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What is Green FDI? And how does it matter?

ABSTRACT

Green Foreign Direct Investment (GFDI) is often characterized as foreign investment aimed at promoting positive environmental outcomes. However, current literature lacks conceptual clarity and theoretical precision, with definitions varying significantly across studies and empirical applications. This paper critically deconstructs existing interpretations of GFDI, highlighting inconsistencies and gaps in scope, measurement, and conceptualization. It proposes a more theoretically grounded definition of GFDI, emphasizing two fundamental dimensions: Green & FDI. Green Dimension: refers to investments that contribute to environmentally sustainable outcomes, which includes two main dimensions: 1) Green Industries and Services: Investments in sectors such as renewable energy, pollution control, and environmental services, and 2) Environmental Processes: Investments in cleaner production techniques, energy efficiency, and green technology adoption. FDI Dimension: This represents the mode of foreign investment, distinguishing between 1) Greenfield Investments and 2) M&A. The paper also introduces a multi-level framework identifying key moderators influencing the outcomes of GFDI at the country, industry, and firm levels. By challenging reductionist views and emphasizing contextual complexity, this framework offers a more comprehensive understanding of GFDI's potential impact and limitations.

Keywords:

Green foreign direct investment; Moderating effect; Environmental outcomes

1 INTRODUCTION

Environmental problems such as greenhouse gas emissions, water pollution, destroyed biodiversity, and reduced land resources available for cultivation are visible results of economic development (Bai et al., 2020). To maintain the stable operation of the economy while assuming corporate responsibility for environmental issues, managers try to seek measures to mitigate pollution or improve the environment from a technical perspective so that low-carbon technologies become more attractive to be used to mitigate climate change (Rempel and Gupta, 2021). Enterprises accelerate green transformation and accelerate the transfer of green technology. Using renewable energy technology to reduce energy consumption is in line with the governance framework of the United Nations Framework Convention on Climate Change (UNFCCC) (UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT, 2023).

A lack of knowledge and technology is often cited as a key obstacle to achieving the green energy transition. Green foreign direct investment (GFDI) can serve as an effective way to promote the international dissemination of low-carbon technology and knowledge, helping to overcome the lack of knowledge and technology, and it will be more effective when the technology has more tactical knowledge (Amendolagine et al., 2023). However, no matter which way foreign subsidiaries are established by greenfield investment or merger and acquisition (M&A), how much they contribute to green technology and innovation should ultimately be reflected in environmental outcomes to reflect the knowledge-based replacement efficiency. Therefore, according to the background phenomenon, the existing gaps have been found mainly in the three aspects.

Firstly, GFDI is commonly defined as foreign investment activities that aim to reduce environmental pollution (Uche et al., 2023) or are expected to have a positive impact on the environment (Wang et al., 2021a). However, extant research on the relationship between FDI and the environment has yielded controversial results, with two main hypotheses emerging: the pollution halo hypothesis (Yu and Liu, 2024) (suggesting a positive relationship) and the pollution haven hypothesis (Kharb et al., 2024) (suggesting a negative relationship). Despite these differing views, GFDI is still expected to act as a bridge connecting the home and host countries, as well as the parent company and its subsidiary, contributing to sustainable outcomes. However, most GFDI studies explore the impact of green technology transfer on multinational companies themselves, such as the degree of green innovation (Amendolagine, Lema and Rabellotti, 2021; Shi, Zeng, Wu, & Wang, 2023) or explore the influencing factors in the transfer process (Amendolagine et al., 2023). Fewer studies have been conducted on the environmental outcomes after a series of green technology transfers. To fill this gap, we suggest to divide the environmental outcomes into two core dimensions including environmental performance (EP), the negative effects stem from waste production, water discharges and air emissions (Kassinis and Vafeas, 2006; El Ghoul, Guedhami and Kim, 2017) and environmental innovation (EI), "New designs and novel products and processes to reduce or eliminate the use and generation of hazardous substances" are being funded, developed, and put into action (Berrone et al., 2013) following Ellimäki, Aguilera, Hurtado-Torres and Aragón-Correa (2023)'s measurement. Then, the relationship between GFDI and environmental outcomes is further explored.

Secondly, there remains no universally accepted definition of GFDI, whereby the lack of GFDI common representation. For example, some papers divide the direction of GFDI into Inward FDI (Wang et al., 2021b) and Outward FDI (Shi et al., 2023) according to developed

and developing countries. The basis is that developing countries like China, which consume large amounts of energy, need to absorb more advanced green technologies from developed countries to alleviate environmental problems and reduce energy loss (Pan et al., 2020). However, large energy-consuming countries like China and Saudi Arabia may have a more urgent need for green innovation due to obvious and urgent environmental problems that need to be solved, which may push them to become more active in pursuing green innovation and investing in research and development (Zhang and Sun, 2023), thereby it is unreasonable to judge the flow of green technology demand only based on the country's development level. It is precisely because of this confusion about the dimensions of GFDI that it is particularly important to critically integrate the complex GFDI information and propose a commonly recognized definition of GFDI to fill the research gap.

Finally, due to the unclear definition of GFDI, the dimensions and influencing factors of GFDI-related articles are also rather confusing. For example, Patala, Juntunen, Lundan, & Ritvala (2021) explored how energy consumption is prone to causing damage to the environment in the industrial dimension under the pursuit of green technologies R&D of renewable energy. Wang et al. (2021b) mentioned how the MNEs absorb the advanced technology of the home country after inward FDI developing advanced green technologies and transferring them as their intangible assets for green innovation. So, we decide to help identify the key moderators between GFDI and environmental outcomes at multi-level to fill the gap.

Therefore, this paper will address these gaps mainly in two research questions including: *What dimensions and components define GFDI? And what key moderators may impact the environmental outcomes associated with GFDI?*

Within this paper, we mainly use the conceptual framework development to approach a more complete GFDI definition. Table 2 has been made to show the GFDI definition framework clearly. And a figure shows the key moderators through the multi-level framework.

Reflecting on our background phenomenon and the gaps found, this paper mainly aims to make three theoretical contributions. *First*, it develops a refined conceptualization of GFDI construct. Critically engaging with existing definitions, we believe that GFDI is an effective way to transfer green capital investment between parent and subsidiary companies. Green capital can be understood as capital expenditures that carry knowledge and technology that are expected to have a positive impact on the environment. The implementation of GFDI mainly includes two dimensions (green and FDI) and four components (Table 2).

This comprehensive framework integrates both the informational content and the modes of investment, offering a clearer and more operationalizable understanding of GFDI. *Second*, the paper proposes and theorize key factors that can influence the impact of GFDI on environmental outcomes. These systematically divided these factors into three levels: country, industry, and firm. Country-level factors encompass the host country's knowledge base, environmental policies, developmental stage, marketization level, entry mode of GFDI, and multinational strategies. Industry-level factors focus on the dynamics of technology transmission across sectors, including upstream and downstream linkages, competitive pressures, and human resource mobility. Firm-level factors include absorptive capacity, multinational ownership structures, energy consumption and dependency, and R&D intensity. This structured approach highlights both external (country and industry) and internal (firm) factors, emphasizing the complexity of GFDI's environmental impact. *Finally*, by integrating these elements, the paper

presents a cohesive theoretical framework that not only redefines GFDI but also clarifies the mechanisms and conditions under which it can contribute to positive environmental outcomes. This critical synthesis advances the literature by addressing definitional ambiguities and offering a more nuanced understanding of the GFDI-environment relationship.

The paper is structured in three main parts. First, we critically review and integrate the literature on GFDI definitions, classifying them by dimensions and components. Second, we present and discuss a multilevel framework encompassing moderating factors that may influence GFDI. Finally, we explore the potential impacts of GFDI and motivations for MNEs to engage in GFDI, along with the implications of the refined GFDI definition for future research and practice.

2 GFDI DEFINITION DIMENSIONS AND COMPONENTS

2.1 Decoding the GFDI construct

To find a generally accepted definition of GFDI, we selected papers that explicitly mentioned GFDI or had relevant descriptions for further analysis. By collecting GFDI-related papers, we found that most of the definitions used come from some authoritative organizations, including the Organisation for Economic Co-operation and Development (OECD), United Nations Conference on Trade and Development (UNCTAD), fDi Intelligence and Bloomberg New Energy Finance. The above institutions all have their own data collection channels to form their own databases, such as FDI in renewable energy disclosure at different levels, which may be more authoritative. In addition, we also found different definition directions from some quantitative papers based on their measurement methods of GFDI. Finally, we summarized two dimensions and four necessary generally recognized components to constitute GFDI.

Table 1 shows what GFDI-related or GFDI definitions are mentioned in different papers, and the criticism comments on each point will be expanded in the following paragraphs.

Table 1 GFDI Definition				
	Author and Institutions	GFDI Related	Details	Criticism
1	Golub (2011) OCED	GFDI definition	FDI in green industries and services and FDI in environmental processes	The subdivision of the two dimensions (green industries and services, environmental process) is not comprehensive enough
2	UNCTAD (2010)	Low-carbon FDI	Greenfield FDI in renewable energy, recycling activities and low-carbon technology manufacturing	Mainly based on data availability, ignores M&A FDI and other related green aspects rather than low-carbon and recycling
3	fDi Intelligence (2016)	FDI in Renewable Energy	Greenfield FDI in solar, wind, biomass, hydroelectric, geothermal, marine and other renewable power generation	Also mainly focus on the data availability only on renewable energy, ignores M&A FDI
4	Bloomberg New Energy Finance (2017)	Global investment in clean energy, low carbon services and energy smart technologies	Greenfield and M&A activity in renewables (e.g., biofuels, small hydro, wind and solar), clean energy services (e.g., carbon markets), and energy smart technologies (e.g., digital energy, energy efficiency, and energy storage)	Includes two dimensions on traditional FDI, but only based on energy related, ignores other green activities
5	Johnson (2017)	Add supplement of GFDI	Unsustainable forestry activities or logging in primary forests, harmful fishing practices, nuclear energy, and the trade and production of goods prohibited	These can be added to the two dimensions of OCED respectively
6	Amendolagine et al. (2021)	GFDI definition	Outward FDI: establish or acquire subsidiaries related to the production or distribution of green technology, specifically renewable energy technology.	Since the main focus of the study is on green innovation, it is understandable to directly use outward FDI as GFDI and use green technology (mainly green patents) to supplement the green part, but it is not recommended to use it as the definition of GFDI
7	Ashraf and Doytch (2023)	GFDI definition	Outward greenfield FDI flows and cross-border mergers and acquisitions purchases (M&A)	Using greenfield FDI as GFDI is easily to cause misunderstanding

Golub (2011) provides an OECD working paper on defining and measuring green FDI, which divides the green FDI into two dimensions, including FDI in green industries and services and FDI in environmental processes. The first dimension of the GFDI definition of this working paper is the green industries and services, in other words, the Environmental Goods and Services (EGS) sector. The green is divided into three components: Pollution management, including controlling air pollution, managing wastewater, managing solid waste, cleaning and remediation, reduction of noise and vibration, environmental observation, evaluation, and analysis; Cleaner technologies and products, imply the methods and procedures that are cleaner and use fewer resources, as well as cleaner goods and use fewer resources; Resource management group, concludes control of indoor air pollution, provision of water, recycled resources, plant that produces renewable energy, energy and heat conservation and management, sustainable fishing and farming, forestry that is sustainable, natural risk control. The second dimension is the environmental processes, which specifically represent the environmental damage mitigation process by using cleaner or more energy-efficient technologies.

In contrast, compared with Golub (2011), Johnson (2017) mainly focuses on the segmentation of environmental investments to measure the two dimensions, which are similar to the above. The EGS components are measured by investment in electricity, gas and water. The environmentally relevant FDI is defined as investment in industries with the greatest potential for environmental spillovers. However, the former focuses more on the segmentation of the environment.

Compared with the measurement methods produced by other statistical agencies, Johnson (2017) is the only paper that mentions the measurement of green FDI by official agencies. The British government's calculation method proposes the basis for the classification of green industries, which is based on the Environmental Standard Industrial Classification. However, although this classification method saves screening time, the FDI of MNEs in industries excluded from the classification, such as renewable energy FDI in the retail sector, which is not quite environmental, will be ignored. However, it is precisely the MNEs in such omitted industries that are more representative.

It is worth noting that the UK government is the only entity that uses surveys in its measurement methodology. Compared with the secondary data provided by other institutions, the survey method can design questions according to the research purpose to make the data more targeted and more timely. In addition, the data obtained by the survey is unique and can obtain results that cannot be flexibly obtained with secondary data. However, the survey method is not suitable for conventional GFDI research. First, it is difficult for researchers to obtain a large amount of data from MNEs in various green industries through their own channels, and such a sample size is difficult to be representative. Second, the government as a subject can use policies or regulations to force MNEs to complete relevant surveys, which is difficult to do in conventional research. Finally, because the government has the right to supervise the activities of MNEs, the authenticity of the data provided by MNEs from which the government obtains the data is more guaranteed.

The World Bank, the United Nations, the OECD, the Food and Agriculture Organization, the European Commission, and the International Monetary Fund jointly created a central framework of environmental-economic accounting. The framework provides two motivations for the environmental goods and services sector (EGSS): the purpose of environmental protection and resource management based on the firm operation activities and divides the EGSS into four components: environmental specific services like environmental remediation services, environmental sole-purpose products which directly serve for environmental protection, adapted goods which modified to be more environmentally friendly and environmental technologies aiming to pollution treatment and pollution prevention. From this perspective, it is also worth considering from the perspective of motivation division.

So far, the above-mentioned papers define GFDI as a whole, which is essentially centered around two main dimensions: FDI in green industries and services and FDI in environmental processes. However, we decide to separate GFDI into *green and FDI two dimensions* according to its basic functions: carrying green knowledge and technology and foreign direct investment of capital expenditure after summarizing the above literature. And regards the above two dimensions from papers as our green dimension's components. So, we define the green dimension of GFDI into *two components: green industries and services and environmental processes*. The reason for the dimensions we divided into green and FDI is that, while reviewing the literature in Table 1, although they regard GFDI as a whole, they essentially focus on defining green and then combine its dimensions with FDI. The way they define it can easily cause confusion among others about the definition of GFDI. The components commonly agreed upon by the above agencies mainly focus on renewable energy technologies, practices, processes, products and services in those papers while collecting data for quantitative use. The green dimension of green FDI may lead to results that are friendly or beneficial to the

environment according to those papers. Considering the need for statistical outputs and empirical research data for relevant reports, renewable energy is currently a relatively accessible option with the least chance of error under green constraints.

Therefore, we suggest that to define GFDI in the green dimension, it can be separated mainly into two components, including green industries and services and environmental processes. Then, the green industries and services component can continue to be divided into four elements based on the motivations, including environmental-specific services, environmental sole-purpose products, adapted goods and environmental technologies. FDI in environmental processes can be extended to two other elements through motivations, including environmental protection and resource management. This framework of GFDI in green is expected to provide clear branches while defining green. These two levels of GFDI will be executed through this paper.

In addition to the measurement methods of the above-mentioned institutions, the GFDI measurement proposed in the empirical papers focuses more on its research purpose. For example, Amendolagine, Lema and Rabelotti (2021) define GFDI as outward FDI according to their empirical research design, which aims to establish or acquire subsidiaries related to the production or distribution of green technology, specifically renewable energy technology. Compared with the broad range of clean energy and low-carbon energy used to define green, the direct use of renewable energy here narrows the scope and selects the least controversial renewable energy as the scope of available data. It is worth noting that after determining renewable energy as the scope, they directly used the number of patents to measure GFDI instead of capital expenditure of FDI and used the two entry modes of FDI as one of the conditions for data screening.

While looking for other GFDI relevant empirical papers, we found a possibility of confusion in the reference to GFDI. Generally, GFDI refers to green foreign direct investment. However, Ashraf, Doytch and Uctum (2021) regard GFDI as *greenfield* foreign direct investment. It is important to emphasize the difference between the two GFDIs. In order to explain the difference between the two more clearly, we must first explain the relationship between GFDI and traditional FDI.

The essential difference between GFDI and traditional FDI lies in the restriction of green. Therefore, GFDI also needs to combine the basic components of traditional FDI, the greenfield investment and merger and acquisition (M&A) investment, and it is preferred to still be measured by capital expenditure. So, the second dimension of our GFDI definition is through FDI. It must be noted that there are two explanations for GFDI, including green FDI and greenfield FDI. Green in GFDI should represent only when a company's activities are beneficial to environmental improvement or reduce environmental damage compared to its previous production activities can they be classified as green rather than defined as one of the components of the traditional FDI, the greenfield capital investment. In contrast, the scope of green FDI is much broader than that of greenfield FDI. It can even be said that greenfield FDI is both a type of traditional FDI and a type of FDI component that is focused on in GFDI. Therefore, the greenfield FDI as GFDI mentioned by (Ashraf et al., 2021) seems not appropriate as the definition of GFDI.

2.2 Measurement of GFDI

The differences among definitions in Table 1 also indicate different measurements of the GFDI. The measurements of GFDI are mainly divided into two levels, including the country or region level (Bloomberg New Energy Finance, 2017) and the project level (Ashraf et al., 2021). However, from a holistic perspective, as long as capital investment is used to measure FDI, all other levels are cumulatively derived and superimposed from the project level. For example, firm-level FDI data is based on the cumulative capital expenditure of each green-related project, such as renewable energy, within a company to form a monthly or annual capital expenditure. Similarly, country-level FDI data is also formed by adding up the investment in each green project of all companies in the country. Therefore, the GFDI data is a measurement of different levels obtained by subsequent changes to the project-level data.

According to the above reports and papers, due to the data availability, most of them use renewable energy in greenfield capital investment as one of the component measurements of GFDI, which implies that the data on M&A capital investment in the renewable energy sector at the project level is hard to collect. But even so, the definition of GFDI should still include the M&A component to be more complete.

Overall, except for those defined in green, the two dimensions of GFDI in FDI inherited from traditional FDI are greenfield investment and merger and acquisition (M&A) investment. Therefore, one of this paper's contributions comes out. We offer a new approach to the definition of GFDI and provide the methods to address the challenges in the previous definitions. Further details of the GFDI framework definition can be clearly shown in Table 2.

Table 2 shows the GFDI conceptual framework, including two main dimensions and four main components.

Table 2 GFDI conceptual framework			
Dimensions	Components	Elements	
Green	Green industries and services	Environmental-specific services	Environmental remediation services, and water and wastewater management
		Environmental sole-purpose products	Goods and services whose directly serve for environment and resource
	Environmental processes	Adapted goods	Environmental friendly
		Environmental technologies	Pollution treatment or prevention technologies
GFDI	Environmental processes	Environmental protection	Protection of ambient air and climate, Wastewater management, Waste management, Protection and remediation of soil, groundwater and surface water, Noise and vibration abatament, Protection of biodiversity and landscapes, Protection against radiation, Environmental research and development, Other environmental protection activities and technologies
		Resource management	Management of water, forest resources, wild flora and fauna, energy and renewable resources, minerals, fishing, farming, Heat conservation, Research and development activities for resource management, Natural risk control, Other resource management activities and technologies
FDI	Greenfield investment		
	Merger and acquisition investment		

The above dimensions, combined with components, can form a more complete definition of GFDI. So, the GFDI can be simplified as an effective way to transfer green knowledge and technologies through foreign direct investment. The elements can be regarded as the manifestation of GFDI implementation. Due to the secondary data availability, agencies focus more on using renewable energy to represent the green aspect which is also recommended by our paper. In addition, we suggest that GFDI data on FDI capital expenditures be adjusted starting from the project level, regardless of the level at which it is explored.

However, if we want to explore how GFDI connect with environmental outcomes, then in the process of GFDI transfer, there may be many factors that affect the final result due to the

large span. Besides, the motivation that MNEs do GFDI activities may also imply a direction of the environmental outcomes' effectiveness.

The reason for these problems is that, first, it is unclear what the motivations of MNEs are for conducting GFDI. If they are just doing it for the sake of better financing and reputation, then they do not expect the final environmental output of this expenditure. On the contrary, if MNEs have a positive environmental orientation, then GFDI can be said to be expected to produce positive environmental benefits. In the process of GFDI implementation, which links will become important factors affecting this relationship needs to be found out and paid attention to. Next, we can develop a framework to clarify the dimensions spanned in the GFDI process and the factors that may affect it to work on these conceptual problems, gaps and research questions.

3 THE EFFECT OF GFDI ON ENVIRONMENTAL PERFORMANCE: A MULTILEVEL FRAMEWORK

Spillover effects occur when productivity differences between companies are reduced through the redistribution of market share. To bridge productivity gaps between the home and host countries, advanced knowledge and technology are transferred via FDI. Consequently, the objective of GFDI can be inferred as enhancing production efficiency and minimizing environmental harm during production or directly improving environmental conditions to facilitate the spillover of relevant knowledge and technology between countries. Knowledge spillover theory, therefore, underpins the framework developed in this paper.

Figure 1 presents a conceptual framework, visually structured to highlight the relationships between GFDI, its environmental outcomes, and the moderating factors influencing this relationship. The framework is divided into three interconnected dimensions: country, industry, and firm. Within each dimension, key elements influencing GFDI and environmental outcomes are identified and categorized. The country-level factors include national policies, knowledge base, regulatory environment, market openness, and economic development level.. Industry-level factors encompass sector-specific technological capacity spillovers, competitive dynamics and human capital mobility. Firm-level factors focus on absorptive capacity, ownership structure, R&D intensity, and energy consumption patterns.. The framework also shows how these dimensions interact, emphasizing both macro-level influences (e.g., institutions and national policies) and micro-level mechanisms (e.g., firm strategies and local practices) (Perri and Peruffo, 2016).

The conceptual framework clearly delineates these dimensions and their interactions, providing a comprehensive structure for understanding how GFDI can lead to positive environmental outcomes through cross-dimensional knowledge spillovers.

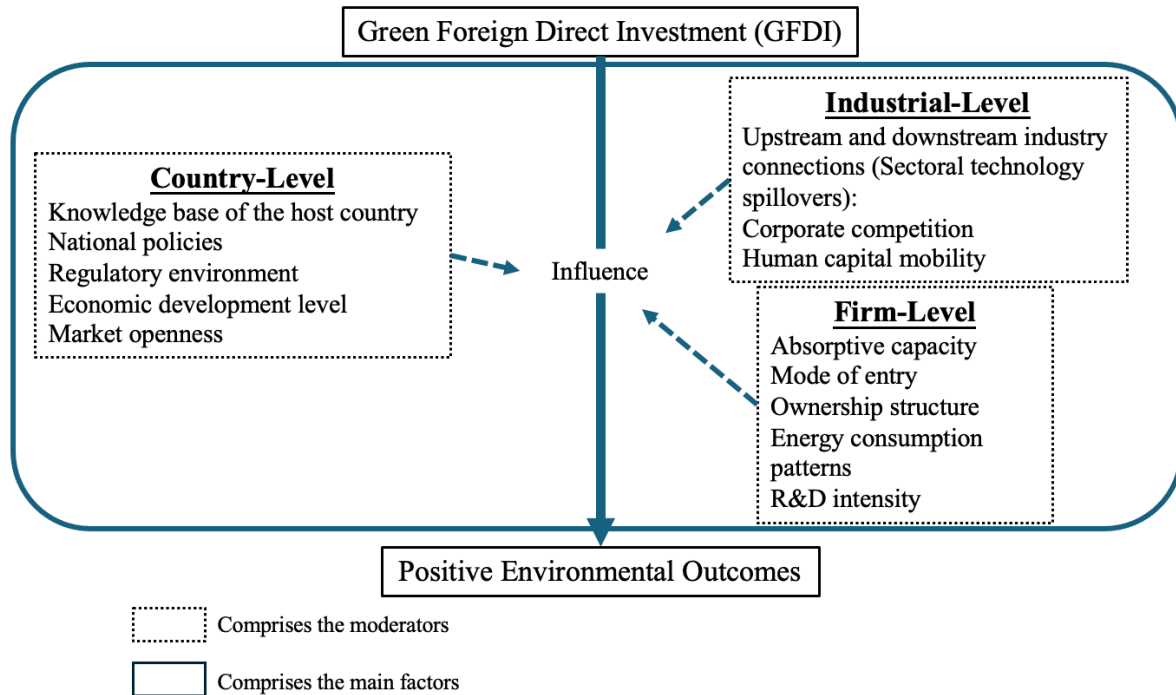


Figure 1. Moderators affecting the process from GFDI to environmental outcomes

Due to the whole process of GFDI, a multi-level framework can completely represent GFDI from home to host countries, then transition within industries and transfer to the absorption within MNEs. GFDI carries green knowledge, technology and capital investment across multiple levels and needs to face multiple difficulties and obstacles through this process. This process is closely linked. For example, it is necessary to overcome national and industry constraints before MNEs can finally receive green knowledge and technology to do the further transition, just as the host country's knowledge level may affect the firm's own absorptive capacity (Bai et al., 2020). Although it cannot be ruled out that these factors have no influence on each other, different theories can be applied to explore the impact of each factor on environmental outcomes, such as environmental policy may use institutional theory (Zilja et al., 2022; Shi et al., 2023), and absorptive capacity may use a knowledge-based view (Bai et al., 2020; Amendolagine et al., 2021; Amendolagine et al., 2023).

3.1 Country Level

Because the knowledge transfer of GFDI mainly happens between the parent company and its subsidiaries across countries, the moderators can be divided into internal and external factors or listed from the country level to the firm level. First, most of the characteristics mentioned in the literature are the host country's characteristics (Amendolagine et al., 2023), the host country's knowledge level (Bai et al., 2020), the strictness of the host country's environmental regulation (Yu & Liu, 2024), the different development stages of the host country (Yu & Liu, 2024), differences in tax systems (Wang et al., 2021b), human capital development and urbanisation process (Uche et al., 2023), the income per capita differences across countries (Papież et al., 2018) and the marketisation level (Wang et al., 2021a). The indicators listed above are all at the country level.

3.1.1 Knowledge base of Host Country

Whether the home country wants to directly input green technology support to the host country or the home country expects its FDI to generate reverse green technology transfer and feedback to the parent company, the country's knowledge level can have a moderating effect. The knowledge level of a country implies its ability to create knowledge and further innovate (Osabutey and Jackson, 2019) which can be measured by the average patent quantity of the host country. A country with a high level of knowledge means that the country has a good innovation environment. The innovative experience and advanced knowledge flowing out of this country can better promote changes at the environmental level (Bai et al., 2020). Moreover, the higher the knowledge level of a country, the more positive impact it has on the quantity and quality of local green patent production. This phenomenon is more evident in less developed countries and countries with less reliance on non-renewable chemical energy such as oil (Amendolagine et al., 2023). When a country's knowledge and technology are less tradable and more implicit, the green innovation performance of FDI will be more obvious (Amendolagine et al., 2023). Therefore, we can propose that after adding green conditions to FDI:

Hypothesis 1: A higher host country's knowledge level can have a positive moderating effect on environmental outcomes in the host country

3.1.2 National Policies

A multinational strategy based on the relevant policies of each country and investment based on market preferences in different regions can better promote GFDI to achieve the expected performance. It can be measured by the types and amounts of MNEs' investments in different countries in other words the investment types and amounts diversity among countries. The formulation of a multinational strategy plays a guiding role in the investment model and entry model of FDI (Clegg et al., 2016). Before this, the international expansion, benefits and costs (Clegg et al., 2016), and expected performance of investment have been systematically formulated in combination with the diversity and characteristics of countries, political influence, the degree of acceptance of foreign culture and the diversity of domestic culture, and the risks of economic and currency fluctuations in countries (Xu et al., 2019), thus laying the foundation for the entry of GFDI. In summary, businesses that use a multinational strategy invest in a variety of nations in order to get a wealth of diverse expertise and experience during the internationalization process. Then, a multinational strategy for environmental outcomes based on the experience gained from multiple investments can be inferred:

Hypothesis 2: A more diverse multinational strategy of the host country has a positive moderating effect on the implementation of GFDI activities in host country

3.1.3 Regulatory Environment

Due to the purpose of GFDI being to make positive changes in the environment, environmental policy of host country is an important factor to be considered before GFDI flows in. When nations link their environmental policies to observable institutional results, such as real pollution reductions or growth in the production of renewable energy, the policies are effective (Zilja et al., 2022). Encouraging environmental policies and rewarding incentives can

effectively promote enterprises' initiative in implementing environmental policies, thus bringing about positive environmental performance (Naidoo and Gasparatos, 2018).

However, the implementation of environmental policies must be accompanied by stricter environmental supervision and regulations. Furthermore, there are existing empirical research papers on environmental regulations as a moderator between FDI and one of its possible environmental outcomes, environmental innovation, which shows that the moderating effects are not significant (Bai et al., 2020). These results may imply more stringent environmental policies may affect economic freedom and then influence the autonomy of green innovation (Ofori et al., 2023). Hu et al. (2019) emphasize that the spread of green technologies from labour-based industries cannot be much aided by environmental regulation. Environmental regulation must be strengthened further in order to guarantee that FDI leads to the diffusion of green technologies. That is, when environmental regulations are strict enough, they can be implemented to regulate the effects of FDI and environmental innovation. The environmental policy can be measured by the relevant taxes and transactions.

Hypothesis 3: Encouraging environmental policy in the host country can positively affect the environmental outcomes of host country

3.1.4 Economic Developing Level

The above view of environmental regulation is confirmed by Yu and Liu (2024), who proved that regional heterogeneity has demonstrated that FDI has an inhibiting influence in less developed regions and a strong beneficial function in urban green development efficiency in developed regions when environmental regulation intensity surpasses the turning point. This finding also confirms that a country's development level, like developed and developing status, will also influence the FDI and its green development efficiency (Zhu and Ye, 2018). The country's development level can be measured by checking if it belongs to developing or developed or its economic developing level GDP per capita.

Hypothesis 4: A higher economic development level of the country and stage of the host country can lead to positive environmental outcomes in host country

3.1.5 Market Openness

The level of marketisation of a country can be understood as the extent to which the national economy operates according to market principles, such as the degree of freedom of competition and whether the degree of government intervention is relatively small can retain the decision-making freedom of enterprises and thus reduce the pressure on enterprise operations. Marketisation can be measured by the comparison between price and utility Effects (Godechot, 2016). The higher the degree of marketization, the more intense the competition between enterprises in different countries (Albornoz et al., 2009). However, market competition will further highlight the technological advantages of multinational enterprises in clean production, and the host country will also respond to the competition. Moreover, the price effects of market-oriented reforms and fierce competition will drive FDI to spill over into clean technologies and thus improve environmental pollution (Wang et al., 2021a). Because pollution-intensity technologies are less expensive and yield higher profits than clean technologies, market rivalry

frequently pushes businesses to choose them. As a result, clean technology use is frequently inadequate in a free market. In summary, it can be assumed that a higher degree of marketization will lead to more intense competition among domestic enterprises so that the technological advantages of MNEs can be better reflected and host country enterprises are forced to improve their technological level.

Hypothesis 5: A more open country marketisation level of the host country can positively influence environmental outcomes in the host country

3.2 Industrial Level

Between the country and company levels, industry factors also play a role in helping implement GFDI. The links between upstream and downstream industries such as the flow and development of human capital, and the intensity of competition between industries can be the key implemental factors of GFDI (Pan et al., 2020) and sectoral technological spillovers. When GFDI is used as a channel for green technology, after one party is exposed to the spillover technology, the economic connection between upstream and downstream industries can promote the flow, transmission and diffusion of technology in the industry space. Specifically, upstream industries stimulate the development of downstream industries and attract foreign investors by absorbing advanced knowledge or technology provided by GFDI. Downstream industries provide market scale and demand in return to assist the market-oriented research and development or integration of advanced knowledge and technology and promoting industrial upgrading.

3.2.1 Corporate Competition

Competition between industries has promoted the improvement of production efficiency and technological level, providing convenient conditions for receiving technology and continuing to spread it (Nabeshima et al., 2018). The more competitive the industry, the greater the survival pressure faced by enterprises, which in turn prompts enterprises to seek more advanced knowledge and technology from foreign countries to improve their own industry competitiveness. Enterprises receive information from GFDI and integrate it with their own production to improve production efficiency, and then further integrate the needs of the local market, thus improving industry competitiveness as a whole and reducing survival pressure. The competition level can be measured by market share volatility.

Hypothesis 6: Higher corporate competition in industries in the host country can positively affect environmental outcomes of the industry

3.2.2 Human Capital Mobility

In addition, the development of human capital mobility will further diffuse the advanced technology carried by it, making the technology of GFDI better utilized. After GFDI, employees in MNEs may bring the technology and management experience they have learned to local enterprises, promoting knowledge dissemination further increases the possibility of effective environmental improvement. The human capital mobility can be measured by job transition rate or average tenure length.

Hypothesis 7: Higher human capital mobility within industries of the host country can positively affect the environmental outcomes of the industry

3.3 Firm Level

Next, we can narrow down from the country level to the firm level indicators which may affect the GFDI activities. As the main body of GFDI, multinational enterprises often have their own characteristics and conditions that affect the investment and final performance of GFDI, such as absorptive capacity (Bai et al., 2020), specific technologies involved in GFDI (Amendolagine et al., 2023), enterprise and department characteristics and specific capabilities, mode of entry, accumulated experience and ownership type (Patala et al., 2021), the enterprise's own demand for energy consumption, and R&D expenditure (Adedoyin et al., 2020). In addition, the company's financial issues are also a factor that needs to be considered, such as whether the company's financing costs have a higher interest rate (Mahama et al., 2021), whether it can maintain stable and sufficient financing and long-term capital to support the company's overall operations.

3.3.1 Absorptive Capacity

Ahimbisibwe, Nkundabanyanga, Nkurunziza and Nyamuyonjo, (2016) stated that absorptive capacity refers to an enterprise's ability to identify the value of new external information, absorb it, and apply it to business purposes and divided absorptive capacity into four dimensions: acquisition, assimilation, transformation, and application. Absorptive capacity, as an endogenous core competitive skill of enterprises that promotes the integration of resources and capabilities, can create more value (Bacq and Eddleston, 2018). Therefore, enterprises can improve the environmental value of GFDI by combining the knowledge and technology acquired through GFDI with their own absorptive capacity. At the same time, enterprises can also use their absorptive capacity to perceive and identify advanced green resources and then further analyze, understand, process and internalize them. Then, they can combine green technical knowledge with existing production background conditions and management to transform them into new and more advanced green products to better meet market needs and serve customers, thereby increasing profits. The absorptive capacity can be measured by R&D input and the number of patents granted.

Hypothesis 8: Higher absorptive capacity of the subsidiary party that seeks more knowledge spillovers will lead to a positive moderating effect on environmental outcomes

3.3.2 Mode of Entry

The mode of entry of FDI is regarded as an influential factor separating greenfield investment and merger and acquisition investment, which especially affects the degree of knowledge transfer. One common claim is that because subsidiaries can use and combine their existing knowledge with the corporate parent's capabilities, acquisitions include a higher level of knowledge transfer from parent MNEs (Dezi et al., 2018). Besides, subsidiaries under the greenfield investment have more difficulty acquiring local knowledge than subsidiaries through acquisition investments and are less affected by various aspects of the home country

(Amendolagine et al., 2023). Li (2022) claimed after empirical analysis that acquisition is the fastest way to acquire technological resources, improve the target company's absorptive capacity and maintain green innovation. Therefore, if the merger and acquisition investment of the mode of entry may be a better influence on GFDI and its environmental results compared with the greenfield investment can be further judged:

Hypothesis 9: The merger and acquisition entry mode can lead to positive environmental outcomes more significantly than greenfield entry

3.3.3 Ownership Structure

Patala et al. (2021) incorporate the ownership issues of firms to understand whether firms can leverage their specific advantages to meet the market's attractiveness for renewable energy investments. They believe that private multinational enterprises are at the forefront of renewable energy investment even though they face high risks. In contrast, state-owned multinational enterprises only need to face lower risks to invest in renewable energy due to the complex restrictions they need to follow. In addition, they argue that state-owned MNEs are more responsive to incentives than private MNEs. Private MNEs use their international experience in conjunction with renewable energy investments. In contrast, state-owned MNEs combine their international experience with investments in non-renewable energy.

Hypothesis 10: The privately owned MNEs can better affect environmental outcomes than the state-owned MNEs

3.3.4 Energy Consumption Patterns

Since energy consumption drives the economic development of enterprises and even helps enterprises to increase their economic benefits (Ozcan and Ozturk, 2019; Caetano, Marques and Afonso, 2022), the dependence of enterprises in sectors mainly engaged in energy business on energy will become the main driving force for their development. Thus, the demand for energy consumption by enterprises will continue to increase. However, it is this demand for energy consumption that has further exacerbated environmental damage and pollution, affecting the ecological environment and the quality of the human living environment (Saint Akadiri et al., 2019). For enterprises with large energy demands, their energy loss is closely related to their operating profits. Therefore, whether such enterprises have the subjective initiative in implementing GFDI or whether they want to carry out green technology reforms due to requirements related to environmental policies, such as reducing energy loss in the production process on the original basis or introducing advanced technologies to update the use of clean energy, will affect the implementation and results of GFDI. In addition, the capital expenditure required for GFDI by enterprises will also be affected by the capital structure of the enterprise (Mahama et al., 2021), the operating costs required to maintain daily operations and retained earnings. Moreover, whether the subsidiary is the recipient or the knowledge and technology spillover back to the parent company, the time cost spent by the enterprise on absorption and the research and development (R&D) cost required to integrate new knowledge with its own production plan are internal factors that affect the enterprise's decision on GFDI. The energy consumption and dependence can be measured by energy used and energy costs.

Hypothesis 11: MNEs with lower energy consumption and dependence can positively affect environmental outcomes

3.3.5 Firm R&D Intensity

Before undertaking GFDI activities, enterprises need to systematically estimate the time, manpower, and any capital expenditures incurred during the knowledge and technology transfer process in order to successfully complete GFDI. Even if the recipient of knowledge and technology transfer may have previously made an overall estimate and forecast of the R&D costs required for the integration of new technologies, the actual application of new technologies to production or further upgrading in combination with past technologies still requires specific circumstances and subsequent market performance to reflect whether GFDI can meet the expectations of MNEs. Adedoyin et al. (2020) found a significant negative correlation between R&D expenditure and ecological footprint in the long run, which was also proved by Wei, Mohsin and Zhang (2022). The amount of renewable and non-renewable energy that needs to be improved in R&D also has an impact on the ecological footprint (Hernández Soto, 2024). Meanwhile, the prices of conventional energy such as oil, natural gas, coal and nuclear energy are also potential factors in the development and application of renewable energy (Singh et al., 2019), but the replacement of resources needs to consider the capital capability of the MNEs (Papież et al., 2018; Soltani, 2024). As the sustainable development model becomes a trend in corporate operation transformation, inclusive green growth consisting of economic growth, social equity and environmental protection (Kolk et al., 2017) is also exerting invisible pressure on MNEs due to their strong influence, urging them to conduct research and development on sustainability (Zhu and Ye, 2018a; Zhu and Ye, 2018b; Adedoyin et al., 2020; Baloch, Ozturk, Bekun and Khan, 2021; Luo, Salman and Lu, 2021; Castellani, Marin, Montresor and Zanfei, 2022; Zhang and Sun, 2023; Kharb et al., 2024).

Hypothesis 12: Higher R&D intensity while subsidiaries integrating advanced knowledge during the production process can have a positive impact on environmental outcomes

4 DISCUSSION AND CONTRIBUTIONS

In this paper, we critically discuss the inconsistencies in defining GFDI and propose a new approach for defining GFDI. Comprehensively, due to data availability, renewable energy is widely used as the main green measurement in GFDI because renewable energy has the least pollution to the environment, reduces the loss of non-renewable resources and is in line with the issue of sustainable development (Østergaard et al., 2022). The new definition of GFDI clarifies the dimensions and components of GFDI as a channel for transferring knowledge and technology to improve the environmental performance of parent and subsidiary companies of multinational enterprises. That is, our goal is to help clarify the overall process of GFDI activities and identify factors that potentially affect GFDI and its environmental outcomes.

We believe this definitional framework is valid for three reasons. First, from the perspective of the levels spanned by GFDI activities, FDI is a cross-border business, so GFDI will be affected by country-related factors and will also be affected by national differences, and these

obstacles need to be adapted to or overcome during implementation. However, in reality, GFDI cannot avoid the influence of such macro factors. Therefore, in the link between GFDI and environmental results, country-level elements will become the first thing it faces and bears.

Secondly, the type of industry in which a multinational company operates determines the company's overall demand for energy consumption. For example, the manufacturing, chemical, and power industries have a large demand for non-renewable energy, and the feasibility of their resources being replaced by non-renewable energy is low. Considering the company's business purpose of maximising shareholder wealth (Krüger, 2015), the conversion to renewable energy has a greater impact on the company's profits and takes a long time to consume, so the impact of the industry on GFDI cannot be ignored.

Finally, after MNEs decide to conduct GFDI, GFDI goes through the steps of cross-border transmission, and the final implementation requires firm-level enterprises to mobilize their own strength to cooperate with the completion of this process. The process of integrating and improving the original production efficiency with the acquired advanced knowledge and technology will not only consume the company's internal resources such as manpower and financial resources but also affect product output and market feedback. These requirements for corporate capital are extremely high, so companies need to mobilize resources to cooperate and speed up subsequent integration or R&D period.

We believe that the classification of moderators based on the different stages that GFDI goes through can help better identify potential risks in the process. Furthermore, the integration of these factors helps to improve the framework of GFDI definition completely.

4.1 Implications for Research and Practice

Our aim is to provide a clear GFDI definition framework to clarify what GFDI is, which dimensions the process passes through, and what potential factors affect GFDI and its environmental outcomes. The framework is based on three dimensions across which GFDI occurs: country, industry and firm. However, our framework requires continued review, and next, we will identify areas for possible future research.

It is necessary to examine the MNEs' situation and their motivations for conducting GFDI. As influential entities, multinational enterprises are more concerned by internal and external stakeholders. Faced with these pressures, the purpose of MNEs' GFDI may also become one of the factors affecting GFDI results. If MNEs are indeed faced with the need to transform their production efficiency towards sustainability, and this process will actually increase profits in the long run, then whether their greater initiative in GFDI means that the resources brought by GFDI will be better reflected in the environment is worth further study. However, in order to maintain their reputation and facilitate their fundraising, MNEs, relying on their strong capital, may regard GFDI as not solely for the environment, resulting in unsatisfactory environmental performance.

Besides, it is worth exploring how to better measure GFDI using qualitative, mixed, or quantitative research. Compared with the degrees of freedom of qualitative methods, the measurement of GFDI using secondary data in quantitative methods requires a more critical assessment of the appropriateness of the data in conjunction with the definition of GFDI.

In practice, this definition can serve as a guide to help other scholars explore GFDI-related topics in more depth. The listed moderators can help scholars better consider the potential

factors affecting GFDI and its environmental performance when designing research methods, reduce omission variables, and improve the degree to which GFDI is better interpreted. Importantly, the framework suggests that managers should formulate better strategies after fully considering the factors that affect GFDI, improve the coordination between the country, enterprises and employees, help GFDI to be better implemented, and the environment to be effectively improved. For other stakeholders, this can also be used to strengthen the comprehensiveness of supervision of MNEs' implementation of sustainable development concepts and meet their expectations.

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