indicating a relatively high speed of adjustment.
- The results of estimating the long-term relationship indicate a positive and statistically significant long-term effect of fossil fuel consumption on sustainable development at a 1% significance level. This result aligns with the findings obtained when using data from all available countries in the Organization of Islamic Cooperation. This effect can be explained by an environmental Kuznets curve-like relationship, where higher fossil fuel consumption leads to improved sustainable development due to the accumulation of capital and manufacturing, with specifications supporting environmental pollution reduction. Additionally, the comprehensive index is composed of environmental, economic, social, and political indicators, and the balance may ultimately lean towards the non-environmental indicators.
- The results for the high-income country group showed consistency with the results obtained from the sample of all countries regarding the positive and statistically significant

Figure 1: Global historical emissions (CO_2e)



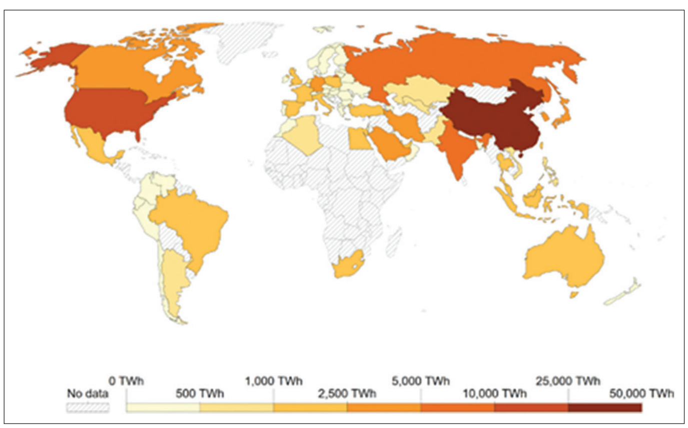
Source: Climate Watch Data, 2023

Figure 2: World map of CO_2 emissions (Kt)



Source: Climate Watch Historical GHG Emissions (1990-2020). 2023. Washington, DC: World Resources Institute

Figure 3: Global fossil fuel consumption

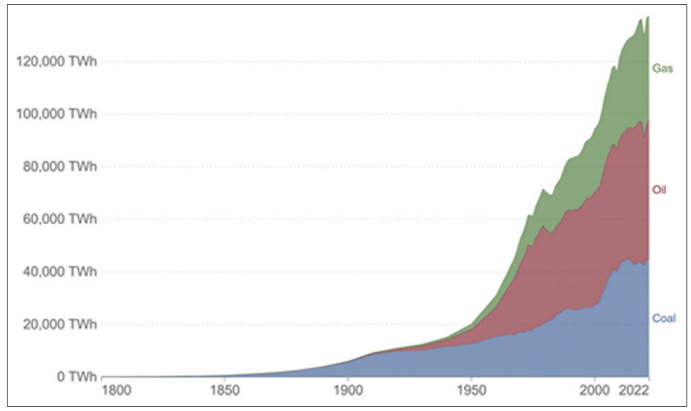


Source: Energy Institute Statistical Review of World Energy (2023)

long-term effect of urbanization on the comprehensive sustainable development index, as well as the negative and statistically significant long-term effect of trade openness and foreign direct investment.

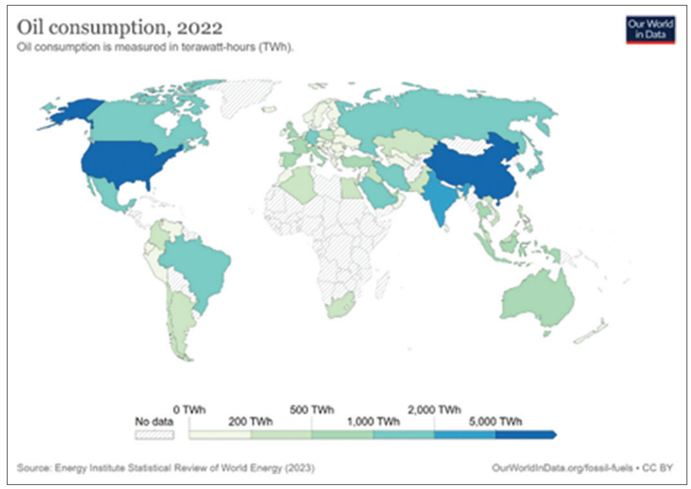
- Similarly, the results of short-term relationship estimations matched the negative and statistically significant effect of fossil fuel consumption on the comprehensive sustainable development index at a 5% significance level. This could be

Figure 4: The countries using the most energy from fossil fuels



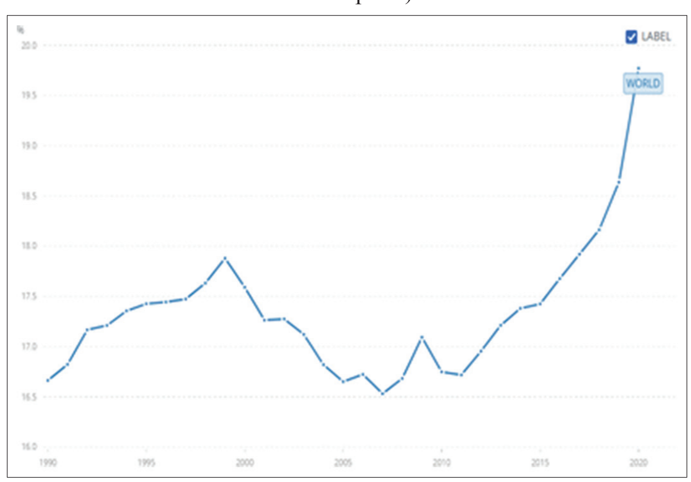
Source: Energy institute statistical review of world energy (2023)

Figure 5: Global oil consumption



Source: Energy Institute Statistical Review of World Energy (2023)

Figure 6: Renewable energy consumption (% of total final energy consumption)



Source: IEA, IRENA, UNSD, World Bank, WHO. 2023. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC. ©World Bank.

attributed to the nature of the countries under study, which lack basic life components and require increased spending

Table 7: ARDL results of the middle-income country group (upper category)

FOSSIL PARDL (1, 1)		FOSSIL-OPEN PARDL (4, 4, 4)		FOSSIL-MANUF PARDL (2, 4, 4)		FOSSIL-URBAN PARDL (3, 4, 4)		FOSSIL-FDI PARDL (4, 4, 4)		FOSSIL- OPEN- MANUF-URBAN-FDI PARDL (2, 2, 2, 2, 2, 2)	
Long-run	1.588***	Long-run	1.546***	Long-run equation	11.621	Long-run	2.493***	Long-run	1.541***	Long-run	−0.549***
equation	(0.000)	equation	(0.000)	FOSSIL	(0.396)	equation	(0.000)	equation	(0.000)	equation	(0.000)
FOSSIL		FOSSIL	−0.0009***	MANUF	0.152	FOSSIL	−0.008	FOSSIL	−0.002***	FOSSIL	−0.0007***
		OPEN	(0.000)		(0.334)	URBAN	(0.115)	FDI	(0.000)		(0.000)
										OPEN	−0.016***
											(0.000)
										MANUF	0.008***
										URBAN	(0.000)
											0.001***
										FDI	(0.000)
Short-run	−0.0134***	Short-run	−0.49***	Short-run equation	−0.024	Short-run	−0.353***	Short-run	−0.456*	Short-run	−0.309
equation	(0.016)	equation	(0.002)	ECT	(0.119)	equation	(0.000)	equation	(0.043)	equation	(0.137)
ECT	−0.277*	ECT	−0.581**	D (SDG_{t-2})	−0.366***	ECT	−0.858***	ECT	0.001**	ECT	−0.51*
D	(0.06)	D	(0.014)	D ($FOSSIL_{t-1}$)	(0.009)	D (FOSSILt)	(0.009)		(0.011)	D (SDG_{t-1})	(0.092)
(FOSSILt)		($FOSSIL_{t-1}$)			0.587***		−0.498*	D (FDI_{t-1})			0.156*
					(0.000)	D ($FOSSIL_{t-1}$)	(0.057)			D (FOSSILt)	(0.086)
							0.623**				0.263**
						D ($URBAN_{t-1}$)	(0.035)			D ($FOSSIL_{t-2}$)	(0.047)
							−0.765**				
						D ($URBAN_{t-2}$)	(0.011)				

***P<0.01, **P<0.05, *P<0.1

Table 8: ARDL results of the middle-income country group (lower category)

FOSSIL PARDL (1, 1)		FOSSIL-OPEN PARDL (4, 4, 4)		FOSSIL-MANUF PARDL (1, 1, 1)		FOSSIL-URBAN PARDL (3, 3, 3)		FOSSIL-FDI PARDL (4, 4, 4)		FOSSIL- OPEN-MANUF- URBAN-FDI PARDL (1, 1, 1, 1, 1, 1)	
Long-run	2.596***	Long-run	4.663***	Long-run	3.968***	Long-run	−0.069 (0.92)	Long-run	3.46***	Long-run	−2.559***
equation	(0.000)	equation	(0.000)	equation	(0.000)	equation	0.004 (0.167)	equation	(0.000)	equation	(0.000)
FOSSIL		FOSSIL	0.009***	FOSSIL	0.019** (0.017)	FOSSIL		FOSSIL	0.08***	FOSSIL	0.0005**
		OPEN	(0.001)	MANUF		URBAN		FDI	(0.003)	OPEN	(0.088)
											−0.002***
										MANUF	(0.004)
											0.024***
										URBAN	(0.000)
											0.0008
										FDI	(0.779)
Short-run	−0.09* (0.08)	Short-run	−0.33	Short-run	−0.03 (0.296)	Short-run	−0.055 (0.537)	Short-run	−0.057	Short-run	−0.107
equation		equation	(0.455)	equation		equation	−0.242** (0.017)	equation	(0.115)	equation	(0.195)
ECT		ECT	0.348*	ECT		ECT	−0.211* (0.081)	ECT	−0.205*	ECT	0.001***
		D (SDG_{t-3})	(0.082)			D (SDG_{t-1})	−0.278* (0.078)		(0.079)	D (FDIt)	(0.008)
		D ($OPEN_{t-3}$)	−0.0009***			D (SDG_{t-2})		D (SDG_{t-1})	−0.354***		
			(0.009)			D (URBAN t)			(0.008)		
								D (SDG_{t-2})	−0.003*		
								D (FDI_{t-3})	(0.066)		

***P<0.01, **P<0.05, * P<0.1

on various sectors to improve the quality of life and enhance human knowledge accumulation.

4.1.2.2. Middle-income country group (upper and lower)

Tables 7 and 8 present the results of estimating the models' using data from the middle-income country group, divided into upper and lower subgroups. The following conclusions can be drawn from these results:

- In contrast to the results for the high-income country group, the error correction parameters ECT for the upper subgroup of the middle-income country group were found to be statistically significant and negative in several models (first, second, fourth and fifth). This confirms the existence of a long-term relationship between sustainable development and energy consumption in these countries. The speed of adjustment towards the equilibrium in the long run ranged from 1.3% to 49%.
- The results of estimating the long-term relationship indicate a positive and statistically significant long-term effect of fossil fuel consumption on sustainable development at a 1% significance level. This result aligns with the findings obtained when using data from all available countries in the Organization of Islamic Cooperation or the high-income country group.
- The results for the upper subgroup of the middle-income country group showed a difference from the results of the sample of all high-income countries, where trade openness had a positive and statistically significant long-term effect, and the level of urbanization did not show a significant effect on sustainable development. The results only matched in terms of the negative and statistically significant long-term effect of foreign direct investment.
- Similarly, the results of short-term relationship estimations matched in terms of the negative and statistically significant effect of fossil fuel consumption on the comprehensive sustainable development index at a 5% significance level (economic analysis) between the upper subgroup of the middle-income countries and the high-income countries.
- As for the lower subgroup of the middle-income country group, there was no evidence of any long-term relationship between sustainable development and fossil fuel consumption, except in the first model, which showed a slower speed of adjustment towards equilibrium at approximately 9%. Although the positive and statistically significant long-term effect of fossil fuel consumption on sustainable development was found, the short-term relationship effects were not statistically confirmed for this lower subgroup.

The Sustainable Development Index (SDG) was selected as the dependent variable because it is the most suitable for the study's topic and reflects various aspects of sustainable development. Additionally, it is internationally well-known. The explanatory variables for the model were used, and the estimation of the model relied on the Autoregressive Distributed Lag (ARDL) approach using Panel Data time series models. These techniques were applied to all countries in the Organization of Islamic Cooperation (OIC), and then to specific subgroups (high-income, upper middle-income, lower middle-income). It should be noted that the low-income subgroup was not documented due to the unavailability of this data. The results indicated that fossil fuel consumption has a positive and statistically significant long-term impact on sustainable development. Furthermore, the study's results revealed a positive and statistically significant long-term effect of urbanization on the Comprehensive Sustainable Development Index. On the other hand, trade openness and foreign direct investment showed negative and statistically significant long-term effects on the Comprehensive Sustainable Development Index.

5. DISCUSSION

Methods of energy production and consumption have garnered increasing international attention due to the challenges posed by climate change on the Earth's surface (Anser et al., 2021). Their significance has grown since the beginning of this century, particularly in the context of sustainable development and the use of performance indicators at the international level, with the SDG (Sustainable Development Goals) being the most significant (Christoforidis and Katrakilidis, 2021). Islamic law sources emphasize the importance of preserving resources and the environment, encouraging personal moderation in consumption, dealing with wholesome items, preserving wealth, and preventing harm (Cui et al., 2023). This reflects a comprehensive approach that demonstrates the enduring nature of the concept and objectives of sustainable development. Analyzing directional relationships is challenging, as previous applied studies have shown correlations between fossil fuel consumption, growth rates, trade openness, and environmental deterioration (Farooq et al., 2023). While the shift towards renewable energy consumption relatively reduces environmental degradation rates (Islam et al., 2022), it collaborates with fossil fuel consumption in promoting sustainable development opportunities (Jebli and Hakimi, 2023). However, the positive impact of fossil fuel consumption on sustainable development depends on a country's situation, level of advancement, manufacturing capabilities, knowledge accumulation, and strategic planning balance (Khan et al., 2022). One significant feature of the applied study's sample, comprising countries in the Organization of Islamic Cooperation, is their limited economic diversity (Majeed et al., 2021). Even high-income countries, most of which are oil-producing nations, face challenges in reducing environmental pollution and implementing sustainable development programs (Mendoza-Rivera et al., 2023).

Despite renewable energy investments, meeting the needs of impoverished countries, especially in remote areas, is hindered by the lack of basic requirements for achieving sustainable development (Murshed et al., 2022). The long-term estimation results indicate that fossil fuel consumption has a positive and statistically significant effect on sustainable development at a 1% level in all models (Murshed et al., 2021). This relationship can be interpreted from two perspectives: the integrated consumption of fossil fuel and renewable energy and the overall weak share of renewable energy consumption in total energy consumption (Naseem et al., 2021). The ARDL results for all countries with available data in the organization indicate a positive and statistically significant long-term impact of urbanization on the

Comprehensive Sustainable Development Index at a 1% level in the fourth and sixth models (Rusydiana et al., 2021). However, there is a long-term negative and statistically significant effect of trade openness and foreign direct investment, showing up at a 1% level in the second, fifth, and sixth models (Shaari et al., 2020). The short-term relationship estimation results also show a negative and statistically significant impact of fossil fuel consumption on the Comprehensive Sustainable Development Index at a 5% level (Siddik et al., 2023). This negative effect of fossil fuel consumption on the Sustainable Development Index slows down for 1-2 years in the fifth model. Additionally, there is a long-term relationship between sustainable development, fossil fuel consumption, trade openness, manufacturing, urbanization, and foreign direct investment (Tweneboah-Koduah et al., 2023).

In terms of supported hypotheses, our findings align with previous studies, indicating a positive and statistically significant long-term impact of fossil fuel consumption on sustainable development (Anser et al., 2021; Murshed et al., 2021; Xu et al., 2022). The positive relationship suggests that advanced countries focus their fossil fuel consumption outputs on sustainable development activities. Urbanization also stands out as a positive factor contributing to the Comprehensive Sustainable Development Index (Rusydiana et al., 2021; Tweneboah-Koduah et al., 2023), indicating the importance of urban development in fostering sustainable outcomes. However, our results do not support the hypothesis regarding trade openness and foreign direct investment, revealing a long-term negative and statistically significant effect on sustainable development (Shaari et al., 2020; Mendoza-Rivera et al., 2023). This challenges the assumption that increased trade openness and foreign direct investment necessarily lead to improved sustainability. Additionally, the short-term negative impact of fossil fuel consumption on the Comprehensive Sustainable Development Index contradicts the notion that fossil fuel consumption has an immediate positive effect (Siddik et al., 2023). This highlights the complex and multifaceted nature of the relationship between energy consumption, economic factors, and sustainable development.

6. CONCLUSION

The study has unveiled intricate relationships among energy consumption, sustainable development, and economic factors, with a specific focus on countries within the Organization of Islamic Cooperation. The findings highlight the multifaceted nature of these dynamics, revealing a positive correlation between fossil fuel consumption and urbanization with sustainable development, while challenging conventional assumptions about the presumed benefits of trade openness and foreign direct investment. These insights contribute significantly to the evolving discourse on sustainable development, offering a more nuanced understanding of the diverse factors shaping global sustainability outcomes.

The scientific contribution of this research lies in its ability to bridge gaps in existing knowledge, providing fresh perspectives on the complexities inherent in the pursuit of sustainability. By emphasizing the importance of tailored indicators for Islamic countries, the study contributes not only to academic scholarship but also offers practical implications for addressing sustainability challenges in diverse socio-cultural contexts. The knowledge implications of this research extend beyond the boundaries of academic discourse, offering valuable insights for scholars, policymakers, practitioners, and the broader public. The positive correlation between fossil fuel consumption and sustainable development prompts a reconsideration of traditional narratives surrounding energy use. These insights challenge existing paradigms and provide a foundation for further exploration into sustainable development strategies that integrate energy consumption patterns effectively. For practitioners, the findings emphasize the need to align development initiatives with cultural and ethical considerations, advocating for a more nuanced approach to environmental preservation and resource conservation. Recognizing the positive impact of urbanization on sustainable development underscores the importance of strategic urban planning and development policies that contribute positively to long-term sustainability goals. Policy makers can draw upon the study's insights to inform evidence-based decision-making, tailoring interventions to the specific needs and characteristics of their regions. The revelation of a nuanced relationship with trade openness and foreign direct investment prompts policymakers to consider alternative models that balance economic growth with sustainable development objectives. However, it is essential to acknowledge the limitations of this study.

The focus on countries within the Organization of Islamic Cooperation introduces a degree of economic homogeneity, limiting the generalizability of findings to more diverse global contexts. Additionally, the scarcity of comprehensive data for certain countries underscores the challenges inherent in drawing definitive conclusions. Future research endeavors should build upon these findings by exploring diverse global contexts and delving deeper into the intricate relationships between energy consumption patterns and sustainable development outcomes. Investigating cultural and regional nuances in more detail can provide a more comprehensive understanding of the factors influencing sustainability across diverse societies. In summary, this study not only contributes valuable knowledge to the ongoing discourse on sustainable development but also holds practical implications for shaping policies and practices that promote a more sustainable and equitable future.

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