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Article

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Embracing Green Foreign Direct Investment in a Journey toward Global Sustainable Economy: An Empirical Approach Using Statistical Analysis

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ABSTRACT

In particular, the link between green foreign direct investments (GFDI) and environmental performance (EP) is the focus of this study's empirical analysis of the effects of GFDI on environmental sustainability. According to measurements like the environmental performance index (EPI) and indicators like health and ecosystem preservation (HLT and ECO), the results show that bigger GFDI sizes benefit environmental performance. Using a variety of econometric approaches, this result is derived using a worldwide sample that includes European nations from 2001 to 2023. Even after adding more explanatory factors and using a variety of econometric techniques, these results hold up well. Furthermore, the research explores the immediate and long-term impacts of GFDI on EP, emphasizing that the relationship between GFDI and EP becomes increasingly evident with time. Additionally, research will investigate how different transmission mechanisms allow green FDI to influence environmental sustainability. These results highlight how GFDI may be used to support industry environmental sustainability.

Keywords: Green FDI, Environmental Sustainability, Global Uncertainty
JEL Classifications: F21, G21, O16, C33

1. INTRODUCTION

Climate change and environmental issues have been a focal point of political and economic discussions in the last decade, as highlighted by studies conducted by Adebayo (2022, 2023), Ahmed et al. (2024), Fareed et al. (2021) and Nuvvula et al. (2022). Contemporary society relies on consistent energy sources, as highlighted in studies by Elavarasan et al. (2021) and Madurai et al. (2020). Nonetheless, many developing economies grapple with a substantial energy crisis that significantly harms the country's economy Ali et al. (2023). As shown in the research by Xiang et al. (2022), people's duties in their jobs and leisure activities are significantly impacted by energy scarcity. The studies by Ikram et al. (2021), Irfan et al. (2019, 2020), and Irfan and Ahmad (2022) highlight how vital energy is to emerging economies. In recent years, there has been an unmanaged disparity between electricity demand and supply, particularly noticeable during summer. This results in severe power cuts, with urban areas enduring 10-12 h of load shedding daily and rural areas experiencing even more extended outages of 16-18 h/day, as reported by Chandio and colleagues in 2021 (Chandio et al., 2021). In Pakistan, about 51 million people—or 27% of the total population—do not have access to lights, and almost 50% of people do not have access to cooking facilities or sanitary facilities. The country's power generating capacity was 34,501 MW as of May 2021, and this capacity is expected to reach 53,315 MW by the year 2030.

As Bergius et al. (2020) point out, creating a green economy necessitates allocating assets and investing in industries committed to pollution reduction. In order to reduce pollution and promote the growth of green businesses, Anser et al. (2020) emphasize the critical role that the financial system and financial resources play. Pollution, species loss, habitat deterioration, and progressive depletion of natural resources such as soil, water, and air have a negative impact on the ecosystem. According to the definition in a report by the United Nations (UN) in 2020 (UN, 2020), an environmentally friendly world is one that serves present requirements while also "ensuring future generations' capacity to achieve their goals.

Numerous research has been conducted in recent years to investigate the elements that contribute to environmental deterioration. These investigations have examined a variety of reasons, including foreign direct investment (cited by Albulescu et al. (2019) and Waqih et al. (2019)), climate change (as discussed by Prăvălie (2016)), economic growth (referenced in works by Seetanah et al. (2019) and Zafar et al. (2020), information technology (as analyzed by Asongu and Odhiambo (2020)), climate variations (studied by de Angelis et al. (2019); nations are unable to effectively remedy environmental degradation, as noted by Yang and Khan (2022). As Douglass and Ling (2000), Asian nations have failed to implement effective policies and measures to alleviate the negative effects of environmental deterioration. This study facilitates and enhances foreign direct investment, which benefits Asian economies, as was previously noted. As a result, this makes a substantial contribution to economic growth, environmental preservation, and general economic progress. In addition, Asian countries have significant environmental difficulties resulting from erratic climatic fluctuations, natural calamities, limited resources, and more concerns.

It is more likely that both developed and developing countries have a high potential for attracting green FDI (GFDI) (Karaman et al., 2020) and are also heavily impacted by climate change (Afum et al., 2022). This makes GFDI a viable solution to assist governments in achieving their sustainable development goals. Nonetheless, the majority of FDI firms in these countries are fairly constrained and face resource limitations, which makes the industry less competitive. In this context, implementing sustainable FDI practices may help these economies increase the competition of FDI enterprises (Agyabeng-Mensah et al., 2020).

The results of our study fill in a number of gaps in the literature. The relationship between a country's acceptance of GFDI and environmental sustainability is being empirically investigated for the first time in this study. Therefore, our study adds to the body of knowledge already available about the effects of economic expansion on the environment (Boleti et al., 2021) or energy consumption (Abbasi et al., 2021; Le, 2022). In this paper, we evaluate the efficacy of GFDI. An extensive understanding of the connection between GFDI adoption and environmental sustainability is provided by the dataset used in this study, which makes it easier to investigate the transmission mechanism by which GFDI affects sustainability. The analysis focuses on the period from 2001 to 2023, using a range of strategies and empirical methodologies. The absence of comprehensive GFDI data in the region is the reason we chose this database. Using the Panel-Corrected Standard Error (PCSE) model, tests for longitudinal correlations and asymmetry are conducted before analyzing the link between GFDI adoption and environmental sustainability in the next section. This approach works well with dynamic panel data that has cross-sectional dependence. Further validation is performed using the Feasible Generalized Least Squares (FGLS) model, which accounts for heteroscedasticity. Endogeneity issues are resolved by using a two-step Generalized Method of Moments (GMM) technique. Additionally, to evaluate the short- and long-term consequences, the Autoregressive Distributed Lag (ARDL) approach is used in conjunction with the Dynamic Fixed Effects (DFE) estimator. According to Ha (2022, 2023) and Thanh et al. (2022), time-fixed and country-fixed impacts can both be found using the DFE-ARDL method.

Below is the arrangement of the remaining sections of the paper. The literature on the variables is covered in Section 2. The study procedures and an explanation of the variables and data are covered in section three. The findings and discussion are covered in section four. The last thoughts, the consequences of policy, and the limitations for further strategies are presented in Section 5.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. The Effects of Green Foreign Direct Investment

With the continued expansion of industrial activity, environmental pollution has become a major worldwide problem that affects both developed and developing nations. In response to this issue, numerous strategies and actions have been devised to enhance environmental conditions, as highlighted in the studies by Solarin and Al-Mulali in 2018 and Shahbaz et al. in 2015 (Shahbaz et al., 2015; Solarin and Al-Mulali, 2018). Theoretically, there may be several forms of FDI linked to environmental problems. In conclusion, foreign direct investment has an impact on environmental quality, a claim that is backed by a wealth of scientific data. An important result of foreign direct investment, for instance, is a rise in greenhouse gas emissions, as demonstrated by a 2019 study carried out in China by Shahbaz and Sinha. However, the regional analysis of Aust et al. (2020) showed that FDI had a beneficial impact on environmental concerns, notably the development of more environmentally friendly and sustainable technology. In a different context, Sbia and Shahbazan Hamdi's 2014 study found that two types of environmental deterioration have resulted from foreign direct investment in the Middle East: a decrease in the region's reliance on renewable energy sources and an increase in carbon emissions. In contrast, Omri et al., in their 2014 study, highlighted the possibility of reverse causation in the relationship between carbon emissions and foreign direct investment. With these conflicting empirical results, it becomes crucial to conduct an extensive analysis of regional-level data to understand how foreign direct investment has a distinct impact on carbon dioxide emissions.

To find gaps in the body of current literature, we might differentiate between two different research streams. While the second study stream focuses primarily on Southeast Asia, the first focuses on the more general issue of green economic development and investment across numerous nations. The first research corpus contains studies examining the link between green economic growth and global investment. For example, Scholtens's research from 1995 to 1999 showed that green tax policies boosted net tax receipts and promoted economic development in the Netherlands. Gao and Jang (2021) looked at the effect of foreign direct investment (FDI) on China's environmental efficiency in a different research.

The study's main findings suggest that foreign direct investment (FDI) can improve the quality of the environment and encourage the creative capacities of local people. Raising the proportion of green investments in total FDI inflows is one way to support nations' infrastructure and procedures for pursuing green economic growth, according to Kardos (2014), who examines the role of FDI in sustainable development within the European Union. Green investment modeling was carried out in Romania by Doval and Negulescu (2014), who emphasized the necessity of greater private-sector cooperation for the successful promotion of green investment. Abdouli and Hammami (2017) used a panel data technique to evaluate the influence of FDI and other variables in lowering CO_2 emissions in research encompassing 17 economies in the MENA area.

Their findings supported the existence of the pollution haven theory by indicating that FDI leads to environmental deterioration. A study conducted in 2019 by Pisani and colleagues investigated how GFDI affected the environmental sustainability of cities and found that it might help create greener, better-airing cities (Pisani et al., 2019). Similarly, GFDI in greener technologies was highlighted by Capasso et al. (2019) as one of the key drivers of green growth. Estevão (2020) suggested environmentally friendly fiscal measures, such as green investments and environmental taxes, as a practical way to boost economic growth in the midst of the COVID-19 crisis. In the meantime, Tawiah et al. (2021) carried out a thorough analysis of several green growth locations and recommended that economically underprivileged nations give priority to trade and foreign direct investment (FDI) in order to manage their advancement in green growth initiatives successfully.

Alshubiri et al. (2021) did a study to assess the influence of GFDI on green and fossil fuel use. OPEC member nations' findings demonstrated a favourable connection between GFDI and CO_2 emissions, and GFDI and green energy output have a negative association. Similarly, Zhou and Zhao (2022) produced empirical data supporting the premise that expanding GFDI might help promote green economic growth, which agrees with the idea of pollution halo. Khan et al. (2021) performed a study that discovered GFDI inflows can definitely boost green economic growth, but only if the laws and regulations controlling GFDI and green growth efforts are clear and relevant. Demiral and Demiral (2021) examined the determinants of green development from many perspectives.

In the energy sector, regulatory worries have the largest impact on firms, according to the statistics. Between 1985 and 2012, Doytch and Narayan (2016) looked at the relationship between green energy and foreign direct investment (FDI) in 74 different countries. Their research showed that the growth of renewable energy infrastructure was significantly aided by sectoral FDI. Sbia et al. (2014) utilised the UAE as a case study to investigate the effect of FDI on carbon emissions. Their results indicated that FDI contributed to a decrease in energy intensity and energy demand. Diaconu (2014) recognized the distinguishing features of FDI in the Southeast Asian area, emphasizing the region's multiple competitive advantages that drew international investors. Lucas (1984) conducted a significant investigation on GFDI in East and Southeast Asian nations, revealing that in export markets, wages are less elastic in comparison to capital costs and more sensitive to aggregate demand than in domestic demand beyond GFDI information. Given the preceding summary, a substantial research need may be highlighted, namely the assessment of green growth and FGDI in Southeast Asian nations using a technique of econometric analysis. Our study will attempt to fill a void in the current literature.

2.2. Green Development in the Economy and Green Foreign Direct Investment

In order to attain fast economic growth and create a solid economic structure, nations must possess sufficient resources. Since local resources are frequently insufficient to propel economic growth, foreign direct investment can be used to achieve this goal, especially in emerging nations. Domar's 1947 growth models, on the other hand, contend that savings are the cornerstone of capital accumulation and economic progress. This point of view was supported by Rostow (1959), who provided data to support its claims that savings are the key to economic development. Additionally, emerging nations often find themselves enticed to maintain substantial foreign debts, which can complicate their ability to repay and sometimes result in foreign powers intervening to gain control over their vital assets. The influx of funds could assist the latter in matching the pace of economic growth-however, empirical data points in a different direction. For instance, Abramovitz's research in 1956 indicated that sustained development results from technological advancements rather than overseas financial injections. Enhancing a nation's domestic output relies on a combination of technological advancements and foreign direct investment. Consequently, as suggested by Johnson and colleagues in 2016 (Ashraf et al., 2016), it becomes essential to look at the connection between growth, efficiency, and new investment. Using a comprehensive technique known as the system-generalized approach to moments, researchers examined the effects of financial development on carbon emissions in 46 countries in Sub-Saharan Africa between 2000 and 2015. According to Acheampong's 2019 research, factors including financial development, foreign direct investment, liquid liabilities, and direct loans from the banking sector to the private sector do not appear to have an impact on greenhouse gas emissions (Acheampong, 2019).

In recent research, Vo and Ho (2021) examined the complex relationships between economic growth, environmental deterioration, and green foreign direct investment (GFDI), with a particular emphasis on Vietnam. They discovered that GFDI has a long-term detrimental influence on environmental quality. Green financing and environmental conservation in N11 countries were studied by Nawaz and colleagues in 2021 (Nawaz et al., 2021). Their results imply that green financing has become a crucial element in promoting a green economy, mostly due to green foreign direct investment, or GFDI. Meanwhile, Opoku et al. (2021) undertook a thorough investigation of the relationship between environmental pollution and GFDI in African countries, with empirical data indicating that emissions were negatively impacted by GFDI. Adeel-Farooq et al. (2021) set out to explore how GFDI affected environmental parameters in 76 countries between 2002 and 2012. Their main findings suggested that GFDI from wealthy nations had the ability to assist low- and lower-middle-income nations in improving the quality of their environments.

A link between GFDI and environmental technology, as well as green growth for European manufacturing, was examined by Castellani et al. (2022). Their findings imply combining GFDI and green-tech R&D promotes efficient and productive knowledge transfer across countries. Meanwhile, Chaouachi and Balsalobre-Lorente (2022) recently undertook research to investigate several aspects of GFDI in the context of achieving sustainable Algeria's economy. Their primary findings emphasized the long-standing relationship between national environmental protection and green foreign direct investment (GFDI). Studying the relationship between tax laws, investment, and the green economy in Southeast Asian nations is the subject of another body of text. Scholars have often ignored the question of GFDI and its relationship with Southeast Asian nations' green economies. Ahmed et al. (2022) conducted a new study to study how green innovation may help South Asian countries achieve green growth.

Their findings suggested that promoting foreign direct investment (FDI) in green innovation might have a favorable effect on green growth in these areas. In order to examine the impact of foreign direct investment on the use of green energy in South Asian countries from 1990 to 2019, Kang et al. (2023) used panel cointegration calculations. They suggest that South Asian policymakers should view GFDI and green GDP as important policy tools for attaining environmental sustainability. Ahmed et al. (2022) and Murshed (2020) discovered that increasing GFDI inflows may lead to a decrease in total renewable energy use. Growing economic development and rising CO_2 emissions, on the other hand, may encourage South Asians to utilize renewable energy sources. Caglar et al. (2022) investigated the role of FDI inflows and green energy consumption on pollution reduction across nine countries. The main conclusions demonstrated long-lasting and important relationships between the use of renewable energy, green foreign direct investment (GFDI), and the expansion of the green economy. On the other hand, Mahbub and Jongwanich (2019) looked at the variables affecting the amount of GFDI in Bangladesh's energy sector.

2.3. The Rise of Green Finance and Green Foreign Direct Investment

Research investigating the impact of financial expansion and foreign direct investment on greenhouse gas emissions has produced inconsistent and heterogeneous findings. Vo and Zaman (2020), for example, investigated how energy use affected greenhouse gas emissions in 101 countries between 1995 and 2018 as part of their economic growth framework. The authors found the generalised method of moments (GMM) to consistently demonstrate a reduction in carbon emissions as a result of financial expansion in every country. Increased foreign direct investment has the potential to support positive financial growth, as shown by Busse and Hefeker in 2007. Theoretically, foreign direct investment and financial growth are related, and this was investigated in great detail in the early 1980s. In 1973, for example, McKinnon and Shaw looked at how financial expansion affected the ability to draw foreign direct investment. Their conclusions indicate that, although financial expansion is a crucial component, it is not the main factor influencing foreign direct investment. Other aspects need to be considered when evaluating how economic development affects foreign direct investment inflows into a nation. Furthermore, they claimed that economic prosperity alone is insufficient for a country to attract foreign investment in advanced technology. While industrialized nations tend to be more stable than developing countries, they still expect various factors to impact foreign direct investments, as highlighted by Busse and Hefeker in 2007 (Busse and Hefeker, 2007). In such cases, it is more enlightening and valuable to explore multidisciplinary studies. Studies in law and finance suggest that companies that put investor happiness first are usually better at predicting trends in foreign direct investment. By drawing more foreign direct investments, associations that provide investors with a sense of security are essential in promoting economic growth. As per Roe and Siegel's research in 2007, governments facing social instability often struggle to enact laws that encourage and foster entrepreneurship while safeguarding financial markets. When investigating the links between markets, financial growth, economic development, foreign direct investment inflow, and their causal relationships, it becomes evident that the impact of political stability is easily discernible. For this reason, developing countries must be taken into account while studying the function of stock markets and the phases of growth in the inflow of foreign direct investment since these conditions are common in rising economies.

2.4. Green Finance Development and Deterioration of the Environment

The capacity of a country to maintain a clean and enjoyable environment can receive a boost from robust economic development (Ahmed et al., 2022). Thus, a nation needs a healthy and functional financial market in order to reach the desired degree of environmental sustainability (Sbia et al., 2014). However, excessively prioritizing financial markets can occasionally draw attention away from other critical components of the overall economy, such as ecological and environmental progress. It is commonly known that energy use and economic growth must be carefully balanced. Similarly, research by Shahbaz et al. (2017) and Islam et al. (2013) indicates that expansion or investment of any kind raises the need for energy. Chinese provinces were categorized according to their financial development stage in a research carried out in 2021 by Xu et al. using a panel smooth transition regression technique. From 2001 to 2017, they looked at the statistics of the Chinese province. According to their findings, there is a considerable indirect relationship between financial development and environmental damage. Bank-centered and equity market-centered financial growth exhibit an adverse association with environmental deterioration, as indicated by Shahbaz et al. (2016) and Javid and Sharif (2016). Quite the reverse; Ahmed et al. (2022) have just discovered a noteworthy positive relationship between financial expansion, carbon emissions, and foreign direct investment. These results show that when examining the impact of financial growth on environmental factors—especially when assessing the relationship between financial development and carbon emissions—it is crucial to take into account not only the assessment of financial development but also the various characteristics of individual countries. They also noted that there is a positive connection between the financial system's impact and overall efficiency and carbon emissions in emerging economies. These results highlight the need for further research to achieve sustainable and environmentally friendly economic growth. Zeqiraj and associates studied the effect of stock market expansion on carbon emission reduction in 2020 (Zeqiraj et al., 2020). Utilizing panel time-series data spanning the European Union member states from 1980 to 2016, they applied a cross-sectional autoregressive distributed lags (CS-ARDL) model. According to their results, the long-term development of a low-carbon, sustainable economy is hampered by stock market expansion. Nonetheless, it is widely recognized that long-term technological breakthroughs are essential to achieving a low-carbon economy. Their findings provide more evidence in favor of the claim that switching to renewable energy sources and increasing their production help move society closer to a low-carbon economy.

3. EMPIRICAL METHODOLOGY

To investigate the connection between environmental performance and green foreign direct investment (GFDI), a model was developed by drawing on the previously stated texts.

$$EP_{it} = \beta_0 + \beta_1 GFDI_{i,t} + \beta_2 INC_{i,t}, + \beta_3 TS_{i,t} + \beta_4 FDI_{i,t} + \beta_5 IND_{i,t} + \beta_6 GE_{i,t} + \beta_7 EI\_ISO_{i,t} + \varepsilon_{ijt}, \quad (1)$$

where i and t represent country i and year t, respectively.

3.1. Environmental Performance

According to Hsu and Zomer (2016), metrics like the Environmental Performance Index (EPI) and Health and Ecosystem Protection (HLT and ECO) may be employed to evaluate the environmental performance of a particular nation. The EPI is determined utilizing thirty-two indicators spanning ten topics, according to Ahmed et al. (2022) and Ha (2023). Fu et al. (2020) stress how crucial it is to build environmental policies utilizing the multi-dimensional environmental performance index. Environmental Law and Policy at Yale University provided the statistics on environmental performance (YIELP).

3.2. Key Explanatory Variable

The first portion of the definition of green foreign direct investment (FDI) can be loosely approximated by FDI in Energy, Gas, and Water (EGW), as defined by the International Trade Center, in the lack of precise FDI statistics. Important environmental services, including power and water management, are included in this category. It does not, however, include waste treatment or other environmental non-infrastructure activities or the production of environmental goods. Instead, it comprises energy produced from traditional sources such as coal, oil, and nuclear. As such, it's still uncertain if it truly captures the volume of green FDI. Hence, rather than offering an exact estimate of the first dimension of green FDI, EGW might be seen as offering an order of magnitude. EGW, manufacturing, mining, agriculture and forestry, construction, and transportation are all included in environmentally relevant foreign direct investment (FDI) or prospective green FDI. The International Trade Center provided data for these factors for the years 2001 through 2021.

3.3. Control Variables

In the course of examining how green FDI affects environmental performance, we took into account GDP per capita (in constant 2010 US dollars) (INC) according to research conducted by Fu et al. (2020), Ha (2022), Ha and Thanh (2022), and Thanh et al. (2022). Essandoh et al. (2020) have established that international commerce, which is a measure of a nation's openness, has a considerable impact on environmental performance. Divergent empirical findings have been noted in certain areas, despite the fact that several papers (Aller et al., 2015; Dogan and Seker, 2016; Ha, 2022a; Omri, 2020; Thanh et al., 2022, 2023) link increased environmental performance with more trade. With the use of the share of trade share (TS), we also investigated the relationship between environmental performance and environmental innovation. We have included the net Foreign Direct Investment (FDI) inflow from Bu et al. (2019) and Shahbaz et al. (2018) in our theoretical model. Furthermore, Wang et al. (2022), Yang and Khan (2022), and Yu et al. (2019) provided a measure of industrialization (IND) based on the percentage of industrial value-added to GDP. As suggested by Ha (2022a) and Thanh et al. (2023), we took the government effectiveness index (GE) into consideration to look into the influence of political issues. While information on ISO 14001 certifications (EI_ISO) was gathered from the Organization for Economic Cooperation and Development statistics, information on INC, TS, FDI, and IND was acquired from the Global Development Indicators (WDI). Each variable's details and statistical explanation are given in Table 1. Our final sample comprised 11 nations from 2001 to 2023 based on the cleansed data (the list of countries is provided in Table A.1). Table 2 reports the correlation coefficients between included variables.

According to Pesaran (2021), the next stage for data validation is to conduct a cross-sectional dependency analysis. To determine if data with cross-dependence (CD) are stationary, several tests for stationarity have been devised, including Levin-Lin-Chu (Levin et al., 2002) and Im-Pesaran-Shin (Im et al., 2003). To examine the impact of CD and stationarity on the first difference variable, panel-corrected standard error modeling (PCSE) is utilized (Table 3). Gaps, missing observations, and outliers are eliminated after the empirical phase to guarantee that the data is highly balanced and supports tests and applied procedures. Once the data has been cleaned, empirical estimates will be carried out in 11 European nations from 2001 to 2023. All explanatory factors are one period behind, whether it is due to the restricted availability of data or the synergistic link between digitalization and exporting. Gala

Table 1: Description of variables

Variable	Definition	Measure	Source	Obs	Mean	SD	Min	Max
EPI	Environmental performance index	The score is scaled between 0 and 100, where 0 and 100 mean the worst and best performance, respectively.	YCELP	253	50.58	9.95	23.23	72.73
HLT	Environmental health index	The score is scaled between 0 and 100, where 0 and 100 mean the worst and best performance, respectively.	YCELP	253	68.39	13.74	33.83	93.14
ECO	Ecosystem vitality index	The score is scaled between 0 and 100, where 0 and 100 mean the worst and best performance, respectively.	YCELP	253	52.21	11.72	20.31	69.29
GFDI	Inflow of green FDI	A log of total green FDI inflow value per capita	International Trade Center	253	11.40	2.54	5.52	16.73
INC	Economic growth	The real GDP per capita (constant 2010 US dollars).	WDI	253	10.12	0.57	8.70	11.05
TS	Trade share	The proportion of GDP.	WDI	253	8.90	0.65	7.16	10.22
FDI	Net inflow of foreign direct investment	The proportion of GDP.	WDI	253	5.93	1.38	-1.69	8.62
IND	Industrialization level	The value added to GDP.	WDI	253	1.03	0.56	-0.13	2.10
GE	Level of democratization	The index of democratization	FSSDA	201	10.89	0.57	9.61	11.76
EI_ISO	ISO 14001 certificates	The number of firms with ISO1001	OECD.Stat	161	133.25	82.63	8.20	300.83

Table 2: Correlation coefficients

	EPI	HLT	ECO	GFDI	INC	EXP	FDI	GE	IND	EI_ISO
EPI	1									
HLT	0.632***	1								
ECO	0.584***	0.119	1							
GFDI	0.406***	0.436***	0.182*	1						
INC	0.485***	0.938***	0.113	0.463***	1					
TS	0.690***	0.857***	0.369***	0.487***	0.806***	1				
FDI	0.336***	0.295***	0.283***	0.400***	0.251**	0.483***	1			
GE	0.473***	0.664***	0.219**	0.524***	0.645***	0.750***	0.446***	1		
IND	0.471***	0.925***	0.0208	0.496***	0.958***	0.700***	0.163	0.570***	1	
EI_ISO	−0.0128	0.360***	−0.224**	0.0778	0.292***	0.417***	0.382***	0.274**	0.199*	1

*P<0.05, **P<0.01, ***P<0.001

et al. With Equation (1), the Feasible Generalized Least Squares (FGLS) model is applied by Gala et al. (2018) and Sweet and Eterovic (2019). Equation (1) also includes a two-step technique called the Generalized Method of Moments (GMM) (Ha and Thanh, 2022; Sweet and Eterovic Maggio, 2015) to address any endogeneity difficulties.

This article discusses their difference and looks at the short-and long-term impacts. Autoregressive distributed lags were a strategy developed by Pesaran and Smith (1995) to address this problem. Pesaran and Shin (1998) established causal linkages between variables and evaluated fixed effects while considering EU nations' endogeneity. To determine if two variables are cointegrated, as proposed by Kao (1999), Pedroni (2004), and Westerlund (2005), we then performed the Kao cointegration test, the Pedroni test, and the Westerlund test. The findings show cointegration between Green Foreign Direct Investment (GFDI) and Environmental Performance (EP) when compared to Table 4.

4. EMPIRICAL RESULTS

4.1. Baseline Results

Three key factors-the Ecosystem Vitality Index (ECO), the Environmental Performance Index (EPI), and the Environmental Health Index (HLT)-were the focus of our extensive investigation into the linear link between green Foreign Direct Investment (GFDI) and environmental performance. Table 5 shows the results of our analysis of how green FDI affects circular environmental sustainability using the Environmental Performance Index. Three different estimate techniques were used: two-step GMM (columns 7-9), FGLS (columns 4-6), and PCSE (columns 1-3). Crucially, our results show that, with the exception of the model that includes the EI_ISO variable in both PCSE and FGLS estimations, there is a positive and statistically significant association between green FDI and several Environmental Performance Index measures. This suggests that an increased adoption of green FDI has the potential to enhance environmental performance substantially. This observed relationship aligns with findings from prior studies. Empirical evidence from the European Union (2014) indicates that GFDI is particularly relevant to sectors with environmental impact, thereby contributing significantly to sustainable development. In addition, these findings also show that the inclusion of the control variable EI_ISO in the GFDI model does not render the relationship between GFDI and EPI statistically significant; however, there is a higher likelihood that this connection is negative.

When analyzing the control variables, both the PCSE and FGLS estimates yield identical results. Overall, the variables INC, GE,

Table 3: Cross sectional dependence tests and stationary tests

Variable (in level)	CD-test, Pesaran (2004)	Im-Pesaran-Shin test (Z-bar)	Variable (in difference)	Im-Pesaran-Shin test (Z-bar)
EPI	18.22***	−9.32***	DEPI	−0.47***
HLT	13.54***	−10.21***	DHLT	−12.43***
ECO	6.50***	−5.32***	DECO	−8.93***
GFDI	1.44	−5.91***	DGFDI	−12.25***
INC	3.54***	−14.21***	DINC	−11.15***
TS	8.30***	−7.32***	DEXP	−22.43***
FDI	12.64***	−12.21***	DFDI	−12.93***
IND	8.40***	−7.32***	DIND	−11.93***
GE	3.10***	−5.32***	DGE	−5.93***
EPI	3.40***	−3.32***	DEPI	−3.12***
EI_ISO	2.12***	−4.22***	DEI_ISO	−4.23***

Regarding the CD test, the null hypothesis is that the cross-section is independent. *P* value is closed to zero, implying that data are correlated across panel groups. Regarding the Im-Pesaran-Shin test, the null hypothesis is "All panels contain unit root" and the alternative hypothesis is "Al least one panel is stationary". *, **, *** are significant levels at 10%, 5%, and 1%, respectively

Table 4: Cointegration test

Model: f (GFDI and EP)	Kao test	Pedroni test	Westerlund test
	Dickey-Fuller test	Phillips-Perron t	Variance ratio
GFDI			
EPI	−3.11***	4.73***	2.35**
HLT	2.17***	6.50***	5.15***
ECO	−6.84***	4.63***	4.37*

Regarding the Kao test, the null hypothesis is "No cointegration," while the alternative hypothesis is "All panelsare cointegrated.". Regarding the Pedroni test, the null hypothesis is "No cointegration,", while the alternative hypothesis is "All panels are cointegrated". Regarding the Westerlund test, the null hypothesis is "No cointegration," while the alternative hypothesis is "Some panels are cointegrated"

Table 5: The effects of green FDI on circularity performance environmental sustainability: Benchmark models

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PCSE estimates			FGLS estimate			Two-step GMM		
	EPI	EPI	EPI	EPI	EPI	EPI	EPI	EPI	EPI
L.GFDI	1.09***	0.98***	−0.16	1.09***	0.98***	−0.16	0.72*	0.22**	0.61*
	(0.199)	(0.206)	(0.113)	(0.244)	(0.224)	(0.183)	(0.024)	(0.025)	(0.023)
L.INC	−1.04	10.15***	−5.71**	−1.04	10.15***	−5.71**	−0.31***	0.00	−0.01
	(1.230)	(1.472)	(2.858)	(1.290)	(2.687)	(3.503)	(0.032)	(0.044)	(0.036)
L.TS	12.91***	12.93***	7.29***	12.91***	12.93***	7.29***	−2.01***	0.12	−0.67
	(0.651)	(0.541)	(1.911)	(1.197)	(1.146)	(1.943)	(0.634)	(1.286)	(1.037)
L.GE	−2.07*	−2.34**	1.36	−2.07*	−2.34*	1.36	−0.11	−0.55	−0.49
	(1.065)	(1.185)	(0.893)	(1.473)	(1.383)	(1.184)	(1.473)	(1.383)	(1.184)
L.FDI	−0.10	−0.99***	0.35	−0.10	−0.99***	0.35	−0.15	−0.99***	0.35
	(0.346)	(0.260)	(0.214)	(0.368)	(0.340)	(0.275)	(0.279)	(0.408)	(0.344)
L.IND		−11.70***	4.32*		−11.70***	4.32*		−12.31**	−12.27***
		(1.665)	(2.343)		(2.447)	(2.572)		(5.957)	(5.124)
L.EI_ISO			−0.02***			−0.02***		3.26***	6.22***
			(0.006)			(0.004)		(0.796)	(0.793)
Observations	242	201	140	242	201	140	253	222	147
Number of nations	11	11	7	11	11	7	11	11	7
Standard errors in parentheses									

FDI, and IND exhibit inconsistent trends (negative or positive) and varying levels of statistical significance. While its findings in the two-step GMM model are inconsistent, TS shows a positive and statistically significant correlation with all environmental performance factors in both PCSE and FGLS estimates at a 1% significance level. Regarding EI_ISO, both PCSE and FGLS calculations showed a negative influence with a coefficient of 0.02. With coefficients of 3.26 and 6.22, respectively, at a 1% significance level, EI_ISO, on the other hand, showed a positive and statistically significant influence on EPI in the two-step GMM estimate. These results highlight the complex interactions between environmental performance, control factors, and green FDI, and they also highlight the varied effects of control variables on environmental sustainability.

Table 6 presents the findings of our investigation into how green FDI affects ecosystem vitality (ECO) and environmental health (HLT) using PCSE and FGLS calculations. Our findings reveal a positive and statistically significant correlation between green FDI and various indicators of EPI and ECO, except for the model incorporating EI_ISO regarding the relationship between GFDI and ECO. This suggests that increased adoption of green FDI has the potential to enhance the environmental health index and ecosystem vitality index substantially. Regarding control variables,

Table 6: The effects of green FDI on circularity performance environmental sustainability: Environmental health and ecosystem vitality

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Environmental health						Ecosystem vitality					
	PCSE			FGLS			PCSE			FGLS		
	HLT	HLT	HLT	HLT	HLT	HLT	ECO	ECO	ECO	ECO	ECO	ECO
L.GFDI	0.69***	0.70***	0.90***	0.69***	0.70***	0.90***	1.35***	1.22***	0.17	1.35***	1.22***	0.17
	(0.188)	(0.215)	(0.135)	(0.183)	(0.181)	(0.134)	(0.219)	(0.244)	(0.201)	(0.336)	(0.290)	(0.217)
L.INC	12.17***	3.19	−3.74	12.17***	3.19	−3.74	−4.96***	26.00***	26.86***	−4.96***	26.00***	26.86***
	(1.192)	(2.220)	(2.371)	(0.968)	(2.174)	(2.566)	(0.996)	(2.099)	(4.326)	(1.782)	(3.479)	(4.162)
L.TS	9.91***	11.64***	7.36***	9.91***	11.64***	7.36***	14.98***	12.65***	−4.10*	14.98***	12.65***	−4.10*
	(0.657)	(0.512)	(1.691)	(0.899)	(0.927)	(1.424)	(0.794)	(0.646)	(2.386)	(1.653)	(1.483)	(2.309)
L.GE	0.88	0.84*	2.08**	0.88	0.84*	2.08**	−1.41	−1.72	6.45***	−1.41	−1.72	6.45***
	(0.886)	(0.504)	(0.822)	(1.105)	(1.119)	(0.868)	(1.332)	(1.576)	(1.286)	(2.034)	(1.790)	(1.407)
L.FDI1	−1.57***	−1.65***	0.20	−1.57***	−1.65***	0.20	−0.10	−1.35***	0.61**	−0.10	−1.35***	0.61*
	(0.366)	(0.281)	(0.207)	(0.276)	(0.275)	(0.202)	(0.430)	(0.353)	(0.277)	(0.508)	(0.440)	(0.327)
L.IND		8.75***	18.55***		8.75***	18.55***		−31.57***	−25.27***		−31.57***	−25.27***
		(1.482)	(1.644)		(1.980)	(1.884)		(1.687)	(3.364)		(3.168)	(3.056)
L.EI_ISO			0.01***			0.01***			−0.04***			−0.04***
			(0.003)			(0.003)			(0.006)			(0.005)
Observations	242	201	140	242	201	140	242	201	140	242	201	140
Number of nations	11	11	7	11	11	7	11	11	7	11	11	7

Standard errors in parentheses

INC, GE, and FDI exhibit inconsistent trends (negative or positive) and varying levels of statistical significance. TS demonstrates a favorable and statistically significant relationship between GFDI and HLT in both estimations. The nexus between GFDI and ECO is positive and statistically meaningful, except for the model, which includes the additional EI_ISO variable. Additionally, IND and EI_ISO show positive and statistically significant impacts on HLT at a 1% significance level. However, they demonstrate negative influences on ECO, with coefficients of 31.57 and 25.27 for IND, along with 0.04 for EI_ISO.

As seen in Table 7, the paper delves deeper into the immediate and long-term effects of green foreign direct investment (GFDI) on environmental sustainability. Interestingly, green foreign direct investment (FDI) has a favorable long-term impact at a considerable level of five percent on three measures that evaluate environmental performance. In particular, the influence of GFDI on EPI is the most significant, with a coefficient of 0.77. This finding indicates that an excessive rise in green FDI adoption will promote sustainable environmental performance. In contrast, experimental evidence shows that GFDI has no effect on all aspects of environmental performance in the short term. In addition, the coefficients of CE are negative and statistically significant in three models. This result implies that short-term shocks lead to imbalances in EPI (22%), HLT (34%), and ECO (56%), which will be restored to equilibrium in the long-term scenario.

4.2. Further Discussion: Mechanisms of a Link between Green FDI and Environmental Sustainability

We carry out additional investigations to investigate the impacts of green foreign direct investment (FDI) on environmental sustainability via transmission mechanisms, in addition to our main assessments. With coefficients ranging from 0.25 to 3.20, Panel A's GFDI in Table 8 shows a positive and statistically significant effect on all indicators representing transmission mechanisms. Similarly, all metrics reveal a considerable beneficial impact from TS, but FDI has a negative impact. INC also shows negative effects, with the exception of AIR and H2O. While GE has a negative influence on H2O, WMG, BDH, and ECS, it has a favorable and statistically significant effect on AIR and HMT.

Regarding FSH and AGR, Panel B shows a statistically significant negative influence from GFDI, whereas Panel C and ACD show a beneficial effect. WRS, CCH, and FSH are all negatively impacted

Table 7: The influence of green FDI on environmental performance: Short-run and long-run effects

Variables	(1)	(2)	(3)
	EPI	HLT	ECO
	Short-run impact		
CE term	−0.22*	−0.34***	−0.56***
	(0.085)	(0.083)	(0.082)
D.GFDI	−0.07	−0.001	−0.06
	(0.06)	(0.006)	(0.019)
	Long-run impact		
GFDI	0.77***	0.14***	0.061**
	(0.042)	(0.001)	(0.002)
Observations	253	253	253

Tabe 8: The effects of green FDI on environmental sustainability: Transmission mechanisms

Panel A							
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	AIR	H2O	HMT	HMT	WMG	BDH	ECS
L.GFDI	0.45*	0.75**	2.26***	2.26***	0.25***	3.20***	0.41***
	(0.243)	(0.311)	(0.235)	(0.235)	(0.069)	(0.486)	(0.114)
L.INC	13.21***	23.54***	−3.55***	−3.55***	−6.31***	−9.59***	−2.62**
	(1.223)	(1.570)	(1.322)	(1.322)	(0.701)	(2.059)	(1.169)
L.TS	6.76***	11.86***	15.20***	15.20***	17.11***	25.21***	4.93***
	(0.708)	(1.423)	(0.996)	(0.996)	(0.428)	(1.852)	(0.791)
L.GE	6.50***	−12.32***	5.55***	5.55***	−1.69***	−6.17*	−4.77***
	(1.259)	(1.849)	(2.057)	(2.057)	(0.541)	(3.153)	(0.872)
L.FDI	−0.89**	−2.83***	−3.28***	−3.28***	−0.42**	−0.41	−1.69***
	(0.349)	(0.680)	(0.516)	(0.516)	(0.166)	(0.899)	(0.286)
Observations	242	242	242	242	242	242	242
Number of nations	11	11	11	11	11	11	11

Standard errors in parentheses
***P<0.01, **P<0.05, *P<0.1

Panel B					
Variables	(1)	(2)	(3)	(4)	(5)
	FSH	CCH	ACD	AGR	WRS
L.GFDI	−1.28***	1.01***	2.38***	−1.57***	−0.32
	(0.145)	(0.266)	(0.307)	(0.208)	(0.426)
L.INC	−1.94*	−3.66*	0.20	1.19	−3.47*
	(1.162)	(2.124)	(1.682)	(1.003)	(1.961)
L.TS	1.68***	12.20***	10.09***	4.59***	22.89***
	(0.614)	(1.011)	(0.961)	(1.046)	(1.180)
L.GE	6.17***	−4.35***	−5.70***	11.86***	11.49***
	(1.372)	(1.624)	(1.744)	(1.894)	(2.799)
L.FDI	0.22	0.68	2.82***	2.74***	−2.19***
	(0.219)	(0.485)	(0.431)	(0.482)	(0.759)
Observations	242	242	242	242	242
Number of nations	11	11	11	11	11

Standard errors in parentheses
***P<0.01, **P<0.05, *P<0.1

by INC. At a significance level of one percent, TS has a positive and statistically significant influence on every metric. ACD and AGR are positively impacted by FDI, whereas FSH, AGR, and WRS are positively impacted by GE.

5. CONCLUSIONS

The purpose of this essay is to investigate the question of whether GFDI improves or degrades environmental performance. We examined GFDI statistics from 21 nations between 2010 and 2020. The ecological health index, ecosystem vitality index, and environmental performance index are all included in the environmental performance factor and are used to test theories on this relationship. Moreover, an investigation is conducted on the potential enduring impacts of GFDI on EPI.

The study's empirical results unquestionably show that GFDI advancement and encouragement have a positive effect on environmental sustainability; this is especially true for the environmental performance index (EPI), environmental health index (HLT), and ecosystem vitality index (ECO). Moreover, our study shows that these beneficial benefits last over time, becoming more pronounced as additional green FDI regulations are implemented. These findings have important ramifications for improving environmental performance. It is obvious that governments should place a high priority on encouraging GFDI efforts and stress the need of corporate and policy institution cooperation.

In addition, policymakers may find great significance in the conclusions derived from the favorable long-term effects on environmental sustainability. Governments should support the process of economic openness by devising a well-thought-out plan; that is, they should give priority to enacting the necessary laws and policies to draw in green foreign direct investment. Well-functioning policy establishments create an atmosphere in which companies may increase their investments, launch new technologies, and drive the environmental sector's ongoing progress. Ultimately, this research highlights how crucial it is to advance GFDI as a catalyst for environmental sustainability advancement. It demands cooperative efforts by organizations, corporations, and governments in order to work together to create a future that is both economically and environmentally successful.

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APPENDIX

Table 1A: Countries in the sample

EU countries		
Austria	Hungary	Portugal
Belgium	Iceland	Slovak Republic
Bulgaria	Ireland	Slovenia
Czech Republic	Italy	Sweden
Denmark	Lithuania	
Spain	Luxembourg	
Estonia	Latvia	
United Kingdom	Malta	
Greece	Netherlands	
Croatia	Poland	