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Impact of Foreign Direct Investment (FDI), Institutional Performance and Scientific Innovations on Environmental Degradation: Evidence from OIC Countries

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This research aims to examine the impact of foreign direct investment, institutional performance, and scientific innovations on environmental degradation (ED) proxied by ecological footprints in selected OIC member countries. In this study, panel data of selected OIC lower-middle income member states for 2000-2020 have been analyzed. A cross-section dependence test has been employed to assess whether cross-section dependence is present among the variables. A second-generation unit rot test has been employed to test the level of stationarity. Upon the recommendation of these tests, Pooled Mean Group (PMG) has been used to investigate the long-run association between the dependent and independent variables. The findings of this study advocate that FDI has a significantly negative impact on ecological footprint and has been acting as environmentally friendly in lower-middle countries. Scientific innovations have a positively influenced ecological footprint contrary to Institutional performance which has a significant negative impact on the ecological footprint in lower-middle-income countries. Furthermore, the study has found that trade openness has a significantly positive impact on ecological footprints and GDP per capita has an insignificant impact on ecological footprints.

Introduction

FDI has gained significant importance in the current global economy, with cross-border investment flows reaching $1.39 trillion in 2019 (UNCTAD, 2020). According to a study by Liu et al. (2021), FDI can lead to higher carbon emissions due to the increased consumption and production of services and goods. Additionally, FDI can result in the depletion of natural resources, which can negatively impact the environment and local communities (Yu and Wei, 2020). Furthermore, foreign investors may bring in technologies that are not environmentally friendly, leading to increased pollution and ecological damage (Sun et al., 2022). More specifically, FDI may have a negative impact in the long-run but it may positively affect the environmental quality (EQ) in the short-run (Zhang et al., 2022), but the overall effect of FDI on EQ depends on the type of FDI (e.g., resource extraction vs. manufacturing), the quality of institutions, and the level of economic development (Shabir et al., 2022). Some academics contend, however, that FDI can lead to positive outcomes in these areas by promoting better governance, environmental regulations, and technological progress (Kumar & Prasad, 2017; Singh, 2016). For example, foreign investors may bring new management practices and technologies that lead to greater efficiency and productivity, while also spurring competition and innovation (Liu & Xie, 2021).

Additionally, FDI can enhance IP by increasing transparency and accountability, as well as strengthening the rule of law and protecting property rights (Acemoglu et al., 2016). On the other hand, other scholars raise concerns about the potential negative consequences of FDI on host countries, including the displacement of local firms, environmental deterioration, (Pujiati et al, 2022; Farooq et al., 2023), and weakening institutions (Nair-Reichert & Weinhold, 2001; Acemoglu et al., 2016). For instance, foreign investors may compete with domestic firms, leading to reduced employment and profits. Furthermore, FDI might cause the 'race to the lowest' problem, where host countries compete by lowering environmental and labor standards to attract foreign investment (Goldberg & Pavcnik, 2007). This can lead to negative impacts on EQ, as well as human rights and labor conditions.

In order to promote environmental sustainability, strong institutional is crucial. According to Nduka and Okoroji (2020), IP may significantly influence the effectiveness of environmental policies and the management of natural resources. Institutions with effective policies and regulations can help to reduce pollution, preserve biodiversity, and promote sustainable practices, while weak institutions with ineffective policies and a lack of enforcement can lead to ED and resource depletion. The effect of IP on the EQ can be seen in various areas, including climate change and the management of water resources (Anaman & Oppong, 2021; Adomako et al., 2021). In addition to environmental impacts, institutional quality is also important for GDP growth and plays an important role. Institutional economics literature recognizes the crucial role of institutions in creating and enforcing regulations in the public sphere, setting contextual controls (Acemoglu and Robinson, 2010; Williamson, 1989; North, 1990). Good institutional quality is associated with policies that establish a legal and cultural framework for socio-economic activities, protecting property rights and ensuring a strong rule of law, while weak institutions can result in corruption, an inefficient bureaucratic system, and ineffective environmental policies (Asoni, 2008; Canh et al., 2018). In recent times, IP has gained significant consideration from both economists and policymakers concerned with EQ. Most of the institutional factors can have direct or indirect impacts on EQ (Bhattacharya et al., 2017), specifically, regulatory quality and the law and order have a significantly positive impact on EQ (Zhang et al., 2022). Efficient institutions can promote effective collaboration among market participants, while weak IP can lead to firms ignoring GHG regulatory measures and ignoring external factors related to environment and economic growth implications Azam et al., 2020), (Ali et al., 2019) Strong institutions also play an important role in defining the role of FDI in economic growth and EQ (Mei Ling Wang et al., 2021).

The relationship between SI and ED has become a topic of great concern in recent times. The rapid advancement of technology, coupled with population growth, has resulted in significant environmental challenges such as weather change, poor air quality, and biodiversity loss. Nevertheless, SI offers new opportunities to address these challenges and improve EQ. Studies have shown that advancements in renewable energy technologies, waste management, and artificial intelligence can significantly impact the environment by reducing our impact on natural systems and promoting more efficient and sustainable use of resources. SI can lead to the development of more efficient and cleaner technologies, which can reduce pollution and mitigate the adversative impact of economic activity on the EQ Du et al. (2022). However, the adoption and diffusion of such technologies depend on various factors such as government policies, market demand, and institutional support. While scientific advancements have the potential to bring significant benefits, it is important to note that innovations driven purely by cost-benefit analysis may not always be environmentally friendly. however, by incorporating environmental-related technological innovations into FDI activities, these negative effects can be mitigated or even turned into positive outcomes (Uche et al., 2023).

The Organization of Islamic Countries (OIC), an international body consisting of 57 member countries primarily located in the Middle East, Asia, and Africa, faces significant environmental challenges such as atmospheric and aquatic contamination, deforestation, and desertification. Climate change is also a growing concern, with many OIC member states experiencing rising temperatures, more frequent and severe weather events, and sea level rise. Despite this, the OIC has made significant strides toward economic cooperation, including the establishment of a free trade area and investment agreement, with the economy primarily based on oil and gas production, Despite the challenges faced by OIC member states, many of them are taking measures to address environmental issues. However, many OIC member countries still have high ecological footprints due to high levels of consumption and energy use, as well as the impact of resource-intensive industries such as oil and gas extraction. The Paris agreement has been adopted by many countries, including 43 OIC countries, to mitigate the impact of GHG emissions on the EQ.

The objective of the study is to make an addition to the prevailing knowledge by addressing the gaps in the literature. Previous studies have evaluated the impact of SI and IP on ED, but the relationships remain unclear and need further investigation. This study is unique in that it uses a Principal Component Analysis (PCA) to develop an index of both independent variables instead of using a single proxy. For IP, the study considers twelve indicators: "government stability, socioeconomic conditions, investment profile, internal and external conflicts, corruption, and bureaucratic quality". For scientific innovation, the study considers six indicators, including service exports, fixed telephone subscriptions, internet usage, patent applications, computer and communication services, and research and development expenditure

Literature Review

FDI and Environment

FDI is considered to be one of the main propelling forces of economic growth in many countries. FDI flows are often seen as a way to transfer technology and knowledge from advanced economies to developing countries, which can help foster SI and improve the environment. However, the impact of FDI, IP, scientific innovations, and the environment is complex and varies across countries. This literature review aims to examine recent research on the relationship between FDI, IP, SI, and ED

The FDI-SI nexus has been the topic of discussion of many studies, some of which have found a positive association. For instance, according to Akanbi and Akanbi (2018), the introduction of new technologies as well as expertise by FDI inflows to Africa contributed to innovation. Even so, it's not easy to predict how the FDI will affect the climate. FDI can promote the use of environmentally friendly technologies and sustainable development, but weak regulations and enforcement may accelerate pollution and ED. The findings of scholarly studies on the FDI-environment nexus have been contradictory. For example, while Lee and Yu (2019) found a negative relationship in South Korea, Zeng et al. (2018) found a significantly positive association among FDI and carbon emissions in China.

Studies have also looked at how government laws and rules influence the way FDI affects environmental protection and scientific advancement. According to Asongu et al. (2018), government measures like tax incentives and the effect of FDI on CO2 in Indonesia didn't have any immediate impact on EQ, but over time, they may have a negative influence on ED. By analyzing empirical data, Farooq et al. (2023) determined that economic performance and FDI have a negative and statistically significant effect on EQ. Additionally, they investigated the effects of tourism, generation of electricity, and FDI on ED in the GCC (Gulf Cooperation Council) region. In contrast, tourism and electricity production have positively and significantly influenced EQ.

Institutional Performance and Environment

Firstly, there is a consensus that IP plays a critical role in determining EQ. Strong institutions with effective governance structures and regulatory frameworks are associated with better environmental outcomes (Al-Sadat et al., 2020; Bose et al., 2021; Wang et al., 2021). For example, a study by Li et al. (2020) originated that IP is a crucial factor in the success of China's national plan to reduce air pollution. Geng et al. (2021) found that market-based approaches were effective in reducing air pollution in some regions of China but not in others. IP plays a crucial role in shaping the association among FDI, scientific innovations, and the environment. Strong institutions can help ensure that FDI flows are used to promote sustainable development and scientific innovations, while weak institutions can lead to ED and other negative outcomes. Several studies have examined the impact of IP in shaping the relationship between FDI, scientific innovations, and the environment. Firstly, researchers agree that IP is a crucial factor in shaping environmental outcomes. Strong institutions, with effective governance structures and regulatory frameworks, are associated with better environmental outcomes. For instance, a study by Adedoyin et al. (2021) found that effective IP was a critical determinant of the success of waste management policies in Nigeria.

A study by Xue and Chen (2015) examined the effect of IP on ED in China. The authors concluded that a strong institution, including effective environmental regulations and enforcement, is associated with lower levels of environmental pollution. Another study by Chen et al. (2018) examined the impact of institutional quality on the acceptance of clean energy technologies in China. The authors found that IP has a positive effect on the adoption of clean energy technologies, which can help reduce environmental impacts. Xu et al. (2019) found that strong institutions positively affect the relationship between FDI and IP in developing economies. Similarly, Olugbenga et al. (2020) concluded that IP moderates the impact of FDI and ED in sub-Saharan Africa. Institutional quality is positively related to transparency and accountability, which leads to better environmental outcomes (Sekeris et al., 2020). For instance, a study by van der Ven and Steurer (2020) found that environmental organizations that report their environmental performance are more likely to have better environmental outcomes than those that do not.

Zhang et al. (2022) found that institutional factors: "corruption, law & order, and government stability significantly impact carbon emissions" in BRICS countries. Positive changes in these factors reduce carbon emissions, while negative changes increase them. This highlights the importance of institutional factors in mitigating carbon emissions, as they affect pollution emissions invariably through economic growth and FDI.

Scientific Innovations and Environment

Numerous studies provide insight into the connection between ecological health and scientific innovation in various countries. For instance, Qu et al.'s (2019) discovery that the carbon emissions from China are negatively affected by scientific innovation indicates that this practice has the potential to support environmental sustainability. In the OECD economies, Du Jianguo et al. (2022) found that SI significantly improves EQ. According to Hou et al. (2018), SI has a positive impact on lowering the release of industrial wastewater in China. Ibrahiem (2020) investigated the relationships among scientific innovation, alternative energy sources, economic growth, development in finance, and CO2 emissions in Egypt and discovered that while financial development and economic growth aggravate EQ, scientific innovation and alternative sources of energy improve it. Technology advancements have a critical role in carbon emissions, according to Shahbaz et al. (2020) analysis of the relationship between private-public partnerships investment in the energy industry and carbon emissions in China. In their study of the effect of technological innovation on carbon emissions in Pakistan, Ullah et al. (2021) discovered that while trademarks had favorable long-term effects on carbon emissions, patents had negative short-term effects.

Usman and Hammar (2021) investigated the impact of various determinants of EQ in APEC countries and found that financial development and renewable energy utilization had positive effects, while technological innovation, economic growth, and population size had negative effects in the long term. Sharif et al. (2021) analyzed the effects of SI and IP on EQ in East-Asia and Pacific countries and found that SI had a positive relationship with CO2 emissions but a negative association with N2O, CH4, and ecological footprint. The authors recommend promoting innovative activities, strengthening institutions, and encouraging open trade policies to ensure environmental sustainability. Overall, these studies suggest that promoting strong IP and effective environmental regulations and encouraging scientific innovation can promote environmental sustainability and reduce ED.

Data and Methodology

This study is grounded on panel data analysis of selected six lower-middle income OIC (Organization of Islamic Countries) including Algeria, Bangladesh, Cameroon, Indonesia, Nigeria, and Pakistan from 2000 to 2020. The countries' selection is based on the classification made by the world bank (2020) which depicts that countries having per capita GNI between $1046 to $4095 are lower-middle income countries. The EP is a dependent variable and has been used as a proxy of ED, whereas FDI IP, SI, economic growth, and trade openness have been taken as independent variables. The data source and variable description have been given in table 1. The study has utilized Pooled Mean Group (PMG) technique for regression analysis.

PMG technique is a panel data analysis technique that combines the advantages of various estimation techniques, including pooled OLS and mean group (MG) methods. (i) According to Pesaran et al., (1999), the PMG technique assumes that the slope coefficients of panel data diverge across cross-sectional units but remain the same over time. (ii) PMG technique has been illustrated to have better characteristics when compared to other panel data estimation techniques like fixed effects (FE) and random effects (RE) models, especially when the cross-sectional dimension is modestly small. Baltagi (2005). (iii) PMG method can handle endogeneity and cross-sectional dependence as well as variables that are stationary at the level and first difference. Kao (1999). Moreover, it can handle mixed orders of integration among variables, which could be I(0) or/and I(1), but not I(2), providing flexibility in its applicability. (iv) According to Pesaran et al. (1999), PMG estimator was found to be more resilient and dependable in terms of lag orders and outliers compared to other estimators. (Alola et al., 2019) Bishu and O'Neill (2020) compared the performance of PMG and MG estimation in panel data. They found that PMG is suitable when the coefficients are homogeneous across individuals and the dynamics are stable, while MG is appropriate when the coefficients are heterogeneous across individuals and/or the dynamics are dynamic. In terms of efficiency, they found that PMG is more efficient than MG when the sample size is small, but MG outperforms PMG when the sample size is large.

Table No 1: Data Sources and Variable Explanation

Variable	Description	Unit of measurement	Data Source
GDP per capita (GDPCAP)	Log of GDPCAP	Constant 2015 US$	WDI 2021, World Bank database
Trade Openness (TOP)	Log of TOP	The ratio of the sum of exports and imports to GDP	OIC dataset
FDI	Log of FDI	Real net inward FDI Constant US$ 2015	OIC dataset
Ecological Footprint (EF)	Log of EF	Calculated through panel PCA	Global Footprint Network
Institutional Performance (IP	Log of IP	Calculated through panel PCA	ICRG
Scientific Innovations (SI)	Log of SI	Calculated through panel PCA	WDI 2021, World Bank database

Source: Author's compilation.

The study has followed Mrabet et al. (2019), Managi et al. (2009), Aydin et al. (2019) and Alsamara (2017), has used E as the proxy of ED as dependent variable.

$$LNECF_{7it} = \beta_o + \beta_1 LNIP_{it} + \beta_1 LNSI_{it} + \beta_1 LNFDI_{it} + \beta_1 LNTOP_{it} + \beta_1 LNGDPCAP_{it} + \mu_{it}$$

Where i represents country and t denotes time, whereas LNECF represents ecological footprint, LNIP represents IP, LNSI represents scientific innovations, LNFDI represents a FDI, LNTOP represents trade openness and LNGDPCAP represents GDP per capita. $\beta_{o,}$ $\beta_1, \beta_2, \beta_3, \beta_4,$ and β_5 are the parameters and μ_{it} is the disturbance term.

Cross Section Dependence Tests (CSD)

Before conducting the panel unit root test, a cross-sectional dependence (CSD) test was performed to assess the interrelationships among the countries included in the study. It is pertinent to deliberate CSD, as failing to do so, according to Pesaran (2007), may result in distorted and unreliable findings. To test for CSD in the panel data, the Lagrange Multiplier test, first introduced by Breusch and Pagan (1980), is commonly used. The standardized formula of this test is expressed as:

$$LM_{BP} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2$$

The pair-wise correlation coefficients' sample estimate is denoted by $\hat{\rho}_{ij}^2$. The Breusch and Pagan (1980) introduced LM test which is appropriate when the value of T is sufficiently great, and N is relatively small. However, Pesaran (2004) pointed out that this test is unsuitable when the average pair-wise correlation has the mean tends to zero. So in order to address the limitations of the LMBP test, he presented another test statistic based on a scaled version of the LM test which is valid even when the value of N is large, and T is small.

Scaled $LM\ Test = \sqrt{\left(\frac{1}{N(N-1)}\right)}\ \left[\sum_{i=0}^{N-1} \sum_{j=i+1}^{N} (T\rho_{ij}^2 - 1)\right]$

When dealing with a small T and large N, the test is prone to significant size biases. In order to address this problem, Pesaran (2004) put forth an alternative cross-sectional dependence test that can also be utilized when small T and large N.

$$CD = \sqrt{\left(\frac{2T}{N(N-1)}\right)} \left[\sum_{i=0}^{N-1} \sum_{j=i+1}^{N} \rho_{ij}\right]$$

As T→∞ and N→∞, Assuming the null hypothesis, the Cross-Section Dependence test adopts to an asymptotic standard normal distribution." Unlike the LM test, which utilizes the squares of pair-wise correlation coefficients, this test relies upon the coefficients'' scaled-average. It yields reliable results for heterogeneous dynamic models, as well as models with several interruptions in slope coefficients. By applying the accurate mean and variation from the LM statistics, Baltagi et al. (2012) adjusted the LM test., as shown below:

$$LM_{adj} = \sqrt{\left(\frac{2T}{N(N-1)}\right)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij} \frac{(T-k)\rho_{ij}^2 - \mu_{Tij}}{\sqrt{v_{Tij}^2}}$$

Where μ_{Tij} and v_{Tij}^2 are the precise mean and variance of $(T-k)\ \rho_{ij}^2$ presented by Baltagi et al (2012).

CIP Test for Panel Unit Root

Previous researches, including Maddala and Wu (1999), Levin et al. (2002), and Im et al. (2003), and, have used first-generation unit root tests that assume cross-sectional independence and homogeneity. However, these assumptions may not hold in all cases, leading to unreliable results. To address this issue, Pesaran (2007) and Choi (2006) developed the CIPS panel unit root test, which is used as a second-gen test. It controls both cross-sectional dependence and heterogeneity, resulting in more accurate outcomes.

Panel Cointegration Test

To assess the long-run association among variables, three panel cointegration test including Kao (1999), Pedroni (1999) and Westerlund (2007) cointegration tests have been applied in this study. Kao's cointegration test uses a residual-based test measure to confirm cointegration and is built on an error correction model. The Pedroni cointegration test is a panel data test that evaluates cointegration using group-mean panel data regression whereas enabling cross-sectional dependence. The Westerlund cointegration test is a panel data test that examines cointegration using a bootstrap-based panel data regression and provides for both cross-sectional dependence and individual temporal patterns.

Results and Discussions

Statistical Description of variables

Table No 2: Descriptive Statistics (Lower Middle-Income Countries)

	LNEF	LNIP	LNSI	LNFDI	LNTOP	LNGDPCAP
Mean:	0.893014	1.345611	1.218803	21.54451	3.715232	7.503999
Median:	1.045123	1.522022	1.435269	21.38765	3.745385	7.312056
Maximum:	1.852420	1.980066	2.072576	23.98601	4.197127	8.348547
Minimum:	-2.855595	-2.302625	-2.302585	16.99050	2.752832	6.482815
Std. Dev.:	0.754977	0.629508	0.722432	1.315005	0.316226	0.517235
Skewness:	-2.103510	-4.047717	-1.911428	-0.308262	-0.890942	0.103845
Kurtosis:	9.017796	21.21607	8.239414	3.562496	3.903367	1.880642
Observations:	120	120	120	120	120	120

Source: Author's source

Statistical Description of variables have been given in table 2 which illustrates that LNEF has the lowest mean value which is 0.893014 whereas FDI has the highest mean value which is 21.54451. The table further indicates that LNIP, LNSI, LNTOP, and LNGDPCAP have mean values of 1.345611, 1.218803, 3.715232, and 7.503999 respectively.

Cross-Sectional Dependence Test

In order to determine whether any cross-section dependency exists in the data, a cross-section dependence test has been used. Table 3 presents the result of the tests, while all three tests have significant p-values at a 1 percent significance level, the findings support the dependence across the cross-section.

Table No 3: Test of Cross-Sectional Dependence (Lower Middle-Income Countries)

Tests of Cross Section Dependence	Statistic	d.f	P-Value
Breusch-Pegan LM Test	123.1770	15	0.0000*
Pasaran scaled LM test	18.65489		0.0000*
Pasaran CD	2.683579		0.0073*

"**Note:** *, ** and *** refer to the levels of significance at 1%, 5% and 10%, respectively".

2nd Gen Unit Root Test

The research has applied 2nd-generation test for Unit Root such as CIP and CADF to test the stationarity of data since first-gen Unit Root tests are not informative if there is cross-sectional dependence. The outcome of the tests given in table 4 which shows that mixed level of stationarity. A few of the variables such as LNEF, LNFDI, and LNGDP are stationary at a I(o) whereas LNIP, LNSI, and LNTOP are stationary at I(1).

Table No 4: Results of 2nd Gen Test for Panel Unit Root (Lower Middle-Income Countries)

Variable	CIP		CADF	
	Level	I(o)	Level	I(1)
LNEF	-2.945*	-4.772	-2.754*	-2.611*
LNIP	-2.076	-3.332*	-1.650	-2.887*
LNSI	-2.566	-4.169*	-2.565	-2.840**
LNFDI	-3.614*	-5.119*	-1.796	-2.404**
LNTOP	-1.052	-3.226*	-0.360	-3.187*
LNGDPCAP	-2.431**	-2.724	-3.546*	-4.008*

Tests of Cointegration

In order to verify the long-run associations in variables, the study has applie Pedroni, Kao, and Westerlund tests. The null hypothesis of the test is that there is no long-run association among the variables. Whereas the alternative hypothesis, states that there is long-run cointegration among the variables. Table 5 contains the results of the Pedroni Cointegration Test. The p-values of Modified Phillips-Perron (P-P) and Phillips-Perron (P-P) are significant at a 1% and reject the null hypothesis and accept the alternative hypothesis and confirm the occurrence of long run association among the variables.

Pedroni Test of Cointegration

Table No 5: Pedroni Cointegration test (Lower Middle-Income Countries)

	Statistics	p-value
ADF	-1.2751	0.1011
Modified P-P	2.0434	0.0205*
P-P	-2.6223	0.0044*

Kao Test of Cointegration

Table 6 confirms that long-run association among the variables since all except ADF test are significant.

Table 6: Kao Test of Cointegration (Lower Middle-Income Countries)

	Statistics	p-value
ADF	-0.6081	0.2716
Unadjusted modified DF	-1.3832	0.0833***
Dickey-Fuller	-3.4794	0.0003*
Modified DF	-1.6466	0.0498**
Un-adjusted DF	-3.3886	0.0004*

The figures shown in Table 7 do not support any long-run cointegration among the variables.

Westerlund Test of Cointegration

Table No 7: Westerlund Cointegration test (Lower Middle-Income Countries)

	Statistics	p-value
Variance ratio	-0.5595	0.2879

Long Run Estimates of PMG Regression Analysis

Depending upon the availability of data, the study has selected six lower-income countries which are members of OIC. Table 8 has presented the result of regression analysis with the dependent variable Ecological footprints while independent variables are IP, technological innovations, FDI, trade openness, and GDP per capita. The results show that FDI has a negative and significant impact on EF quite consistent with Adeel-Farooq et al. (2021), Xie & Sun, (2020), Hao et al., (2020) and An et al., (2021), and IP also has a significantly negative impact on EF which is quite in line with Sarkodie and Adams, (2018), Zakaria and Bibi (2019), Le and Ozturk (2020), and Christoforidis & Katrakilidis, (2021). The finding suggests that better and more efficient institutions can improve EQ by making sure of the implementation of environmental laws.

SI have a positive effect on EF which is quite consistent with Yu and Du (2019), Ibrahiem, (2020), Shahbaz et al. (2020), and Usman and Hammar (2021). Trade openness has a positively influenced ecological innovations which confirms the pollution haven hypothesis that FDI source countries use such technologies in developing countries which are the cause of the deterioration of EQ. surprisingly GDP per capita has shown a negative but insignificant effect on EF might be due to the low per capita income of these economies.

Table 8: Dependent Variable: Ecological Footprint, Long Run Estimates (Lower Middle-Income Countries)

Variables	Coefficients	Std. Error	t-Statistics	Probability.*
LNFDI	-0.092918	0.046402	-2.002452	0.0516***
LNIP	-1.110549	0.176368	-6.296752	0.0000*
LNSI	0.784081	0.110903	7.069979	0.0000*
LNTOP	1.042411	0.215737	4.831867	0.0000*
LNGDPCAP	-0.004417	0.150467	-0.029356	0.9767

Conclusion

The research on factors influencing EQ has raised substantial questions about its relationship with FDI. The role of IP and scientific advancements in defining the EQ of the different hypotheses prevailing in current literature has come under increased scrutiny due to the body of existing research. This has prompted researchers to empirically examine the effect of IP, SI, and FDI on ED. The objective of this study is to assess the influence of FDI, IP, and SI on ecological footprints (a measure of environmental pollution) in selected OIC lower-middle-income member countries.

Panel data analysis has been conducted on selected lower-middle-income member countries of the OIC from 2000 to 2022. A cross-section dependence test has been performed to check for confirmation of cross-sectional dependence among the variables. Based on the unit root test result, a second-generation unit root test is to determine the level of stationarity. Based on the recommendation of these tests, the PMG method has been utilized to investigate the long-term associations between the dependent and independent variables.

The results of the study demonstrate that FDI has a significantly negative impact on EP and has been acting as environmentally friendly in lower-middle countries. SI has a significant positive impact on EP whereas IP has a significant negative impact on the ecological footprint in lower-middle-income countries. Furthermore, the study has found that trade openness has a positive and significant impact on EP, and GDP per capita has an insignificant impact on ecological footprint.

For policy implication, the outcome of this study suggests that FDI, IP, and SI have been contributing to the deteriorating environmental condition in selected member countries of OIC and it demands a strong role of institutions regarding corruption and other mismanagements and there should be some solid environment policies regarding FDI so that inward FDI could be bound to follow the environmental laws.

On the other hand, considering the critical role of FDI, Scientific innovations, and IP in economic growth, governments of respective countries should adopt such policies which could attract foreign investment. Furthermore, strong and effective institutions have been playing important role in economic growth so these countries should improve their regulations regarding rule of law, political stability, and the absence of violence.

For future directions, the study can further be expanded by making a comparison of lower-income with upper-middle-income OIC member countries within the parameters applied in this study. Furthermore, depending upon the availability of data, comprehensive research can be conducted by expanding the sample size by including all 57 OIC member countries to get a more generalized conclusion about the EQ of OIC member countries.

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