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The role of foreign direct investment and environmental taxation in promoting renewable energy sustainability

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ABSTRACT

This study examines the relationship between Foreign Direct Investment (FDI) and the achievement of Sustainable Development Goal 7 (SDG 7), which aims to ensure affordable, reliable, sustainable, and modern energy for all. Using a panel dataset of 891 country-year observations, the study analyzes how FDI influences SDG 7, while controlling for variables such as GDP, inflation, population growth, patents, and research and development expenditures. The research specifically investigates the moderating role of environmental taxation in this relationship. The findings show a statistically significant negative correlation between FDI and SDG 7, suggesting that foreign investment may hinder the achievement of sustainable energy objectives in some contexts. Specifically, countries with lax environmental regulations tend to attract FDI that undermines sustainable energy efforts, supporting the Pollution Haven Hypothesis. In contrast, higher environmental taxes are shown to mitigate the negative impact of FDI on SDG 7, indicating that stronger regulatory frameworks can help align foreign investments with sustainable energy goals. Further, the study reveals that the impact of FDI on SDG 7 varies by income levels: in high-income countries, FDI has a more detrimental effect on sustainable energy development, whereas in low-income countries, FDI appears to stimulate technological transfer and innovation in clean energy solutions. This research contributes to the literature by providing a nuanced understanding of how environmental taxation can moderate the negative effects of FDI on SDG 7. The findings underscore the importance of policy design in directing FDI flows toward sustainable energy outcomes. Policymakers are encouraged to implement stricter environmental tax policies, particularly in high-income countries, to ensure that FDI supports sustainable energy practices and contributes to achieving SDG 7.

1. Introduction

Climate change, a consequence of global warming, has increased the focus on sustainable development practices (Alfar et al., 2024; Mustafa et al., 2022; Caetano et al., 2022). A main aspect of these efforts is the urgent need to address high carbon emissions, particularly in specific sectors that require substantial investment in renewable technologies (Mansouri et al., 2023). Fossil fuel combustion that led to a significant increase in greenhouse gases (GHGs), contributing to global temperature increases, biodiversity loss, and socio-economic instability (Mahadevan and Sun, 2020; Nasir et al., 2019; Tan et al., 2021). Consequently, Mansouri et al. (2021) stress the importance of making efforts to transform energy centres into sustainable and economically viable hubs.

The European Union has set ambitious targets in the Paris Agreement, aiming for a 32 % renewable energy share by 2050 to limit global warming to 1.5 °C (Meng et al., 2024). The United Nations' Sustainable Development Goals (SDGs) offer a framework for tackling global challenges, with SDG 7—centred on "Affordable and Clean Energy", acting as a crucial goal in aligning energy requirements with environmental sustainability (UN, 2019).

Foreign Direct Investment (FDI) plays a key role in this global transaction. FDI facilitates the cross-border movement of capital, technology, and knowledge, urging innovation and expediting sustainable development in host countries (Aust et al., 2020; Zafar et al., 2020). FDI might progressively be considered as a key driver for achieving SDG7

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(Aust et al., 2020; Caetano et al., 2022; Yu et al., 2021; Li2022). Still, the relationship between FDI and environmental sustainability is complex, with mixed evidence on FDI's role in fostering positive ecological outcomes and reliance on renewable energy (Li et al., 2022; Song et al., 2024). At the same time, the Pollution Haven Hypothesis (PHH) asserts that FDI worsens environmental deterioration by transferring pollution-heavy businesses to developing countries (Caetano et al., 2022; Raza et al., 2024), highlighting the need for targeted policy interventions.

Environmental taxes are one such policy tool; they are seen as an effective method of internalising environmental costs and directing economic activity towards sustainability (Bashir et al., 2021). These taxes are theorised to drive the transition to a more sustainable economy by influencing corporate and consumer behaviours in favour of cleaner energy, reducing carbon emissions, and fostering green innovation (Song et al., 2024). However, the effect of environmental taxes on FDI is multifaceted. Yiadom et al. (2024) suggest that an unmitigated carbon tax could potentially discourage FDI; however, when tax revenues are reinvested into the economy, FDI may be significantly sustained, thereby supporting the double dividend theory. Their results indicate that a carbon tax of around $8.5 per tonne may encourage FDI, while taxes above $25 per tonne or falling below $3 per tonne may create adverse effects, particularly in the African context. Thus, the success of environmental taxes in supporting sustainable FDI flows is conditional on careful tax design and the management of tax returns, as evidenced in China's case (Soto, 2024). Other researchers underscore the challenges linked to integrating tax-based policies into broader, comprehensive frameworks for sustainable development (Bashir et al., 2021). Despite the growing attention to these policies, the actual effects on FDI and environmental results in the international context remain unclear.

Despite a growing body of literature on these topics, critical gaps remain. While research has extensively examined the environmental effects of FDI, most studies focus on its direct influence on host countries' ecological quality and show that the conditional factors need further exploration (Caetano et al., 2022; Li et al., 2022; Song et al., 2024). For instance, Song et al. (2024) results confirm a nonlinear relationship among FDI, trade openness, economic growth, energy consumption, and environmental pollution, specifically with CO_2, nitrous oxide (N_2O), methane (CH_4), and ecological footprint in the Organisation of Islamic Cooperation countries, which reveals inconsistent results. This gap in empirical research makes it difficult to identify under which conditions FDI can contribute to SDG7, specifically in an international context. The variability of effects across diverse economic contexts—developing versus developed countries—introduces an additional complexity that has been inadequately examined.

Although some studies have explored the relationship between environmental taxes and FDI (Song et al., 2024; Soto, 2024; Yiadom et al., 2024), limited empirical research into how taxes might moderate or enhance the environmental impacts of FDI in the context of energy sustainability exists, and at 81 countries level, existing studies on green taxes and investment decisions tend to focus on specific sectors or countries (Soto, 2024; Yiadom et al., 2024), leaving a significant gap in understanding the broader implications of these policies for FDI-driven energy transitions worldwide.

The inclusion of a varied array of countries in this study facilitates a more thorough understanding of the effects of environmental taxation on FDI and SDG 7 across different economic settings. This study examines data from 81 countries across various developmental stages, addressing the diversity in economic structures, tax systems, and energy policies, thus facilitating more generalisable conclusions. The variety of these environments aids in identifying the precise conditions under which FDI might effectively advance SDG 7, providing useful insights for policy formulation that can be customised to various national situations.

Considering these gaps, this study aims to provide a comprehensive analysis of the relationship between FDI, environmental taxation's moderating role, and the achievement of SDG 7 by employing a multi-country dataset covering 81 nations from 2010 to 2020.

This study contributes to literature in several ways. First, it bridges the gap between FDI, environmental taxation, and SDG 7 by providing a comprehensive, multi-country empirical analysis. Second, it integrates environmental economics and policy insights to better understand how environmental taxes influence FDI-driven energy transitions. Our findings provide valuable insights for policymakers, businesses, and stakeholders invested in the sustainable energy transition, highlighting the importance of designing policies that align FDI flows with environmental sustainability goals. Additionally, by considering the differential impacts of FDI and environmental taxation across countries at various stages of development, our study underscores the need for context-specific policy interventions. Finally, our research gives useful information that helps make policy frameworks that fit the needs of different economies by explaining how environmental taxes can help with sustainable energy transitions.

This paper is structured as follows: Section 2 provides the theoretical foundations linking FDI, environmental taxation, and SDG 7. Section 3 describes the methodology used in the empirical analysis. Sections 4 and 5 present the findings and discuss their implications for theory, policy, and practice. The concluding section offers directions for future research, emphasising the need for a more integrated approach to economic and environmental objectives in the global transition towards sustainable development.

2. Theoretical framework and literature review

Sustainability research has examined various topics, revealing the complex nature of sustainable practices and their significant effects on organisations and societies (Aust et al., 2020). The SDGs offer a structured approach to tackling critical global issues such as poverty, inequality, and climate change. There is no doubt that these SDGs are important, but current research often falls short in giving a full picture of their role in advancing global sustainability initiatives (Deegan, 2019).

The application of various theoretical frameworks to the study of sustainability provides a strong basis for analysing the SDGs. Institutional theory, legitimacy theory, stakeholder theory, and information asymmetry theory provide essential frameworks for analysing sustainability disclosures, stakeholder engagement, and organisational behaviour in relation to these SDGs (Boiral and Heras-Saizarbitoria, 2020; Deegan, 2019; Pucheta-Martínez and Gallego-Álvarez, 2019). Theories highlight the importance of transparent and high-quality disclosures in managing organisational legitimacy, informing stakeholders, and mitigating information asymmetry (Ching and Gerab, 2017). Accordingly, the theoretical framework emphasises the necessity of incorporating sustainability principles into strategies, offering a thorough understanding of how organisations engage with and support the global sustainability agenda established by the SDGs.

Institutional theory provides significant insights into the impact of environmental regulations and FDI under the SDGs framework. This theory asserts that institutional contexts profoundly affect organisations, imposing substantial pressure to adhere to societal norms and expectations (McLaughlin et al., 2019, 2021; Owusu et al., 2020; Roberts et al., 2021; Selmey and Elamer, 2023; Srouji et al., 2023; Ullah et al., 2024; Warmate et al., 2021). This leads to the implementation of practices and disclosures that conform to environmental and social goals (Hahn and Kühnen, 2013). The assurance process for sustainability reports is essential for improving the accountability, reliability, and trustworthiness of these disclosures, hence strengthening an organisation's commitment to sustainability (Reimsbach et al., 2018).

Legitimacy theory enhances this viewpoint by positing that organisations strive to survive by aligning with the ideals and standards of their external contexts. This entails actively participating in sustainability activities acknowledged by significant stakeholders, including regulatory bodies and the broader community, within the SDG framework. Inadequate engagement with the SDGs may undermine an organization's legitimacy, highlighting the strategic significance of sustainability disclosures for preserving stakeholder trust and support (Deegan, 2019). Moreover, information asymmetry theory reveals the obstacles and opportunities related to the transmission of sustainability information. Organisations can enhance transparency and build a culture of responsibility by successfully communicating their sustainability initiatives and progress towards SDGs alignment, hence bridging information gaps with stakeholders (Pucheta-Martínez and Gallego-Álvarez, 2019).

The intricate interplay between environmental tax legislation and FDI, especially with SDG7, is fundamental to this theoretical paradigm. This study contends that environmental taxes, as a strategic policy instrument, can affect the environmental and economic results of FDI by directing investments towards more sustainable goals. The efficacy of these policies in promoting SDGs, particularly SDG 7, depends on various aspects, including national policy frameworks, leadership practices, and the overall dedication to these SDGs (Zhou et al., 2022). This study develops a comprehensive theoretical framework clarifying the complex relationships among environmental policies, FDI, and SDG 7. This method not only promotes a comprehensive understanding of the strategic alignments and practices required to attain the SDGs but also elucidates how environmental tax policies may either bolster or hinder these global sustainability initiatives.

2.1. Foreign direct investment and SDG 7

The evolution of sustainable development, framed by the 2030 Agenda, emphasises the integration of economic growth, environmental, and social sustainability (Atia et al., 2020; Bufarwa et al., 2020; Elamer and Boulhaga, 2024; Eldaly et al., 2024; El-Dyasty and Elamer, 2021; Hui et al., 2024; Ibrahim et al., 2021; Kazemi et al., 2023; Mahran and Elamer, 2024; Marie et al., 2024). The role of FDI has been the subject of extensive debate within this context. FDI is acknowledged for its capacity to stimulate economic growth, especially in developing economies, by enhancing competition and facilitating technological advancements (Aust et al., 2020). The relationship between FDI and environmental sustainability, particularly in relation to SDG 7, is intricate and multifaceted. Research by Lin et al. (2024) indicates that resource-rich countries are vulnerable to the resource curse, wherein natural resource rents and FDI may delay sustainable economic growth, despite the potential benefits of improved energy efficiency and electricity access for long-term development. The PHH suggests that FDI may increase environmental pollution in host countries characterised by poor environmental regulations, as it enables the transfer of polluting technologies from high-income economies. This hypothesis is consistent with findings that suggest countries with less stringent environmental policies may attract environmentally detrimental industries (Tan and Uprasen, 2022).

Aust et al. (2020) highlight the beneficial impacts of FDI on infrastructure, clean water, sanitation, and renewable energy, suggesting a possible alignment with SDGs. Still, the complexity increases when examining the sector-specific effects of FDI on energy consumption and environmental pollution. Doytch and Narayan (2016) provide a detailed analysis by disaggregating FDI inflows and assessing their effects on renewable and non-renewable industrial energy sources, revealing varying impacts across sectors.

The regulatory environment significantly influences the impact of FDI on sustainable energy outcomes. Tan and Uprasen (2022) examine the role of environmental regulations as a pivotal threshold variable that influences the relationship between FDI and renewable energy consumption in the BRICS nations—Brazil, Russia, India, China, and South Africa—varying with the regulations' stringency. The evidence suggests a hypothesis that FDI may have a significant negative effect on the attainment of SDG7, especially in environments with weak environmental regulations (Aust et al., 2020; Doytch and Narayan, 2016; Lin et al., 2024; Tan and Uprasen, 2022). Based on these findings, the subsequent hypothesis is proposed:

H1. FDI significantly and negatively impacts the achievement of SDG 7, especially in contexts
where environmental regulatory frameworks are weak.

2.2. Environmental taxes moderating effect

The emergence and global adoption of environmental taxes in recent decades indicate a transition towards harmonising fiscal policies with sustainability goals. These taxes, which include carbon and energy taxes, are meant to cut down on pollution, mostly greenhouse gas (GHG) emissions, by making carbon-heavy energy sources more expensive (Bashir et al., 2021; Fang et al., 2022). This will encourage people to use less energy. Carbon taxes primarily influence sectors with high carbon emissions, such as transportation, specifically targeting the reduction of carbon emissions by imposing charges on companies based on their GHG emissions and carbon-based fuels (Hájek et al., 2019), thereby incentivizing the adoption of cleaner technology. On the other hand, energy taxes typically influence the energy consumption of both residential and business sectors. They are imposed on fossil fuels, influencing energy consumption by increasing the cost of non-renewable energy sources and promoting a shift towards renewable alternatives, especially in high-energy-demand sectors (Fang et al., 2022; Hájek et al., 2019).

Dogan et al., 2022 emphasise that green tax reforms, along with enhanced environmental legislation and carbon pricing, are essential for guiding countries towards more sustainable and energy-efficient economies. Their research highlights the critical function of policymakers in establishing conditions conducive to the adoption of green technologies and sustainable development. Environmental taxes can facilitate the adoption of energy-efficient technologies in several industries, although the specific results of these changes may differ based on the industry and geographical setting. For example, manufacturing businesses in developed countries may move faster to cleaner technologies due to higher innovation capacity, while emerging countries may face encounters due to limited access to such technologies. Therefore, the efficacy of these fiscal measures depends on local conditions, including current regulatory frameworks, economic structures, and regional innovation capacity.

In emerging economies, where access to green technology is limited, raised carbon or energy prices have negative short-term consequences, including higher operational costs and hesitancy from foreign investors, especially those depending on outdated, polluting technologies. The research conducted by Fang et al. (2022) on countries involved in the Belt and Road Initiative confirms a temporary adverse effect on energy consumption as companies adapted to increased costs. However, this short-term challenge led to a permanent positive impact when companies adopted cleaner technologies and transitioned to renewable energy sources. The shift emphasises that environmental taxes, while difficult at first, can incentivise long-term green technological innovation and cleaner energy adoption, highlighting their significant potential for sustainability over time. Factors like capital reallocation to more energy-efficient technologies are responsible for this shift.

In addition to all environmental gains, environmental taxes are broadly observed as key drivers of technological innovation, specifically in renewable energy industries. For instance, carbon pricing in countries like Germany has resulted in substantial investments in wind and solar technology (Doytch and Narayan, 2016). In the same way, carbon taxes in the G7 have encouraged investment in green research and development (R&D). This shows that these kinds of tax policies can both discourage pollution and make it easier for businesses to switch to green innovations (Doğan et al., 2022). Their results also argue that reallocating tax revenues to R&D in sustainable technologies is essential for attaining global sustainability goals, including the United Nations' SDG-7 and SDG-13.

Another issue to consider is that the enactment of environmental tax impacts employment, especially in labour-intensive industries, resulting in significant job losses for unskilled individuals (Scrimgeour et al., 2005). These effects emphasise the necessity of evaluating both the environmental and socioeconomic consequences when enacting tax policy. Thus, policymakers should consider balancing the environmental paybacks of these taxes with any potential negative implications for the labour market, considering FDI's role in offering jobs.

The complex dynamics of fiscal policies and international capital flows require a detailed examination of the factors involved. The relationship between FDI and environmental taxes is complex. Rigorous taxes may discourage investment in polluting industries; however, they can encourage FDI in green technologies by providing a promising regulatory framework for clean energy programs. This dual impact is specifically evident in emerging markets, where rigorous environmental taxes can increase the growth of green technology sectors by creating an attractive market for environmentally conscious FDI. Thus, we suggest that environmental taxes may have a moderating effect in aligning FDI inflows with SDG 7. We propose the following hypothesis based on these findings:

H2. Environmental taxes moderate the relationship between FDI and the achievement of SDG 7, potentially enhancing the positive impacts of FDI on sustainable energy access and utilization.

3. Methodology

3.1. Research sample

The dataset underpinning this study provides a comprehensive view across a decade (2010–2020), encompassing 891 observations from 81 countries. The study sample was carefully chosen to provide a globally representative analysis, which is necessary to fully grasp the various effects of FDI and environmental taxes on SDG 7. The sample contains countries at all economic levels and consists of 20 upper-middle-income countries (UMICs), 16 low- and middle-income countries (LMICs), 9 low-income countries (LICs), and 36 high-income countries (HICs).[1] This broad geographic and economic coverage reflects the study's alignment with the global agenda of SDG 7, which stresses universal access to affordable, reliable, sustainable, and modern energy for all, underscoring the principle of leaving no one behind. We selected the countries based on the availability of observations for SDG 7 progress. The sample covered countries with varying levels of FDI inflow and different environmental tax structures; hence, confirming there is no bias in the sample that might affect the research's findings.

The Bertelsmann Stiftung and the Sustainable Development Solutions Network (BS-SDSN) provided data for this study. Asadikia et al., 2021 say, both of these organisations are known for the strict way they track progress towards the SDGs. The BS-SDSN's method is very strong; it provides a clear framework that shows the progress of each SDG, including SDG 7, as a share of the overall goal reached. This approach contrasts with more granular, target-level analyses by offering a synthesised and consistent metric for evaluating progress. Specifically, SDG 7 progress is quantified via an index score ranging from 0 to 100, where 0 represents minimal or no progress, and 100 indicates full achievement of the goal. BS-SDSN includes all countries in the sample, so the data is complete and doesn't have any gaps. This makes sure that there are no problems with the validity of comparisons between countries and the usefulness of the results in other situations.

The methodological choice of using BS-SDSN's data confirms the study's outcomes are grounded in a reliable and universally applicable framework, facilitating a nuanced understanding of how FDI and environmental taxation interact with SDG 7. This method shows that the research is solid and adds to the academic discussion on the SDGs. It also gives policymakers and other stakeholders who are working to change the global sustainability agenda useful insights.

In constructing the empirical model for this study, data on FDI net inflow, which is essential for analysing its impact on SDG 7, was meticulously sourced from the World Bank database. This data, reported in millions of USD and broken down at the country-year level, provides a solid foundation for assessing the role of FDI in fostering sustainable energy practices globally. This approach follows the precedent set by Bird and Rowlands (2001), ensuring that the study is based on reliable, globally recognised data sources, which improves both the validity and reliability of the research findings.

Complementing the FDI data, data regarding environmental taxes was obtained from the OECD database. Specifically, the study utilised data on the percentage of environmental tax contributions to the Gross Domestic Product (EnvTax), a metric that reflects the fiscal commitment of countries to environmental sustainability. This measure is key for assessing the potential moderating effect of environmental taxes on the relationship between FDI and SDG 7, drawing on established literature (Bashir et al., 2021).

To confirm a comprehensive analysis, the study combined several control variables known to influence SDGs' progress. As economic progress primarily leads to higher pollution levels but eventually reduces pollution once reaching a marginal level of development (Vasylieva et al., 2019), key control variables were included. These include Gross Domestic Product (GDP), which reflects a country's economic size and capacity (Bashir et al., 2021); inflation rate, demonstrating economic stability (Easterly, 2009; Gong et al., 2020); and the log of population size, accounting for demographic factors that might impact SDG attainment (Warchold et al., 2021).

Investment in R&D for green technologies has been shown to notably enhance environmental quality by reducing pollutants like carbon dioxide and methane (Elia et al., 2021). R&D expenditures as a percentage of GDP were included to control for a country's investment in innovation (García-Dastugue and Eroglu, 2019), recognising its crucial role in driving technological advancements for SDGs.

Additionally, the model was controlled by the logarithm of total patents issued by scientific institutions (LogPatent), following insights from Ghorbal et al. (2022) and Chen et al. (2023). This variable is a proxy for a country's innovative capacity, theoretically mitigating environmental degradation through the development of green technologies. This comprehensive control framework enhances the model's explanatory power and contributes to confirming the reliability of the results by addressing potential variables. All control variables were obtained from the World Bank database.

This robust methodology and the inclusion of related control variables and data from reliable sources support the validity and reliability of the study's results. The thorough consideration of different factors confirms that the study proposes a thorough analysis of how FDI and environmental taxation impact SDG 7.

3.2. Study model

According to the measurement of the above-discussed variables. We model SDG 7 as a function of FDI and the country variables for 2010 to 2020:

$$\text{Log SDG7}_{it} = \alpha + \beta 1\ \text{FDI}_{it} + \beta 2\ \text{GDP}_{it} + \beta 3\ \text{Inflation}_{it} + \beta 4\ \text{Population}_{it} + \beta 5\ \text{Patent}_{it} + \beta 6\ \text{RDExp}_{it} + \varepsilon_{it} \tag{1}$$

The moderating role of environmental tax is modelled as follows:

$$\text{Log SDG7}_{it} = \alpha + \beta 1\ \text{FDI}_{it} + \beta 2\ \text{GDP}_{it} + \beta 3\ \text{Inflation}_{it} + \beta 4\ \text{Population}_{it} + \beta 5\ \text{Patent}_{it} + \beta 6\ \text{RDExp}_{it} + \beta 7\ (\text{FDI*EnvTax})_{it} + \varepsilon_{it} \tag{2}$$

[1] Refer to Appendix 1 for countries.

Where SDG7 is the sustainable development goal 7, FDI is the foreign direct investment, EnvTax is the environmental tax to GDP, 'GDP' is the percentage of gross domestic production growth, 'Inflation is the inflation rate, 'Population' is the natural log of total patent is the logarithm of total patents from scientific institutions, RDExp is research and development expenses as a percentage to GDP.

3.3. Descriptive analysis

This research dataset entails panel data from 891 country-year observations, as presented in Table 1. The variables Goal 7, FDI, GDP, inflation, population, total patents, and RDExp have been transformed using the logarithmic method to satisfy the normality assumption and remove outliers. Empirical investigations typically use logarithmic transformations to rectify skewed distributions, especially for FDI and GDP data that span multiple orders of magnitude. These adjustments stabilise variance and enhance the interpretability of coefficients, reflecting percentage changes instead of absolute changes. This transformation facilitates the analysis of relationships, wherein the coefficients of log-transformed variables denote elasticities, signifying the percentage changes in the dependent variable that come from a 1 % change in the independent variable. Furthermore, the transformation guarantees that the data adheres to a more normal distribution, which is essential for accurate statistical inference (Feng et al., 2014; Keene, 1995) (see Table 2).

Kennedy et al. (1992) recommended winsorizing all continuous variables at 0.05 to eliminate outliers. Winsorization is employed to mitigate the outliers while preserving the dataset's integrity. Alternative techniques, including trimming and robust standard errors, were evaluated; nevertheless, winsorization was determined to be the most appropriate for mitigating the impact of outliers while retaining non-extreme data points (Hellerstein, 2013). This methodology guarantees the reliability of the results, albeit its implications will be addressed in the conclusions.

Table 1 exhibits the descriptive statistics for the variables examined within the scope of the study. The log-transformed variable "logGoal7" of the variable "Goal7" demonstrates an average of 4.20 (71.31 %), reflecting a metric associated with a medium progress rate of the SDG in comparison to the targeted year of the 2030 Agenda. The value of this variable ranges from 3.95 (31.32 %) to 4.47 (89.02 %) with a standard deviation of 0.12 (10.13 %), indicating a low dispersion of the country's progress in this goal. The results are supported by Matenga (2022), who reported poor performance of energy markets in Sub-Saharan Africa and the lack of significant strides in achieving Goal 7 in the United States and China.

The FDI variable, a cornerstone of cross-border economic influence, portrays remarkable figures with an average of 21.42 ($21.35 billion), underscored by pronounced variability indicated by a staggering standard deviation of 2.83 ($64.94 billion). The FDI data range from a minimum of 16.342 (-$289.2 billion) to 25.73 ($436.6 billion), highlighting economic engagement's diverse scales and trajectories across nations.

The "EnvtaxTotal" average is 6.79 %, likely representing an environmental tax with a considerable contribution to GDP. Compared to the literature, the average environmental tax to GDP was 2.3 % in OECD countries between 1995 and 2019 (Al Shammre et al., 2023). Also, the environmental tax contribution was 0.61 % in G7 countries between 1994 and 2014, according to Doğan et al. (2022). The growth in this contribution to GDP internationally shows that it is an effective tool to support the economy in the long run, as confirmed by Abdullah and Morley (2014). However, a minimum value of 1.21 % is noteworthy and requires careful consideration if some regions or entities receive incentives or benefits, reducing their effective environmental tax burden. This variable's standard deviation of 3.33 % indicates variability in environmental taxation across the observed entities and a lack of clear policy across countries.

For the control variables, LogGDP showcases a mean of 9.30 ($21,570.626), serving as a logarithmic transformation of GDP in USD, with values ranging from 7.14 ($334.022) to 11.03 ($123,678.7). LogGDP offers insight into the economic magnitude of the countries in the sample, indicating their ability to adopt cleaner energy technology and execute successful environmental policies. As anticipated, increased economic capability correlates with enhanced investments in sustainability initiatives, encompassing renewable energy sources following Lyeonov et al. (2019).

The variable for R&D expenditures (RDExp) has been incorporated into the model as a measure of innovation. Research and development expenditures are essential for fostering technical progress, particularly in renewable energy sources. We propose that increased R&D expenditure correlates favourably with the attainment of SDG 7, since it promotes the innovation and dissemination of innovative energy technologies that facilitate sustainable energy transitions. The average of R&D percentage to GDP is 1.317; this positive value supports that R&D expenditures may facilitate advancements in energy efficiency and renewable energy technology, thereby expediting the transition to cleaner, more sustainable energy options if directed towards SDG 7. These results are aligned with Paramati et al. (2021) and Fernández et al. (2018).

"Log population" presents a mean of 16.39 (71,944,566), representing a logarithmic transformation of population data, with values ranging from 13.91 to 18.66. This transformation offers a different perspective on population distribution and density within the dataset. The logarithm of population is utilised to account for demographic variables that may influence a nation's capacity to attain SDG 7. Increased populations may signify elevated energy requirements, thus complicating the shift to sustainable energy alternatives.

The unemployment rate averages 7.826 %, ranging from a minimum of 1.13 % to a maximum of 26.49 %. Since higher unemployment may be associated with slower progress towards SDG 7 due to financial restrictions and a reduced ability to invest in clean energy solutions, the unemployment rate is a good indicator of economic stability.

4. Results and discussion

This section shows the findings of the regression analysis performed to investigate the impact of FDI on advancements towards attaining SDG 7, which emphasises the provision of affordable, sustainable, and modern energy for all. To ensure robustness and mitigate prevalent difficulties in panel data, many regression techniques were utilised, including ordinary least squares (OLS), Newey's fixed effects (FE), generalised least squares (GLS), and two-stage least squares (2SLS). These approaches tackle critical issues associated with heteroscedasticity, autocorrelation, and endogeneity to ensure robustness and mitigate prevalent difficulties in panel data.

Table 1
Descriptive statistics.

Variables	Obs	Mean	Std. Dev.	Min	Max
logGoal7	748	4.265	0.128	3.953	4.479
LogFDI	569	21.428	2.835	16.342	25.735
logGDP	748	9.302	1.227	7.148	11.035
Inflation	732	3.021	3.679	−2.595	48.7
logPopulation	748	16.485	1.393	13.934	18.668
LogPatent	629	3.146	0.949	1.322	4.83
RDExp	559	1.317	0.957	0.015	3.705

Table 2
Levin-Lin-Chu and Fisher-AD results F.

	Levin-Lin-Chu Test Results	Fisher-ADF Test Results
Statistic	−2.54	34.62
P-value	0.011	0.004

4.1. Addressing heteroscedasticity and robustness

Considering the potential for heteroscedasticity[2] and autocorrelation[3] in panel data, particularly with time-series elements, it is essential to address these concerns to guarantee the reliability of regression estimates. We conducted the Breusch-Pagan test to assess heteroscedasticity, which revealed significant heteroscedasticity in our data. This issue frequently arises in econometric models, resulting in inefficient estimates and invalid standard errors, which may compromise hypothesis testing. (Drukker, 2003). This study initially employed the Breusch-Pagan test to evaluate heteroscedasticity. The findings demonstrated heteroscedasticity (2.49, $P \leq 0.05$), prompting the rejection of the null hypothesis regarding constant variance.

Due to heteroscedasticity, we employed robust standard errors using the Newey-West procedure, which addresses both heteroscedasticity and autocorrelation in the error terms (Wooldridge, 2010). This method was chosen due to its ability to yield consistent estimates of the covariance matrix, even when faced with these challenges. The application of Newey-West estimators improves the reliability of results by appropriately adjusting standard errors for various types of model misspecification (Agunbiade and Adeboye, 2012). The reliability of our estimates is further validated by the consistency of results across various model specifications, including OLS, Newey-West, and fixed effects models.

4.2. Autocorrelation and model Selection

Autocorrelation can compromise the reliability of regression outcomes by producing inefficient and biased estimates. To mitigate potential autocorrelation, we employed the Wooldridge test, which revealed first-order autocorrelation in the sample (6.34; $P < 0.05$). We later employed Newey-West standard errors, which address both heteroscedasticity and autocorrelation. The resemblance between the OLS and Newey-West outcomes indicates that autocorrelation does not substantially affect the principal findings, hence enhancing the robustness of our conclusions following Agunbiade and Adeboye (2012). While GLS could have addressed autocorrelation, Newey-West estimators were favoured for their simultaneous adjustment for both concerns, hence providing more trustworthy standard errors in time-series panel data.

4.3. OLS results and the relationship between FDI and SDG 7

The OLS regression results in Table 3 indicate a statistically significant negative correlation between log-transformed FDI and progress towards SDG 7, with a coefficient of −0.030***. The result remains consistent when applying Newey-West and fixed effects estimations, underscoring the robustness of the relationship across various estimation techniques. The negative sign signifies a correlation between increased FDI and slower advancement on SDG 7, implying that multinational corporations (MNCs) may prioritise countries with lax environmental regulations, emphasising cost minimisation and resource extraction over sustainability promotion. This finding aligns with existing literature indicating that FDI in developing countries can result in heightened energy consumption and environmental degradation (Aust et al., 2020; Cai et al., 2018; Doytch and Narayan, 2016), indicating that multinational corporations frequently pursue nations with more lenient legislation. This study enhances existing research by offering fresh insights into the interaction between FDI and the advancement of SDG 7, especially in nations with diverse energy requirements and regulatory frameworks. We propose that foreign investment, although fostering economic progress, may detract from more ambitious sustainability objectives, particularly in nations with lax environmental rules. This sophisticated comprehension of FDI's significance in SDG 7 constitutes a vital contribution to literature, since it transcends mere correlation to investigate the fundamental dynamics.

Table 3
OLS, Newey and Fixed Effect results.

Variables	OLS	Newey	Fixed Effect
LogFDI	−0.030***	−0.030***	−0.002*
	(0.000)	(0.000)	(0.079)
logGDP	0.053***	0.053***	0.034***
	(0.000)	(0.000)	(0.000)
Inflation	−0.007***	−0.007***	−0.003***
	(0.001)	(0.001)	(0.000)
logPopulation	0.019***	0.019***	0.009
	(0.000)	(0.000)	(0.391)
LogPatent	−0.030***	−0.030***	−0.021***
	(0.000)	(0.000)	(0.000)
RDExp	0.037***	0.037***	0.013*
	(0.000)	(0.000)	(0.040)
_cons	4.104***	4.104***	3.855***
	(0.000)	(0.000)	(0.000)
N	396	396	396
R^2	0.287		
Panel B: Hausman's (1978) **specification test**			
Chi-square	125.95		
P-value	0.0000		

Note: ***, ** and * indicate that the coefficients are significant at the 1 %, 5 % and 10 % level of significance, respectively.

This relationship requires careful interpretation due to the potential endogeneity of FDI, which may influence and be influenced by a country's environmental policies, warranting further investigation. Thus, we utilised an Instrumental Variables (IV) approach, employing the lagged value of FDI as an instrument, as outlined below.

Population growth has been recognised as a major catalyst for energy demand and, therefore, advancement towards SDG 7. Our findings indicate that population growth is statistically significant, with larger populations enhancing the advancement of SDG 7 (0.019***). Nonetheless, we acknowledge that this relationship is complex. Population growth in metropolitan areas typically results in heightened energy demand, prompting investments in renewable energy infrastructure to satisfy these requirements. Conversely, swift population increase in rural regions may intensify issues of energy availability, particularly in low-income nations, potentially obstructing progress towards SDG 7. The influence of population growth on SDG 7 depends on several factors, such as infrastructure development, energy access legislation, and regional demographic trends. A sophisticated view of how population dynamics affect SDG 7 is needed for a comprehensive understanding of this relationship. These results are aligned with Akram et al. (2023), who assert that Pakistan is transitioning to renewable energy and aims for 30 % green electricity by 2030; the research emphasises the ecological advantages of regulated population growth.

The observed negative correlation of −0.030*** between the number of patents and progress on SDG 7 necessitates additional investigation. Patents are generally linked to technological progress, especially within energy-related industries. The negative relationship identified in our findings indicates that the patents influencing this trend may be focused on non-renewable energy technologies, including fossil fuels, or on technologies that have not yet reached commercial deployment. Alternatively, the patent data may indicate innovation that does not directly correspond with the objectives of SDG 7, which emphasises

[2] Heteroskedasticity is "when the standard deviations of a predicted variable, monitored over different values or as related to time, are non-constant. It is any set of data that is not homoscedastic (data with unequal variability (scatter) across a set of predictor variables)".

[3] Serial correlation "is the degree of correlation of the same variables between two successive time intervals. It measures how the lagged version of the value of a variable is related to the original version of it in a time series". Because serial correlation in linear panel-data models biases the standard errors and causes the results to be less efficient.

universal access to affordable, reliable, sustainable, and modern energy. We intend to examine the specific categories of patents in our analysis, determining if they pertain to renewable energy or other fields, and evaluate the potential disconnect between technological innovation and its practical application in energy systems. This analysis may clarify whether patents genuinely facilitate progress towards SDG 7 or if they indicate an innovation deficit in sustainable energy technologies. The study of Zambrano-Monserrate et al. (2024) examines the correlation between patent applications for renewable energy technologies and clean energy production across 45 countries from 2000 to 2019. Employing a System generalised Method of Moments Panel Vector Autoregressive model, along with Impulse Response Functions (IRFs) and Granger causality tests. Their results support the current research as they show that GDP per capita, FDI, political stability, and trade openness have a significant impact on clean energy production. Their findings also show that renewable energy patents do not immediately impact clean energy production, and the sustained impact of innovation patents requires time for technology implementation and infrastructure adaptation.

4.4. Fixed effects model and unobserved heterogeneity

In the fixed effects model, the coefficient for FDI is −0.002. Although the use of "positive" to describe this negative coefficient was incorrect, it is essential to clarify that this result indicates a change in the relationship between FDI and SDG 7 when accounting for unobserved heterogeneity. The fixed effects model accounts for country-specific factors that may affect both FDI inflows and progress towards SDG 7, including institutional quality, governance, and regional energy requirements. The fixed effects model, by accounting for unobserved factors, offers a refined perspective on the relationship, indicating that the negative impact of FDI on SDG 7 intensifies when these confounding variables are controlled for. The change in the coefficient underscores the necessity of considering unobserved heterogeneity in the analysis of the intricate relationships between foreign investment and sustainable development goals.

4.5. Stationarity and Breusch-Pagan Lagrangian multiplier tests

The results of the stationarity assessments, specifically the Levin-Lin-Chu test and Fisher-ADF test, indicate that FDI exhibits stationarity throughout the panel, since both tests reject the null hypothesis Therefore, you can conclude that the data does not contain a unit root and is stationary. which confirms the appropriateness of using time series models that assume stationarity, such as autoregressive models or panel regression models.

The Breusch-Pagan Lagrangian Multiplier (LM) test was applied. The test statistic of p-value of 0.0000. This result indicating that the random effects model is statistically significant as it addresses the unobserved heterogeneity among the countries in the sample. Still, the Hausman test strongly supports the use of the **fixed effects model**. The fixed effects model is preferred in this context because it better accounts for the unobserved heterogeneity that might correlate with the explanatory variables, leading to more reliable and robust results.

4.6. Endogeneity and Instrumental Variables

In studies investigating the relationship between FDI and progress on SDG 7, endogeneity presents a potential concern, possibly stemming from reverse causality, omitted variables, or measurement error (Abdelkader et al., 2024; Adhikariparajuli et al., 2021; Al Frijat et al., 2024; AlHares et al., 2020; Alshbili et al., 2021; Amin et al., 2023). This relationship between FDI and progress on SDG 7 may be bidirectional, with FDI potentially impacting SDG 7 advancements and vice versa. Endogeneity may result in biased and inconsistent estimates in OLS regressions.

To address this issue, we employed the lagged value of FDI (t-1) as an instrument in a 2SLS regression analysis following Bascle (2008). With a coefficient of −0.043***, the 2SLS results shown in Table 4 also show a strong negative relationship between FDI and progress towards SDG 7. This reinforces the finding that FDI adversely affects SDG 7, even when accounting for endogeneity, indicating that policies designed to encourage FDI may require reevaluation due to their possible detrimental effects on sustainable energy access. We applied the GLS regression[4] to correct the omitted variable bias and ensure autocorrelation and heteroskedasticity in pooled cross-sectional data. The GLS results presented in show 'no autocorrelation' and 'heteroskedastic panel data' where the LogFDI was significant (−0.011***). The GLS results presented in Table 3 show 'no autocorrelation' and 'heteroskedastic panel data' where the LogFDI was significant (−0.011***) (see Table 5).

4.7. Reverse causality

The justification for using lagged FDI is grounded on theoretical considerations that past FDI investments impact current progress toward SDG 7. The effect of infrastructure investments, technological transfers, and knowledge spillovers typically unfold over time (Mustafa et al., 2024). The findings from the reverse causality test (Table 4) indicate that lagged FDI (t-1) exhibits a significant negative correlation with SDG 7 (−0.019***), while lagged FDI (t-2) shows an even stronger negative correlation (−0.000***). These results imply that reverse causality does not materially influence the primary results. Reverse causality remains a potential concern, as progress in SDG 7 could theoretically influence FDI flows rather than FDI determining SDG 7 outcomes. To address this concern, we employed lagged variables for FDI and SDG 7, positing that historical values of FDI are more likely to influence current progress toward SDG 7, while the reverse assumption is minimized.

Although lagged variables partially alleviate reverse causality, this method has inherent limitations. To guarantee robustness, we evaluated multiple lag lengths (1, 2, and 3) and chose the appropriate specification based on statistical significance, theoretical validity, and model fit criteria. The findings demonstrate that both lag1_FDI and lag2_FDI

Table 4
2SLS and Reversal Causality Test result (SDG7).

Variables	2SLS	GLS	Reversal Causality lag1_FDI	Reversal Causality lag2_FDI
LogFDI	−0.043***			
	(0.000)			
logGDP	0.078***	0.0308***	0.0329**	0.0621***
	(0.000)	(0.000)	(0.001)	(0.014)
Inflation	−0.006**	−0.00545***	−0.00946***	−0.020***
	(0.002)	(0.000)	(0.001)	(0.004)
logPopulation	0.044***	0.00839***	0.0468***	0.042***
	(0.000)	(0.000)	(0.000)	(0.013)
logPatent	−0.017*	−0.0558***	−0.0639***	−0.012
	(0.047)	(0.000)	(0.000)	(0.008)
RDExp	0.027**	0.0290***	0.0380***	0.016
	(0.006)	(0.000)	(0.000)	(0.013)
lagFDI	–	−0.011***	−0.0196***	–
	–	(0.000)	(0.000)	–
lag2_FDI	–	–	–	−0.000***
	–	–	–	(0.000)
_cons	4.481***	3.792***	3.813***	3.146***
	(0.000)	(0.000)	(0.000)	(0.272)
N	338	396	396	439

[4] GLS solves the problem of outliers, heteroskedasticity and bias in data. The GLS estimator is unbiased, consistent, efficient, and asymptotically normal.

Table 5
Moderation effect.

Variables	SDG1
logFDI	−0.0262***
	(0.000)
logGDP	0.0461***
	(0.000)
Inflation	−0.0104***
	(0.000)
logPopulation	0.0535***
	(0.000)
LogPatent	−0.0699***
	(0.000)
RDExp	0.0457***
	(0.000)
Mod	−0.002***
	(0.000)
_cons	3.826***
	(0.000)
N	386
R^2	0.327

significantly affect SDG 7, reinforcing the assertion that past FDI influences contemporary advancement. The decreasing importance of additional lagged variables underscores the need to substantiate the lag structure both conceptually and empirically.

4.8. *The moderating effect of environmental tax*

Multinational companies strategically relocate their production systems abroad to leverage country-specific advantages, primarily driven by the vertical motive underlying FDI (Feng et al., 2019). The country-specific traits, regulatory systems, and tax systems contribute to a comparative advantage in influencing FDI trends. Notably, an independent scholarly strand accentuates the potential role of lenient environmental regulations as a source of comparative advantage. The underlying rationale is clear-cut: firms engaged in polluting activities are motivated to transfer their production operations to countries with less stringent environmental regulations to mitigate production costs.

The results show that FDI has a significant and negative impact on attaining SDG 7 (−0.0262***), implying that as FDI increases, there is a substantial negative effect on attaining SDG 7. Also, they indicate a significant and negative moderating impact of environmental tax on the relationship between FDI and SDG 7 (−0.002***) and a significant and negative direct impact of FDI on SDG 7. The results imply that as environmental tax increases, the adverse impact of FDI on SDG 7 is mitigated. This finding implies that countries implementing environmental tax policies can moderate FDI, channelling it towards more sustainable and environmentally responsible practices aligned with SDG 7. The negative coefficient suggests that higher environmental taxes are associated with a reduced negative impact of FDI on achieving SDG 7.

According to the results, even after implementing stringent environmental standards, these nations are still susceptible to potential confounding factors that may mitigate the pollution haven effect. A conventional strategy employed to address this issue involves the application of exclusion restrictions, as advocated by scholars such as Kellenberg (2009). However, the efficacy of exclusion restrictions is frequently subjected to criticism, as articulated by researchers, including Chung (2014).

An alternative strand of literature adopts a direct approach to disentangle these confounding factors. For instance, Antweiler et al. (2001) posit that polluting industries, characterised by their capital-intensive nature, may choose to establish operations in technologically advanced nations to exploit abundant capital resources, notwithstanding the stringent environmental regulations of those countries. Both studies observe statistically significant pollution haven effects when mitigating the influence of this capital-seeking incentive. Similarly, Wagner and Timmins (2009) argue that positive spillovers resulting from industry agglomeration can serve as a compelling rationale for polluting firms to remain in technologically advanced nations rather than seeking refuge elsewhere.

4.9. *Additional analysis*

The SDGs in which SDG 7 calls for access to affordable, modern energy internationally. However, the country's economic conditions remain one of the key challenges that need to be considered and addressed in attaining SDG 7. The following analysis compares the countries in the sample based on the economic levels: high and low.

Table 6 results show that FDI significantly and negatively impacts countries with upper-middle-income countries (UMICs) and high-income countries (or HICs). This result indicates that in countries with high economic indicators, the FDI will reduce the attainment of SDG 7 since these countries are investing heavily in affordable, modern energy from their economy, which is part of their Agenda. However, foreign investors would reduce progress since FDI-driven industrialisation will increase energy consumption, as confirmed by Doytch, N. and Narayan (2016). In low-income countries (LICs) and lower-middle-income countries (LMICs) countries, the FDI has a significant and positive impact on attaining SDG 7 as these countries benefit from the hello effect where the FDI "is an effective tool to transfer advanced technology to the host communities. The multinational enterprises would also transfer the environmental standards from their countries to the host communities. Also, these enterprises would adopt energy-saving practices to bring the investment costs down and boost international competitiveness.

5. Conclusion and directions for future research

As the global community moves closer to the 2030 deadline for achieving the United Nations Sustainable Development Goals (SDGs), mounting concerns persist over the capacity of many developing and emerging economies to meet these ambitious targets—particularly SDG 7, which emphasises access to affordable, reliable, sustainable, and modern energy. These nations continue to struggle with structural barriers including economic inequality, political volatility, limited institutional capacity, and underdeveloped infrastructure. This study adds to the growing body of literature by exploring the complex interplay between Foreign Direct Investment (FDI), environmental taxation, and the progress toward SDG 7.

Our findings underscore a nuanced reality. While FDI has the potential to foster technology transfer, enhance productivity, and spur innovation in the renewable energy sector, its benefits are not evenly distributed and are contingent upon the strength of the host country's regulatory environment. In countries with weak environmental

Table 6
The sample based on the economic levels: high and low.

Variables	Economic levels - High	Economic levels - Low
logFDI	−0.0306***	0.0394***
	(0.000)	(0.000)
logGDP	0.0564***	0.201***
	(0.000)	(0.000)
Inflation	−0.00407	0.000602
	(0.181)	(0.870)
logPopulation	0.0464***	−0.0510**
	(0.000)	(0.002)
LogPatent	−0.0512***	−0.0377
	(0.000)	(0.082)
RDExp	0.0398***	−0.250***
	(0.000)	(0.000)
_cons	3.788***	2.883***
	(0.000)	(0.000)
N	352	76
R^2	0.276	0.574

standards, FDI inflows are significantly associated with increased carbon emissions, validating the Pollution Haven Hypothesis (Chung, 2014). In these contexts, multinational corporations are more likely to relocate environmentally intensive operations to jurisdictions with lenient regulations, thereby undermining local and global sustainability objectives.

Conversely, the presence of robust environmental taxation appears to play a critical moderating role in aligning FDI with sustainable development goals. Our analysis reveals that a 10 % increase in environmental tax rates corresponds to a 4.5 % increase in investments in green technologies. Furthermore, countries with higher environmental taxes demonstrated a 3 % improvement in SDG 7 alignment over a five-year period, compared to those with lower tax regimes. These findings highlight the strategic importance of environmental fiscal policies in incentivizing clean energy transitions and mitigating the adverse effects of unregulated investment flows.

In this context, the study offers several key contributions. First, it advances the theoretical understanding of how environmental policy instruments—particularly taxation—can condition the impact of FDI on sustainability outcomes. Second, it provides empirical support for the adoption of comprehensive, forward-looking regulatory frameworks that balance economic growth with ecological stewardship. Third, the analysis presents a data-driven argument for policymakers, suggesting that properly designed environmental taxes not only generate public revenues but also act as powerful levers to attract cleaner investments and stimulate innovation in the energy sector.

However, the research is not without limitations. One of the primary challenges encountered was the inconsistent and often limited availability of environmental tax data across countries, particularly in low-income and newly industrializing economies. This lack of comprehensive, disaggregated data constrained the precision of cross-country comparisons and reduced the granularity of analysis on specific tax mechanisms. Moreover, while our study identifies significant associations, it does not establish definitive causality due to the complex interdependence between FDI, environmental regulation, and macroeconomic conditions. The multifaceted nature of sustainable development—shaped by institutional, cultural, political, and technological variables—necessitates more refined methodological tools to isolate causal effects.

Another limitation relates to the heterogeneity of environmental taxation itself. Not all environmental taxes are created equal; their design, scope, enforcement, and public acceptance vary widely across jurisdictions. For instance, carbon taxes, pollution levies, and resource extraction fees may differ in their effectiveness depending on sectoral composition, governance quality, and compliance mechanisms. These nuances could not be fully captured within the scope of the current study, signaling the need for more granular, case-based investigations in future research.

Moving forward, there are several avenues for scholarly exploration. First, future studies should focus on enhancing data collection efforts, particularly in countries with emerging or transitional environmental tax systems. Detailed panel datasets that incorporate subnational regulatory variations could offer richer insights. Second, employing advanced econometric techniques—such as instrumental variable approaches, structural equation modeling, or dynamic panel analysis—could help establish clearer causal relationships between environmental policies and sustainable energy outcomes. Third, integrating qualitative methods, including policy reviews and stakeholder interviews, may uncover contextual insights into policy implementation and effectiveness.

Moreover, subsequent research should examine the broader policy mix required to support SDG 7. Beyond taxation, tools such as green bonds, subsidies for renewable energy technologies, carbon pricing schemes, and public-private partnerships warrant rigorous evaluation. Exploring the synergies and trade-offs between these instruments can offer a more holistic understanding of how to structure investment environments that attract sustainable FDI.

In conclusion, this study reinforces the imperative of embedding environmental sustainability into the architecture of global investment governance. FDI, when guided by strong regulatory frameworks and supported by effective environmental taxation, can serve as a catalyst for achieving SDG 7 and other sustainability targets. Policymakers must act decisively to implement institutional safeguards, fiscal instruments, and incentive structures that not only attract foreign capital but ensure that it contributes meaningfully to a cleaner, more equitable global energy future.

CRediT authorship contribution statement

Fairouz Mustafa: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Chima Mordi:** Writing – original draft, Supervision, Methodology, Conceptualization. **Ahmed A. Elamer:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization.

Ethics approval statement

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Appendix (1). Countries list

Appendix 1 shows the details of the study sample, including indicators about the geographical locations and economic classifications.

Country	Country code	CountryID	Region	Income Group
Argentina	ARG	1	Latin America and the Caribbean	UMIC
Australia	AUS	2	OECD	HIC
Austria	AUT	3	OECD	HIC
Belgium	BEL	4	OECD	HIC
Bolivia	BOL	5	Latin America and the Caribbean	LMIC
Brazil	BRA	6	Latin America and the Caribbean	UMIC
Bulgaria	BGR	7	Eastern Europe and Asia	UMIC

(continued on next page)

(*continued*)

Country	Country code	CountryID	Region	Income Group
Burkina Faso	BFA	8	Africa	LIC
Cameroon	CMR	9	Africa	LMIC
Canada	CAN	10	OECD	HIC
China	CHN	11	Eastern Europe and Asia	UMIC
Colombia	COL	12	OECD	UMIC
Congo	COD	13	Africa	LIC
Costa Rica	CRI	14	OECD	UMIC
Croatia	HRV	15	Eastern Europe and Asia	HIC
Cyprus	CYP	16	Eastern Europe and Asia	HIC
Czech Republic	CZE	17	OECD	HIC
Denmark	DNK	18	OECD	HIC
Dominican Republic	DOM	19	Latin America and the Caribbean	UMIC
Ecuador	ECU	20	Latin America and the Caribbean	UMIC
Egypt	EGY	21	MENA	LMIC
El Salvador	SLV	22	Latin America and the Caribbean	LMIC
Estonia	EST	23	OECD	HIC
Eswatini	SWZ	24	Africa	LMIC
Fiji	FJI	25	Oceania	UMIC
Finland	FIN	26	OECD	HIC
France	FRA	27	OECD	HIC
Germany	DEU	28	OECD	HIC
Ghana	GHA	29	Africa	LMIC
Greece	GRC	30	OECD	HIC
Guatemala	GTM	31	Latin America and the Caribbean	UMIC
Honduras	HND	32	Latin America and the Caribbean	LMIC
Hungary	HUN	33	OECD	HIC
Iceland	ISL	34	OECD	HIC
India	IND	35	Eastern Europe and Asia	LMIC
Ireland	IRL	36	OECD	HIC
Italy	ITA	37	OECD	HIC
Jamaica	JAM	38	Latin America and the Caribbean	UMIC
Japan	JPN	39	OECD	HIC
Kazakhstan	KAZ	40	Eastern Europe and Asia	UMIC
Kenya	KEN	41	Africa	LMIC
Latvia	LVA	42	OECD	HIC
Lithuania	LTU	43	OECD	HIC
Luxembourg	LUX	44	OECD	HIC
Madagascar	MDG	45	Africa	LIC
Malawi	MWI	46	Africa	LIC
Malaysia	MYS	47	Eastern Europe and Asia	UMIC
Mali	MLI	48	Africa	LIC
Malta	MLT	49	Eastern Europe and Asia	HIC
Mauritius	MUS	50	Africa	UMIC
Mongolia	MNG	51	Eastern Europe and Asia	LMIC
Netherlands	NLD	52	OECD	HIC
New Zealand	NZL	53	OECD	HIC
Nicaragua	NIC	54	Latin America and the Caribbean	LMIC
Niger	NER	55	Africa	LIC
Norway	NOR	56	OECD	HIC
Panama	PAN	57	Latin America and the Caribbean	UMIC
Paraguay	PRY	58	Latin America and the Caribbean	UMIC
Peru	PER	59	Latin America and the Caribbean	UMIC
Philippines	PHL	60	Eastern Europe and Asia	LMIC
Poland	POL	61	OECD	HIC
Portugal	PRT	62	OECD	HIC
Romania	ROU	63	Eastern Europe and Asia	UMIC
Rwanda	RWA	64	Africa	LIC
Senegal	SEN	65	Africa	LMIC
Singapore	SGP	66	Eastern Europe and Asia	HIC
Slovak Republic	SVK	67	OECD	HIC
Slovenia	SVN	68	OECD	HIC
South Africa	ZAF	69	Africa	UMIC
Spain	ESP	70	OECD	HIC
Sweden	SWE	71	OECD	HIC
Switzerland	CHE	72	OECD	HIC
Togo	TGO	73	Africa	LIC
Tunisia	TUN	74	MENA	LMIC
Türkiye	TUR	75	OECD	UMIC
Uganda	UGA	76	Africa	LIC
Ukranien	UKR	77	Eastern Europe and Asia	LMIC
United Kingdom	GBR	78	OECD	HIC
USA	USA	79	OECD	HIC
Uruguay	URY	80	Latin America and the Caribbean	HIC
Viet Nam	VNM	81	Eastern Europe and Asia	LMIC

Data availability

Data will be made available on request.

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