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Research Article

Do green foreign direct investments promote environmental innovation in European countries?

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Abstract. Environmental innovation (EI) plays a critical role in helping a country pursue sustainable development, while green foreign direct investment (GFDI) impacts creative local green innovation. However, there is a lack of research on this link. This paper aims to conduct an empirical investigation into how GFDI affects EI. The estimation findings demonstrate that GFDI has had positive effects on EI—by applying multiple econometric methods, including a panel-corrected standard error modelling (PCSE), a feasible generalized least squares model (FGLS), and autoregressive distributed lag (ARDL) model, to a globally representative sample of 15 European countries between 2012 and 2021. To clarify the connection between GFDI and EI, we present examples of the effects of the latter in both the short and long term. The results show that GFDI has an important beneficial impact on the environment for early-stage investments in the short term. Notably, our findings indicate that GFDI's long-term effects are more likely to be favorable. Furthermore, we analyze interactions between variables representing institutional quality and the impact of GFDI on EI. Our findings suggest that the positive effects of GFDI may be greater in nations with highly developed institutional systems.

Keywords: GFDI; green innovation; European countries; institutional quality; green financing.

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1. Introduction

Over the past several decades, foreign direct investment (FDI) has significantly impacted the technical innovation landscape of host nations, especially when it comes to manufacturing advanced and high-tech products (Shao *et al.*, 2023). FDI is acknowledged as a key contributor to employment and economic growth, in addition to its function in transferring technology to host countries. Nonetheless, there is rising concern about the possible negative environmental effects of FDI (Adebanjo & Akintunde, 2024; Ali *et al.*, 2022; Chen *et al.*, 2023; Martín-Ortega *et al.*, 2024; Oje, 2024; Raihan, 2024; Shao *et al.*, 2023; Yassine *et al.*, 2024). Due to their weak environmental regulations, industrialized countries relocate their polluting factories and establish offices in developing countries, which results in environmental degradation in the host developing countries, establishing a negative nexus between foreign direct investment and environmental quality. Although FDI improves industrial processes and benefits host nations economically, the environmental implications of these operations are recognized (Ali *et al.*, 2022; Chen *et al.*, 2023; Ioanna *et al.*, 2022; Kyriakopoulos *et al.*, 2023; Sebos *et al.*, 2016). Governments have taken action in response to these worries due to the ecological impact of FDI, especially with regard to production processes. As a result, many countries are aggressively pushing green innovation as a calculated move to lessen the negative environmental effects of FDI-related industrial production processes (Ali *et al.*, 2022).

In host economies, green or environmental innovation (EI) is essential for reducing CO_2 emissions and promoting environmental sustainability. Interestingly, multinational companies frequently use more ecologically friendly production processes than their local counterparts in developing nations (Al-mulali *et al.*, 2015; Losada-Puente *et al.*, 2023; Papadogiannaki *et al.*, 2023; Progiou *et al.*, 2023). All forms of innovation, both technological and non-technological, that create business opportunities and benefit the environment by reducing their impact or by optimizing resource use are considered eco-innovation. As a result of the use of natural resources, the production and consumption of goods, as well as the concepts of eco-efficiency and eco-industry, eco-innovation is closely related to all of these concepts. Manufacturing businesses can benefit from the shift from end-of-pipe solutions to closed-loop approaches that minimize material and energy flows by changing products and production methods - giving them a competitive advantage. Green innovation is a desirable endeavour for developing countries looking for environmentally friendly technologies and production methods because of its significant capacity for addressing environmental issues (Guo *et al.*, 2021). Before these types of technologies are able to achieve positive environmental outcomes, they must first undergo a

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period of acceptance, commercialization, and positive diffusion (de Souza *et al*., 2019; Mehrad *et al*., 2021; Pavolova *et al*., 2021).

Environmental sustainability has become a critical worldwide policy issue, especially for developing countries whose ecosystems are susceptible (Jackman & Moore, 2021; Sebos *et al*., 2016). The emphasis on environmental sustainability means that consistent efforts are required to safeguard and preserve ecological resources (Guo *et al*., 2022). The importance of environmental sustainability has been highlighted in recent international talks and debates, which have been sparked by pressure for environmental protection from both domestic and foreign sources (Murshed *et al*., 2020). Historic accords such as the Paris Agreement emphasize dedication to the preservation of biodiversity. Due to increased awareness of the damaging effects that non-renewable energy sources have on the environment, there is a desire for alternate and renewable energy sources (Balsalobre-Lorente *et al*., 2022; Bouyghrissi *et al*., 2022). As part of the worldwide commitment to sustainable development and environmental stewardship, the United Nations 2030 Agenda for Sustainable Development Goals actively encourages FDI in renewable energies.

There are several drawbacks to empirical research (Kok & Acikgoz Ersoy, 2009; Lu *et al*., 2017; Mwakabungu & Kauangal, 2023), including the following: i) case studies and national surveys are the main sources of information showing how multinational enterprises (MNEs) influence regional EI; ii) research on whether the "greenness" of FDIs effectively increases regional EIs is lacking; iii) the mechanisms through which GFDI influences the region's capacity for expertise in ecological technologies are understudied; iv) more research is needed to assess whether green FDI (GFDI) can act as "sources of structural change" in the sustainable domain and facilitate the region's transition to a green economy; and v) FDIs' interactions with other drivers of the geographical area of ecological innovation and their possible impact on the typical place dependence of the sector need to be examined more closely (De Marchi *et al*., 2020; Marchi *et al*., 2019).

This current research is unique in that it focuses specifically on the connection between GFDI and green innovation, particularly in the context of European countries. As far as we are aware, no previous research has utilized dynamic panel frameworks to investigate the connection between green innovation and GFDI. Another contribution of this paper is to analyze the critical role of institutional quality in moderating the nexus between GFDI and EI. In this paper, we aim to address the following queries: (i) In what ways does GFDI encourage the adoption of green innovation within the European Union (EU)? and (ii) What policy recommendations are there to assist EU nations in attracting more GFDI and utilizing it to support the implementation of green innovation successfully?

The utilization of a system-generalized technique for moments to evaluate these models is a suitable strategy that has not been used before in this field. In the literature, many scholars have indicated the existence of cross-sectional dependence issues in the dynamic panel data. Employment of a traditional empirical approach will lead to biased results (Bouyghrissi *et al*., 2022; Canh & Dinh Thanh, 2020; Khan *et al*., 2023; Thanh *et al*., 2022; Zakari *et al*., 2023; Zakari & Khan, 2021). With the use of this technique, we can deal with the model misspecification bias and potential endogeneity resulting from simultaneity, two problems that have not been sufficiently addressed in previous research. After examining stationarity and cross-sectional dependence, we used a panel-corrected standard error modelling (PCSE) structure to estimate the connection between green innovation implementations and GFDI. Our results were further supported by considering heteroscedasticity and using the practical generic least squares model (FGLS). The aggregated mean groups estimator (PMG) - autoregressive distributed lag (ARDL) model was utilized to assess the influence over the short- and long-term periods. Prior research conducted by Nham and Ha (2022), Ha (2022a, 2022b, and 2022c) and Thanh *et al*. (2022) show that the PMG-ARDL approach can successfully handle problems about time- and country-fixed effects.

2. Literature review and hypothesis development

2.1. A review of the theoretical research

2.1.1. Definitions and measurements of GFDI

Defining GFDI is critical because it allows policymakers and stakeholders to assess the extent to which FDI helps achieve environmental goals and develop strategies for fostering environmentally responsible financial flows (OECD, 2011). GFDI, according to UNCTAD's 2008 definition, includes investments that either (1) conform to stricter environmental requirements than those imposed by host-country legislation or (2) are aimed toward the creation of environmental goods and services (EGS). This term effectively addresses how and what is produced, encompassing both the procedures utilized during manufacturing as well as the kinds of goods and services that are produced. While various definitions of GFDI share the notion of EGS as a classification for environmentally friendly products and services, the first component of the UNCTAD definition, which stresses higher environmental requirements, is not widely used in other methods.

Low-carbon foreign investment is included in green foreign direct investment (GFDI), according to the 2010 UNCTAD World Investment Report, "Investing in a Low Carbon Economy." Multinational enterprises (MNEs) engage in equity (FDI) and non-equity forms of involvement to transfer technology, processes, or goods to host countries. This approach emphasizes the viewpoint that the production of solar panels or electric car batteries, for example, should be regarded as "green" because of their long-term contributions to global emissions reduction, even if immediate or localized negative environmental consequences are associated with their production (OECD, 2011).

Furthermore, the notion is not restricted to certain firms or industries, such as renewable energy or waste disposal. Instead, it is determined by the performance of an economic activity, in contrast to a business-as-usual climate. Although this strategy adds complexity to operationalization by requiring the estimation of ongoing operations utilizing FDI figures at the project, sector, or facility level, it highlights the fact that achieving green development necessitates a comprehensive economic change. Because of the methodological hurdles inherent in determining low-carbon FDI based on this definition, UNCTAD's estimate in the same research employed a narrower, sector-based methodology. Greenfield FDI was focused on recycling, energy from renewable sources, and environmentally friendly manufacturing in order to assess low-carbon FDI flows.

The Organization for Economic Co-operation and Development (OECD) defines green investment as follows: (a) investments in a transfer of substantial assets (for example, through privatization); (b) sustainable natural resource and service management (forests, fisheries, nature-based tourism, wildlife, water security, soil productivity, and minerals); and (c) environmental products and services, including throughout entire parts of green value chains (e.g., convention). This idea spans a broader variety of activities than UNCTAD's definition of low-carbon FDI. However, due to the complexity involved in defining activities that qualify as "sustainable resource management," the OECD does not disclose GFDI estimates based on this criterion (OECD, 2011).

2.1.2. Theoretical foundations

Over the past few decades, several theoretical models have been developed to clarify the connection between environmental degradation and global financial activity. One of the first structures of this kind was created by Pethig (1976), who added a pollution variable to the traditional Ricardian framework for comparative advantage.

McGuire (1982) added the environment as another component of production to the conventional Heckscher–Ohlin model. This model illustrates how factors of production can shift from economies with tougher rules to those with more lenient laws as a result of individual or uncoordinated reinforcement of environmental standards. The theory of pollution havens, which addresses carbon dioxide emissions in agriculture as well, is based on this theoretical paradigm. The growing acceptance of carbon pricing schemes, especially in industrialized nations, is one illustration of this (World Bank, 2018). These programs increase the price of fertilizer and electricity, two important agricultural inputs (Kyriakopoulos *et al*., 2023; Meng, 2015; Progiou *et al*., 2023). Producers who are not able to adjust by raising energy effectiveness may be encouraged to move their operations to nations without carbon pricing schemes to avoid higher operating costs. Assuming that current agricultural enterprises have less emission-intensive manufacturing, this might potentially result in an upsurge in the host nation's emission levels (Kyriakopoulos *et al*., 2023; Sebos *et al*., 2016). Another possibility calls for laxer forest protection laws, which may encourage investment and agricultural growth, while increasing emissions from altered land use. Finally, emission-intensive agricultural production sectors, such as rice or livestock raising, may become especially attractive to foreign investors who broaden these sectors in the host country due to beneficial laws and incentives in some countries. This would ultimately increase the agricultural sector's carbon dioxide emission intensity.

Copeland & Taylor (2013) established the foundation for a theoretical structure that evaluates the influence of trade and FDI on environmental deterioration. This model is frequently used as the foundation for empirical investigation reviewing the interaction between FDI and polluted outputs, as is the case in this research, and it can be expanded to handle the issue of greenhouse gas releases. This paradigm states that changes in three important areas, the size and content of economic activity, as well as the methods of production, will have an impact on how GFDI and commerce affect the environment. Because of the increased production brought about by GFDI inflows, the host nation experiences increasing environmental deterioration, which is correlated with the level of financial activity. Regardless of potential differences in technology and emission levels between foreign and local farmers, the increase in agricultural output results in elevated emissions in absolute terms since it is a cause of pollution releases.

2.2. The type of FDI that comes in and how it affects local green technology specialization

It is challenging to forecast the overall influence of the wide range of GFDI on local EIs. This ambiguity is reflected in the empirical research that is currently available, most of which focuses more broadly on how GFDIs affect environmental performance, including emissions, rather than on EIs in particular (Zugravu-Soilita, 2017; Cole *et al*., 2017). According to the literature, MNEs may adopt various strategies. For example, they may look for areas with lax environmental regulations, which could negatively impact the ecological performance of the host economy, or they may seek out regions where they can transfer sustainable methods and technologies through their subsidiaries abroad. The literature emphasizes that while receiving countries are typically the centre of attention rather than particular regions, it is impossible to predict how FDIs will impact the ecological performance of host countries (Adebanjo & Akintunde, 2024; Oje, 2024; Raihan, 2024). This uncertainty might also apply to regional developments in green technologies. The complex relationship between the various tactics used by regional MNEs (De Marchi *et al*., 2020) and the unique regulatory framework and green skills of the locations (Montresor & Quatraro, 2020) makes it difficult to draw firm conclusions about how inward FDIs will impact regions' capacity for expertise in environmental technologies by either increasing or decreasing their green knowledge base.

Focusing on what recent literature refers to as "GFDIs," taking into account the long-term effects of the technologies and/or industries associated with FDIs, seems to make the role of FDIs in promoting local EIs less uncertain (Greeninvest, 2017). Compared to non-GFDIs, GFDIs might have a bigger direct influence on the development of environmental technology locally. It may be more successful for MNEs to invest in non-environmental industries or technology to encourage the region to pursue alternative, non-green specializations (Rastogi & Sawhney, 2015). However, if foreign MNEs' subsidiaries consistently exhibit greater innovativeness, even in the environmentally friendly domain (Castellani *et al*., 2022), GFDIs could more significantly boost regional eco-innovativeness. Additionally, GFDIs could indirectly improve regional eco-innovativeness by having a spillover effect on the creativity of local (regional) enterprises, including distributors, customers, and competitors (Crescenzi *et al*., 2015). However, as with the evidence on their overall regional impact—the subject of this paper—the evidence on these possible effects of GFDIs is scant, inconsistent, and fragmented. First of all, as various factors in the home and host countries can affect this relationship, it is unclear how directly FDIs affect domestic green innovation (Noailly & Ryfisch, 2015; Tatoglu *et al*., 2014). Second, a few studies (Cainelli *et al*., 2012; Dechezleprêtre & Glachant, 2014) have suggested that innovative activities by foreign companies in green fields may indirectly boost the sustainability of domestic companies. However, this also depends on particular situations (Rezza, 2013; Singhania & Saini, 2021), raising questions about the research findings.

The importance of consistency in expertise patterns with the understanding profile of regions has been extensively emphasized in the literature on regional technical specialization and diversification. Prior research indicates that new environmental technologies are developed in a place-dependent manner, similar to other technologies, using expanding methods from prior technologies, which are more hazardous and less expensive than other processes (Santoalha & Boschma, 2019; Montresor & Quatraro, 2019). In conclusion, the cognitive proximity or relatedness of a regional ecologically friendly technology to existing technologies in the local knowledge base promotes its regional specialization. Several studies in this field of literature have discovered variables that might either strengthen or weaken the influence of relatedness on patterns of sustainable specialization. These variables include local Key Enabling Technologies (Montresor & Quatraro, 2019) and attitudes toward ecological policy (Boschma & Santhola, 2019). Investigating whether GFDIs may be counted among these criteria is an important matter. GFDIs contribute external knowledge and capabilities to the host region, especially in the green sector, which lessens the dependence of green technology development on a specific location (Elekes *et al.*, 2019). GFDIs may enable greater exploration and cognitive freedom by introducing such knowledge assets into the host areas (Zhu *et al.*, 2017). As a result, they could help areas reallocate their current capacities to achieve green specialization, allowing them to focus on environmentally friendly technologies that are less associated with their previous competencies. Conversely, the technological aspect of inbound GFDI may coincide with the current area knowledge base and strengthen previous specialization patterns.

The literature has indicated the nexus between GFDI and EI. Erdoğan *et al.* (2021) highlight the role of GFDI and EI in pursuing the goal of environmental sustainability by increasing the pressure on the environment. Hence, we believe that the focus of authorities should be paid to the GFDI to reduce environmental degradation by promoting EI adoption. The literature has kept silent on the link between GFDI and EI, or more specifically, the path toward sustainable development. Therefore, this paper will fill this gap by providing a theoretical and empirical discussion on this nexus.

3. Methodology

A model used to examine the relationship between GFDI and EI in this paper is described as follows:

$$EI_{it} = \beta_0 + \beta_1 GFDI_{i,t} + \beta_2 INC_{i,t} + \beta_3 EG_{i,t} + \beta_4 TS_{i,t} + \beta_5 FDI_{i,t} + \beta_6 IND_{i,t} + \beta_7 CAP_{i,t} + \beta_8 GE_{i,t} + \beta_9 EPI_{i,t} + \beta_9 NR_{i,t} + \varepsilon_{ijt}, \quad (1)$$

where t and i stand for year t and country i, respectively.

3.1. Environmental innovation (EI)

Table 1
Description of variables

Variable	Definition	Measure	Source	Obs	Mean	SD	Min	Max
EI_Index	Environmental innovation index	The composited index	OECD.Stat					
EI_Input	Environmental innovation inputs	The percentage of enterprises implementing environmental innovation investment (% of surveyed firms)	OECD.Stat	150	113.31	38.32	46.45	181.55
EI_GovEn	Government environmental	Government's environmental and energy R&D appropriations and outlays (% of GDP)	OECD.Stat	150	101.16	37.00	33.00	211.00
EI_RD	Investments in R&D personnel and researchers	Total R&D personnel and researchers (% of total employment)	OECD.Stat	150	80.18	38.10	6.76	154.33
EI_GreenInv	Environmental early-stage investments	Total value of green early-stage investments (USD/capita)	OECD.Stat	150	132.69	51.23	25.00	226.00
EI_Out	Environmental innovation outputs	Total investments (financial and human resources) aiming to trigger environmental innovation activities	OECD.Stat	150	123.18	118.08	0.00	422.00
EI_Pat	Environmental innovation-related patents	Environmental innovation-related patents (per min population)	OECD.Stat	150	118.46	64.66	0.00	290.00
EI_Ene	Energy productivity	Government's environmental and energy R&D appropriations and outlays (% of GDP)	OECD.Stat	150	92.61	50.93	0.00	274.00
EI_Ghg	GHG emission intensity	Total value of green early-stage investments (USD/capita)	OECD.Stat	150	101.69	54.94	4.00	217.20
GFDI	The inflow of GFDI	A log of total GFDI inflow value per capita	International Trade Center	150	119.46	71.35	0.00	405.00
INC	Real output growth	The real GDP per capita (constant 2010 US dollars).	WDI	150	1.55	3.17	-11.33	8.43
TS	Trade share	The proportion of GDP.	WDI	150	124.47	70.71	54.87	388.12
FDI	Net inflow of foreign direct investment	The proportion of GDP.	WDI	150	0.27	0.80	-3.19	4.16
CAP	Gross capital formation	(Gross capital formation, total)/population	WDI	150	21.60	4.00	11.89	31.33
IND	Industrialization level	The value added to GDP.	WDI	150	0.23	0.05	0.10	0.34
GE	The level of government effectiveness	The government effectiveness index	WBGI	150	1.23	0.55	0.16	2.21

Table 2
Correlation coefficients

	EI_Index	EI_Input	EI_GovEn	EI_RD	EI_GreenInv	EI_Out	EI_Pat	EI_Ene	EI_Ghg	GFDI	INC	TS	FDI	CAP	IND	GE
EI_Index	1															
EI_Input	0.749***	1														
EI_GovEn	0.360***	0.804***	1													
EI_RD	0.839***	0.785***	0.315***	1												
EI_GreenInv	0.681***	0.607***	0.277***	0.646***	1											
EI_Out	0.821***	0.614***	0.362***	0.694***	0.538***	1										
EI_Pat	0.726***	0.723***	0.438***	0.673***	0.627***	0.710***	1									
EI_Ene	0.530***	0.414***	0.0525	0.626***	0.607***	0.416***	0.487***	1								
EI_Ghg	0.468***	0.265**	-0.0638	0.386***	0.289***	0.303***	0.421***	0.504***	1							
GFDI	-0.249**	-0.290***	-0.251**	-0.263**	-0.154	-0.221**	-0.201*	-0.208*	0.0970	1						
INC	-0.00175	-0.0478	-0.0242	-0.0802	0.0450	-0.0343	-0.132	-0.133	-0.0435	0.155	1					
TS	0.228**	-0.0838	-0.373***	0.186*	0.238**	0.0837	-0.0599	0.113	0.183*	0.257**	0.203*	1				
FDI	-0.0172	0.0229	0.0365	-0.00834	0.0312	0.00963	0.152	0.120	0.0384	0.0106	-0.0155	-0.0201	1			
CAP	0.216**	0.0629	0.113	-0.0992	-0.0586	0.163*	0.0856	-0.341***	0.0228	0.300***	0.282***	0.0421	-0.0523	1		
IND	-0.296***	-0.0931	0.219**	-0.430***	-0.457***	-0.213**	-0.103	-0.552***	-0.291***	0.0793	0.129	-0.338***	-0.0174	0.453***	1	
GE	0.860***	0.673***	0.324***	0.707***	0.623***	0.719***	0.780***	0.414***	0.316***	-0.228**	0.0320	0.220**	0.148	0.276***	-0.160	1

*, **, *** are significant levels at 10%, 5%, and 1%, respectively.

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)
EI_Index	7.712***	4.135	DEI_Index	-2.524***
EI_Input	4.561***	-0.453	DEI_Input	-4.251***
EI_GovEn	0.56	5.055	DEI_GovEn	-4.224***
EI_RD	19.481***	-0.376	DEI_RD	-5.212***
EI_GreenInv	0.184	-0.068	DEI_GreenInv	-5.050***
EI_Out	8.126***	0.871	DEI_Out	-3.483***
EI_Pat	2.261**	-1.694**	DEI_Pat	-5.360***
EI_Ene	0.454	9.812	DEI_Ene	-2.015**
EI_Ghg	37.513***	-0.387	DEI_Ghg	-4.252***
GFDI	3.372***	-0.237	DGL	-5.722***
INC	157.30***	4.00	DINC	-19.84***
TS	47.17***	-6.73***	DTS	-22.25***
FDI	23.55***	-11.97***	DFDI	-31.15***
IND	46.50***	-5.32***	DIND	-20.43***
GE	1.44	-7.91***	DGE	-18.93***

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

Al-Ajlani *et al.* (2021) evaluate the effectiveness of EI in European nations using three distinct metrics: 1) government environmental EI (EI_GovEn), which represents the percentage of GDP allotted to the government's environmental and energy research and development projects; 2) enterprises with EI (EI_Input), which is the percentage of surveyed firms

Table 4
Cointegration test

Model: f(GFDI and environmental innovation*)	Kao test	Pedroni test
GFDI		
EI_ENTER	-3.69***	4.41**
EI_ACT	2.78***	4.83***
EI_ISO	1.55*	3.15***
EI_PATENT	2.11**	5.17***

implementing EI investment; and 3) the number of EI-related patents (EI_Pat), which represents the number of patents related to EI (per million people). We analyze the effects of the following to shed light on this relationship: energy productivity (EI_Ene), which is the percentage of GDP that the government appropriates and spends on environmental and energy R&D; greenhouse gas (GHG) emission intensity (EI_Ghg), which is calculated as the total value of green early-stage investments* (USD/capita); total investments made in R&D staff and researchers (EI_RD), which is calculated as a percentage of total employment; and the total value of green early-stage investments per capita (EI_GreenInv), which is the total investments made in human and financial resources to initiate environmental innovation activities (EI_Out). These figures come from the OECD statistics covering the years 2012–2021 (OECD Statistics).

3.2. *Key explanatory variable: GFDI (GFDI)*

In the absence of comprehensive FDI data, the ISIC classification's definition of FDI in Energy, Gas, and Water (EGW) offers an insufficient and exceedingly rough estimate for Part 1 of the definition of GFDI. Water management, which is by far the most significant environmental service, and electricity are included in this category. It is unclear whether this estimate overestimates or underestimates the first aspect of GFDI because it also includes traditional sources of energy (such as fossil fuels, nuclear energy, and coal) and leaves out waste treatment, other environmental non-infrastructure services, and the production of environmental products. In this particular context, Part 1 of the GFDI definition can be understood as having an order of magnitude provided by EGW rather than as an exact estimate. The following industries have the potential for GFDI: manufacturing, mining, transportation, forestry, agriculture, and EGW. The International Trade Center provided the information for these variables between 2012 and 2021.

3.3. *Control variables:*

Empirical data from study designs should guide the selection of explanatory variables. We used GDP per capita (INC) by Ha (2022b, 2022a, 2023), Thanh *et al.* (2022), and Thanh *et al.* (2022, 2023), and GDP per person (in constant US dollars, 2010). The included explanatory variables that offer explanations for changes in EI performance are the gross capital formation per capita (CAP), trade share (TS), and economic growth (EG). In our theoretical model, we have incorporated the percentage of net FDIs, following the lead of Bhattacharya and Dash (2020), Bu *et al.* (2019), and Shahbaz *et al.* (2018). Akkermans *et al.* (2023), Martín-Ortega *et al.* (2024), and Yassine *et al.* (2024) provide a measure of industrialization (IND) based on the percentage of GDP that is added to the industrial value. To evaluate the impact of political factors, we also consider the government effectiveness (GE) index, proposed by Lee & Min (2015) and Thanh *et al.* (2023). In 2019, Le and Nguyen investigated the effects of natural rents (NR), which are also considered in this study. Akkermans *et al.* (2023), Ioanna *et al.* (2022), and Tsepi *et al.* (2024) have led to the addition of an environmental performance (EPI). World Development Indicators (WDIs) are the source of the EG, INC, TS, FDI, IND, CAP, and NR indicators.

Table 1 gives a statistical description along with the details of each variable. The cleaned data included 15 EU countries in the final sample and covered the years 2012 to 2021. A positive correlation appears to exist between EI and GFDI, as shown in Table 2.

According to Pesaran (2021), the next step in verifying the data would be to look at dependence cross-sectionally. To evaluate the stationarity of data with CD, several tests have been developed, including those by Levin–Lin–Chu (Levin *et al.*, 2002) and Im–Pesaran–Shin (Im *et al.*, 2003). Table 3 presents the findings. Panel-corrected standard error modelling was used to investigate the relationship between GFDI and EI (PCSE). Traditional methods, such as fixed-effect or random-effect models, are inappropriate for the dynamic panel with CD, where the time is short (T = 10), and the number of entities is small (N = 15), as Pesaran (2021) argues. The outcomes of these methods will be skewed (Balsalobre-Lorente *et al.*, 2022; Nguyen & Su, 2021b). To ensure that the highly balanced data support the tests and applied methods, we used the empirical procedure to eliminate gaps, missing observations, and outliers from the data. The research of Ha (2023), Nguyen and Su (2021), Thanh *et al.* (2022), and Thanh *et al.* (2022) serves as the foundation for our empirical approach. We have carried out empirical calculations. All of the explanatory variables are one period behind because of either a deficiency of data or the mutually reinforcing nature of GFDI and EI. As in Gala *et al.* (2018) and Sweet and Maggio (2015), equation (1) was regressed using a FGLS model for comparative analysis. The FGLS model will help us resolve the heterogeneity issue.

This article examines the differences between the short- and long-term effects of GFDI on EI. Pesaran and Smith (1995) developed a technique for using ARDLs to solve this problem. Using endogeneity and causal relationships between variables, Pesaran and Shin (1998) estimated the fixed effects in EU member states. In order to ascertain whether the two variables put forth by Kao (1999), Pedroni (2004), and Westerlund (2005) are cointegrated, we ran the Kao cointegration test and the Pedroni test. The results show that GFDI and EI cointegrate over the long run, as shown in Table 4.

4. Results and discussions

4.1. Baseline results

Table 5 illustrates the linear relationship between GFDI and EI based on PCSE and FGLS estimates. The nine variables in

* It is the value of early-stage investments in cleantech industries.

Table 5
Impacts of GFDI on environmental innovation implementation
Panel A: PCSE estimates

VARIABLES	(1) EI_Index	(2) EI_Input	(3) EI_GovEn	(4) EI_RD	(5) EI_GreenInv	(6) EI_Out	(7) EI_Pat	(8) EI_Ene	(9) EI_Ghg
L.GFDI	1.88**	-1.45	-1.59	-3.27	1.88	-0.71	6.03***	3.28***	25.10***
	(0.248)	(3.005)	(4.435)	(2.158)	(4.326)	(1.777)	(1.037)	(0.232)	(2.315)
L.INC	-2.14***	-2.69	-0.68	-6.43***	13.30***	-0.63	-0.76	-4.34**	-7.38**
	(0.695)	(1.745)	(2.294)	(2.006)	(3.742)	(1.952)	(1.460)	(1.918)	(3.285)
L.TS	0.03*	-0.10***	-0.21***	0.01	-0.20	-0.12***	-0.20***	-0.09***	-0.02
	(0.014)	(0.020)	(0.025)	(0.033)	(0.123)	(0.031)	(0.029)	(0.032)	(0.047)
L.FDI	-7.58	-3.92	-1.78	-7.46*	-11.44	-7.43	0.06	-0.31	-1.53
	(4.619)	(3.726)	(4.406)	(3.811)	(13.493)	(6.445)	(3.520)	(3.960)	(3.917)
L.IND	-84.26***	11.40	108.23***	-231.94***	-971.78***	-259.58***	-68.20**	-479.54***	-251.94***
	(17.453)	(25.052)	(33.470)	(34.207)	(139.335)	(34.813)	(29.179)	(36.826)	(56.593)
L.GE	61.01***	47.36***	29.08***	63.41***	119.73***	95.32***	77.18***	36.59***	42.92***
	(2.409)	(4.393)	(5.065)	(4.198)	(11.520)	(3.803)	(2.119)	(2.199)	(3.131)
Observations	135	135	135	135	135	135	135	135	135
Number of economies	15	15	15	15	15	15	15	15	15

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

Panel B: FGLS estimates

VARIABLES	(1) EI_Index	(2) EI_Input	(3) EI_GovEn	(4) EI_RD	(5) EI_GreenInv	(6) EI_Out	(7) EI_Pat	(8) EI_Ene	(9) EI_Ghg
L. GFDI	1.88**	-1.45	-1.59	-3.27	1.88	-0.71	6.03***	3.28***	25.10***
	(0.253)	(3.296)	(4.308)	(4.011)	(10.736)	(4.109)	(0.092)	(0.554)	(1.136)
L.INC	-2.14**	-2.69**	-0.68	-6.43***	13.30***	-0.63	-0.76	-4.34*	-7.38**
	(0.919)	(1.345)	(1.758)	(1.637)	(4.381)	(1.677)	(1.262)	(2.267)	(3.310)
L.TS	0.03	-0.10***	-0.21***	0.01	-0.20*	-0.12***	-0.20***	-0.09	-0.02
	(0.025)	(0.036)	(0.047)	(0.044)	(0.118)	(0.045)	(0.034)	(0.061)	(0.089)
L.FDI	-7.58***	-3.92	-1.78	-7.46**	-11.44	-7.43**	0.06	-0.31	-1.53
	(1.733)	(2.535)	(3.313)	(3.085)	(8.256)	(3.160)	(2.378)	(4.271)	(6.233)
L.IND	-84.26***	11.40	108.23*	-231.94***	-971.78***	-259.58***	-68.20*	-479.54***	-251.94**
	(29.425)	(43.048)	(56.267)	(52.387)	(140.212)	(53.672)	(40.388)	(72.542)	(105.932)
L.GE	61.01***	47.36***	29.08***	63.41***	119.73***	95.32***	77.18***	36.59***	42.92***
	(2.734)	(3.999)	(5.228)	(4.867)	(13.027)	(4.986)	(3.752)	(6.740)	(9.858)
Observations	135	135	135	135	135	135	135	135	135
Number of economies	15	15	15	15	15	15	15	15	15

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

Table 5 measure environmental innovation: Environmental innovation index (EI_Index); Environmental innovation inputs (EI_Input); Government environmental (EI_GovEn); Investments in R&D personnel and researchers (EI_RD); Environmental early-stage investments (EI_GreenInv); Environmental innovation outputs (EI_Out); Environmental innovation-related patents (EI_Pat); Energy productivity (EI_Ene); and GHG emission intensity (EI_Ghg). It is clear that there is some similarity between the estimated coefficients in the two FGLS and PCSE estimates. In the literature, most of the relevant studies provided empirical evidence to support the favourable impacts of conventional FDI on green innovation adoption (Abdelzaher and Newberry, 2016; Albornoz *et al.*, 2016; Ascani & Iammarino, 2018; Boschma *et al.*, 2017; Brohi &

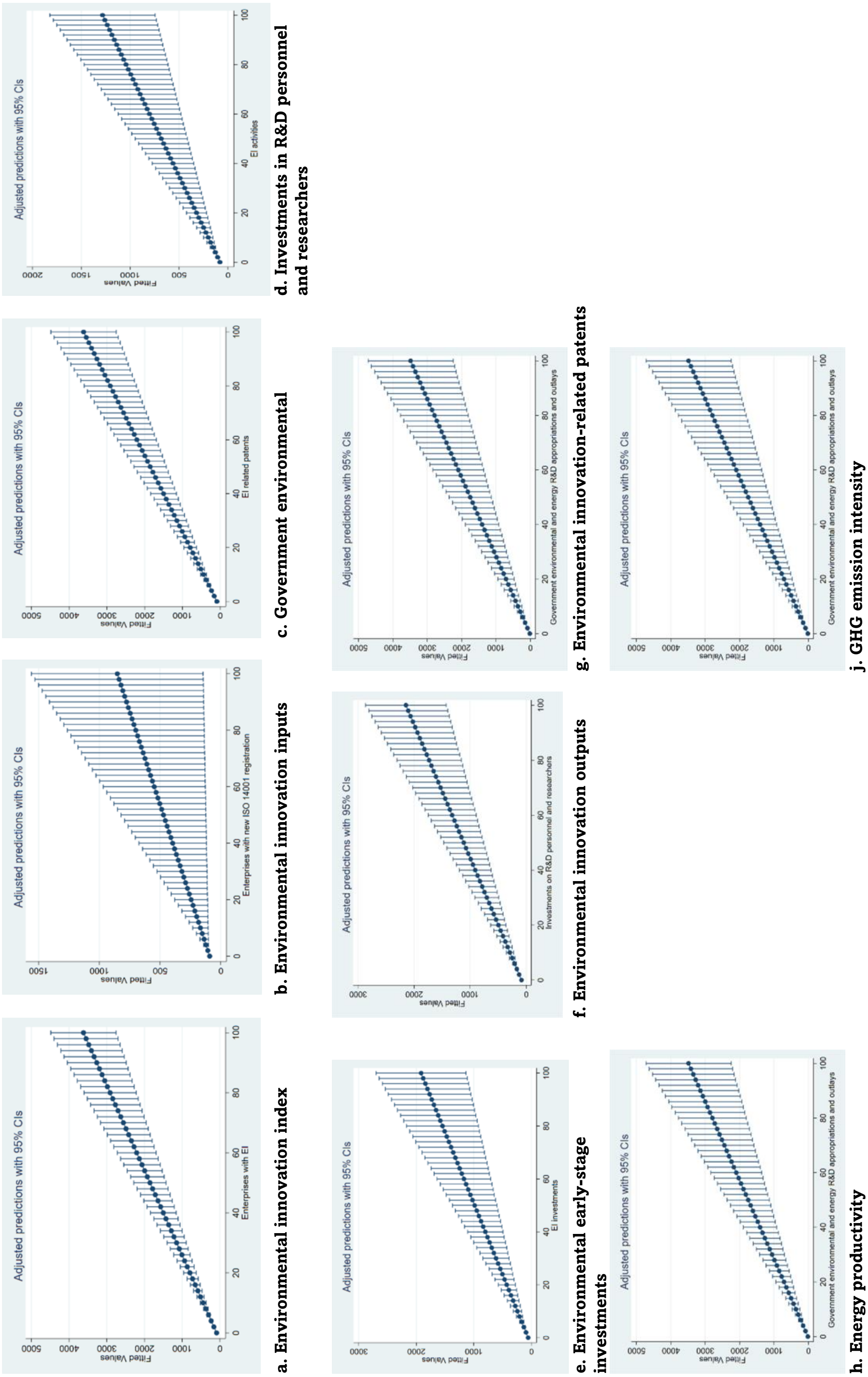

Fig 1. Predictive margin: GFDI and environmental innovation

Suzuki, 2023; Chen *et al*., 2023; Geels *et al*., 2017; Shao *et al*., 2023; She & Mabrouk, 2023; Song & Han, 2022). Our article advanced these works by linking GFDI and EI adoption. Our results are in line with the only other study that has been done on this relationship, that by Castellani *et al*. (2022). This paper uses a combination of international business studies and (eco-)innovation geography to examine how GFDIs affect regional specialization in environmental technologies. Their results indicate that FDIs have a positive impact on a region's specialization in green technologies. This means that when FDIs take place in sectors of the economy where environmental patents account for a sizable share of all inventive activity, the impact becomes statistically significant (green-tech FDIs).

To provide a comprehensive analysis, the four environmental innovation implementation indicators—EI_Index, EI_Pat, EI_Ene, and EI_Ghg— are utilized. The findings demonstrate a strong positive correlation with GFDI, which has a statistical significance level of 5%. One significant finding is that, with a coefficient of 25.10, the greatest impact is on EI_Ghg, suggesting that GFDI has the greatest influence on GHG emission intensity. These results suggest that altering the increasing GFDI would lead to the greatest rise in the intensity of GHG emissions as well as an increase in the EI index, patents connected to EI, and energy productivity. The results of our estimation point to a distinct mechanism by which GFDI influences the adoption of EIs. Figure 1 is a graph that visualizes the relationship between GFDI and EI.

Examining the control variables, GE has a positive level of influence, with all indicators being statistically significant at 1%. EI_GreenInv has the highest coefficient of all the GE coefficients, 119.73. At the 5% significance level, PCSE estimates show that real output growth (INC) negatively affects EI_Index, EI_RD, EI_Ene, and EI_Ghg. Furthermore, it correlates negatively with EI_Input in FGLS estimates. Specifically, INC (coefficient of 13.30) significantly and positively affects EI_GreenInv. This suggests that when real output rises, environmental early-stage investments will rise along with it, but at the same time, investments in R&D workers and researchers, energy productivity, greenhouse gas emission intensity, and the EI index will decrease. Trade share (TS) has an inconsistent correlation with EI. It only positively affects EI_Index, and has a negative correlation with EI_Input, EI_GovEn, EI_GreenInv, EI_Out, EI_Pat and EI_Ene. Moving on to FDI, it only has a negative correlation with three of the nine aspects of environmental innovation implementation: EI_Index, EI_RD, and EI_Out in estimation FGLS. For the industrialization level (IND), these variables have statistical significance. With the exception of EI_GovEn, which is positive, and EI_Input, which is not statistically significant, seven of the nine mechanism indices are negative.

Table 6
Short- and long-term impacts of GFDI

VARIABLES	(1) EI_Index	(3) EI_Input	(5) EI_GovEn	(7) EI_RD	(9) EI_GreenInv	(11) EI_Out	(13) EI_Pat	(15) EI_Ene	(17) EI_Ghg
					Short-run influences				
ec	-0.35***	-0.52***	-0.51***	-0.26***	-0.22***	-0.83***	-0.85***	-0.67***	-0.37***
	(0.049)	(0.079)	(0.118)	(0.087)	(0.062)	(0.057)	(0.034)	(0.091)	(0.110)
D.GFDI	-8.56***	-15.85***	-19.63**	-1.09	51.68**	-18.81***	2.48	-4.43	-3.27
	(3.299)	(4.500)	(8.779)	(6.622)	(21.198)	(5.668)	(5.760)	(6.044)	(12.070)
					Long-run influences				
GFDI	12.30	23.34***	9.73***	0.39	63.98	17.70***	1.71	0.07	17.07***
	(9.187)	(3.202)	(3.381)	(2.814)	(97.749)	(4.584)	(3.204)	(0.667)	(5.049)
Observations	135	135	135	135	135	135	135	135	135

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

4.2. Robustness checks

4.2.1. Short- and long-term impact of GFDI

Table 6 looks at how GFDI affects EI in the short and long term. At the 1% significance level, the results show that GFDI has a statistically significant and positive impact over the long run on four environmental innovation aspects: EI_Input, EI_GovEn, EI_Out, and EI_Ghg. In particular, GFDI has the strongest influence on EI_Input, with an estimated coefficient of 23.34. This implies that, in the long run, promoting GFDI will improve several aspects of EI implementation, such as EI inputs and EI outputs. In the short term, however, there are erratic correlations between GFDI and the nine dimensions of EI. To be more precise, at the 5% significance level, GFDI only significantly positively affects EI_GreenInv while negatively affecting EI_Index, EI_Input, EI_GovEn, and EI_Out. This implies that while successfully luring in GFDI will support environmental investment activities in their early stages, and it will negatively affect other aspects of EI, including the government environment, EI inputs, and the EI index.

Furthermore, in each of the nine models, the coefficient EC_term, which varies from -0.85 to -0.22, is statistically significant and negative. This finding shows that about 22%–85% of the disequilibrium caused by shocks in the previous period will return to equilibrium in the long term.

Table 7
Moderating effects of institutional quality
Panel A: Environmental Innovation Index

VARIABLES	(1) VA	(2) PV	(3) GE	(4) RQ	(5) RL	(6) CC
GFDI	-1.39*	1.90***	-0.48***	-0.75***	0.40***	0.09
	(0.757)	(0.485)	(0.111)	(0.242)	(0.097)	(0.077)
IQ	153.89**	445.05***	14.58	-115.85**	219.57***	74.89***
	(4.602)	(3.685)	(16.858)	(7.652)	(7.445)	(8.462)
GFDI *IQ	**1.26***	**2.84**	**0.36*****	**0.80*****	**0.78**	**0.53*****
	(0.759)	(0.644)	(0.116)	(0.298)	(1.112)	(0.121)
INC	0.32***	0.94***	0.40**	0.81***	-0.03	0.79***
	(0.109)	(0.152)	(0.162)	(0.132)	(0.120)	(0.124)
TS	-27.93***	-23.77***	-30.46***	-22.88***	-30.31***	-31.03***
	(2.475)	(2.584)	(2.927)	(2.964)	(2.825)	(4.340)
FDI	-8.61**	-2.65**	-9.92**	-1.04**	-8.88***	-3.89**
	(1.447)	(0.494)	(1.388)	(1.459)	(1.831)	(1.468)
IND	-24.03***	-25.98***	-37.98***	-37.78***	-43.87***	-39.89***
	(5.172)	(6.570)	(60.697)	(7.405)	(6.271)	(7.819)
Observations	135	135	135	135	135	135
Number of nations	15	15	15	15	15	15

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

Panel B: Environmental Innovation inputs

VARIABLES	(1) VA	(2) PV	(3) GE	(4) RQ	(5) RL	(6) CC
GFDI	0.84**	4.39***	-1.28***	-0.61*	-0.64***	-0.23***
	(0.402)	(0.565)	(0.095)	(0.363)	(0.079)	(0.082)
IQ	263.42***	728.63***	-95.33***	-194.63**	76.90***	80.88***
	(63.169)	(99.386)	(13.425)	(78.691)	(17.702)	(27.859)
GFDI *IQ	**-0.78**	**-2.81**	**1.80*****	**1.05****	**1.03*****	**0.50*****
	(0.435)	(1.758)	(0.125)	(0.473)	(0.125)	(0.141)
INC	0.72***	1.37***	0.16	1.12***	-0.36*	0.30***
	(0.119)	(0.136)	(0.112)	(0.146)	(0.194)	(0.102)
TS	-22.48***	-19.11***	-24.12***	-16.13***	-17.83***	-26.94***
	(2.333)	(2.506)	(2.005)	(2.821)	(2.746)	(3.341)
FDI	-5.62	-3.74	-5.34	-4.73	-12.09	-11.57
	(8.450)	(7.734)	(10.326)	(10.471)	(11.410)	(10.088)
IND	-13.39	-91.01**	-17.81	-55.11	-13.45	-29.63***
	(35.339)	(4.998)	(33.396)	(41.504)	(48.721)	(8.302)
Observations	135	135	135	135	135	135
Number of nations	15	15	15	15	15	15

Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1
Note: We employed a PCSE model to obtain the results in these tables. *, **, and *** represent a 1%, 5% and 10% significance level, respectively.

Table 7 (cont'd)
Panel C: Government Environmental

VARIABLES	(1) VA	(2) PV	(3) GE	(4) RQ	(5) RL	(6) CC
GFDI	-1.06**	0.14	-0.22**	-0.51**	0.01	0.20***
	(0.447)	(0.230)	(0.094)	(0.250)	(0.091)	(0.060)
IQ	-63.81	23.71	-11.71	-87.28**	108.48***	76.65***
	(53.177)	(39.192)	(10.856)	(13.847)	(12.776)	(19.323)
GFDI *IQ	**1.25*** **	**-0.03**	**0.42*** **	**0.88*** **	**0.14**	**-0.22**
	(0.480)	(0.308)	(0.114)	(0.330)	(0.120)	(0.117)
INC	0.13	0.27***	0.02	0.15*	-0.54***	0.08
	(0.081)	(0.080)	(0.062)	(0.088)	(0.126)	(0.069)
TS	-18.73***	-18.42***	-20.73***	-15.03***	-19.12***	-24.02***
	(2.201)	(2.357)	(2.170)	(1.927)	(1.968)	(3.207)
FDI	-9.71	-8.51	-11.30	-11.23	-12.10*	-8.78
	(6.889)	(6.890)	(7.137)	(8.249)	(7.121)	(6.849)
IND	-18.24***	-17.57***	-19.80***	-17.17***	-20.74***	-23.54***
	(3.999)	(4.431)	(3.900)	(4.729)	(3.612)	(1.427)
Observations	135	135	135	135	135	135
Number of nations	15	15	15	15	15	15

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Note: We employed a PCSE model to obtain the results in these tables. *, **, and *** represent a 1%, 5% and 10% significance level, respectively

4.2.2. Moderating effects of institutional quality

We contend that because of the existing information asymmetries, the relationship between GFDI and EI adoption may be negatively moderated by weak and insufficient institutional systems. Government effectiveness (GE), regulatory quality (RQ), rule of law (RL), political stability and absence of violence or terrorism (PV), voice and accountability (VA), and GFDI are among the variables that we include in the interactions in order to conduct this analysis. These variables have been meticulously selected based on the International Country Risk Guide. The six indices are individually examined within the three dimensions of EI , serving both as independent variables (InstQ) and interaction variables when combined with GFDI. The findings, as illustrated in Table 7, outline the estimates.

As reported in Panel A, the impact of GFDI on EI_index is not uniform across models. To be more precise, GFDI has a significantly negative impact on the models that include both VA and RQ as indicators of institutional quality, but at the 1% significance level, PV and RL exhibit a significant positive relationship. Regarding the size of EI_index, the variable lQ, except RQ, recorded a negative effect. This suggests that while institutional quality indicators may help to promote EI, they may also work to mitigate the negative environmental effects of GFDI. Additionally, we discovered that a shift in PV caused the largest decrease in VA but the most dramatic increase in the impact of GFDI on EI. Notably, the interaction effect created by the combination of lQ and GFDI has a beneficial impact on EI's efficacy, of which the most significant is the interaction between GFDI and policy mechanisms such as VA, GE, RQ, and CC.

Panel B illustrates how institutional quality indicators like VA and PV, which have positive and statistically significant GFDI coefficients, enhance the effect of GFDI on EI_input with regard to environmental innovation inputs. In contrast, GFDI's effects on EI_input are greatly mitigated by CC, RQ, GE, and RL. Notably, the performance of EI, including CC, RQ, GE, and RL, is significantly improved by the interaction effect produced by the combination of policy institutions with GFDI.

We then look at how institutional quality affects how GFDI and environmental government policies interact. We examine how institutional quality affects the relationship between GFDI and environmental policy. The results displayed in Panel C demonstrate that VA, GE, and RQ have a negative impact on the effects of GFDI on the government environment; however, only CC is statistically significant. This suggests that as CC develops, GFDI will influence EI much more.

Our findings collectively demonstrate that institutional quality moderates the beneficial effects of GFDI on environmentally innovative activities. The arguments made in the literature (Ioanna *et al.*, 2022; Kyriakopoulos *et al.*, 2023; Progiou *et al.*, 2023; Sebos *et al.*, 2016) are in line with our findings. Furthermore, Jianguo *et al.* (2022) and Hunjra *et al.* (2020) demonstrate the moderating effects of institutional quality on the relationship between financial development and environmental quality, while Chen *et al.* (2023) offer empirical evidence of the moderating roles of institutional quality in attracting FDI inflows by encouraging EIs. According to Oyefabi *et al.* (2021), provinces and nations with well-developed institutions experience greater effects of FDI on EG. According to Wang *et al.* (2022) and Yang *et al.* (2020), in order to employ FDI more effectively, each area needs to have a strong institutional framework. Our results add to the body of literature by showing that the relationship between GFDI and ecologically innovative activities depends critically on institutional quality conditioning factors.

5. Conclusions

The relationship between GFDI and EI is thoroughly examined in this article. This article examines how GFDI influences the economy's adoption of environmentally friendly innovations via many different metrics related to EI. The effectiveness of environmental improvements in 15 nations across Europe is evaluated using nine different metrics: environmental innovation index (EI_Index), environmental innovation inputs (EI_Input), government environmental (EI_GovEn), investments in R&D personnel and researchers (EI_RD), environmental early-stage investments (EI_GreenInv), environmental innovation outputs (EI_Out), environmental innovation-related patents (EI_Pat), energy productivity (EI_Ene), and GHG emission intensity (EI_Ghg).

The implications of GFDI for how EIs are implemented are highlighted by our estimation results, and they are expected to be noticeable in the near and long term. One notable indicator of the improvement seen in 15 European countries between 2012 and 2021 is the effect of GFDI on the EI index, which in turn drives environmental activities and patents related to EI, energy productivity, and GHG emission intensity. Moreover, it highlights the significance of the quality of the institutional system in augmenting the favorable impacts of GFDI on how EI is implemented. The results indicate that when political stability shifts and there is less violence or terrorism, the impact of GFDI on EI will increase the most (PV). Simultaneously, the institutional framework and GFDI attraction policies encourage EI initiatives.

An extended understanding of the GFDI–EI nexus is gained through the development of a theoretical framework. As a key component of encouraging EI adoption, GFDI inflows play a significant role. We hope to offer a thorough explanation of the relationship between GFDI and EI, along with theoretical justification and empirical backing. Earlier researchers have used basic versions of emotional intelligence (EI), focusing on certain facets of the economy and society while ignoring others. Through the identification of institutional quality conditioning impacts on GFDI and environmental innovation, this article contributes to the literature on GFDI–EI links.

This study has significant policy implications for those in charge of encouraging Eis in the European region and then adapting the insightful lessons to other developing countries. There will be obstacles to the shift to a green economy, particularly in the form of global investment attraction. Particularly in creative endeavors, the transition to an environmentally friendly economy must happen fairly, openly, and transparently to minimize the potential risks. Additionally, the governments and authorities of the EU ought to support and encourage their ability to profit from the use of EI. Out of all the tactics and tools at a country's disposal to help it accomplish this goal, we suggest making increasing GFDI a first priority. Notably, the empirical findings of this paper highlight the significance of an institution's quality in enhancing the effects of GFDI on putting innovations into practice, particularly in the context of how environmental issues are addressed in connection with infrastructure development. Enhancing the available knowledge is essential for assisting a developing nation in making the shift to a more environmentally conscious world.

It is important to take into account two limitations when interpreting our study's findings. First, there is the limitation arising from our use of historical data that was exclusive to the EU. Changes in GFDI may be required in emerging nations where environmental damage has occurred in order to address environmental concerns through the adoption of green technologies. Regretfully, no surveys have been carried out in compliance with stringent requirements to gather data about the use of EI and GFDI in emerging countries. Also, a more thorough explanation of this mechanism could be required. GFDIs may have additional implications for the application of green innovation. A number of elements need to be taken into account, such as the degree of economic development, the complexity of the economy, and the efficacy of governmental programs. Economists and decision-makers may create policies that promote GFDI and improve the adoption of green innovation by looking at these channels. To gather more data about GFDI and EI in emerging countries and to investigate the role of GFDI benefits in this area, a thorough analysis of the data sources could be required.

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Consent for publication: Not applicable

Compliance with Ethical Standards:

- Disclosure of potential conflicts of interest
- Research involving Human Participants and/or Animals
- Informed permission

Data availability statement: Due to privacy and ethical constraints, data is only available upon request.

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