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Green Finance and Its Impact on Sustainable Investment Strategies in the US

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ABSTRACT

This research aims to analyze green finance's applicability in forming sustainable investment policies in the USA. This research fills a literature gap to uncover the long-run equilibrium co-integration between FDI inflows, CO2 emissions, renewable energy, and renewable electricity. Using VECM and Johansen co-integration tests, this paper discusses the long-run relationship of these variables. Time-series data for 32 years (1990-2021) is the basis for analysis, largely gathered from the World Bank. The analysis reveals that the two variables are co-integrated over the long run, though there is a short-run time-varying co-integration relationship. For instance, the co-integration test results present a trace statistic of 72.77, and its p-value is 0.0001, which justifies the existence of co-integration, which is a long-term equilibrium. The IRF analysis also shows that renewable energy consumption positively affects FDI, and levels off at 0.28 after 4 periods, whereas CO2 emissions have a negative long-run effect on FDI with a coefficient of -4.9153. Based on these findings, applying green finance policies for renewable energy import can encourage foreign investments in the short run. However, the cost involved in shifting to renewable energy sources may lead to a restricted number of long-term investments. This motivated the study to recommend a search for more information on such sector dynamics.

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1. Introduction

Green finance can be described as a powerful instrument for channelling international capital into sustainable development, given the increasing frequency of various environmental crises and the need to mitigate climate change (Zhang et al., 2019). Due to the current global shift regarding green and sustainable economies, green finance is essential in facilitating the flow of funds into climate change-related initiatives and initiatives promoting sustainable living (Cheung & Hong, 2021). In the United States, this paradigm shift is discernible since the markets adjust to incorporating green technologies as part of their financial tool kit, which also constitutes a clear indication of the country's overall embrace of sustainable development.

This has reflected the sharp increase in global green financial instruments and investment products. For example, the issuance of green bonds in the international market was ranked at $517.4 billion in 2021, where the U.S. produced about 16 % of this figure (BloombergNEF., 2022). This rise also certainly signals the growing consciousness of environmental issues to work on, and the profitability and stability tied to sustainable investment (Chen & Chen, 2021). Further, consideration of environmental, social, and governance (ESG) criteria has become standard in investment management decisions, and assets under management carrying an ESG factor in the U.S. have been estimated to be $17.1 trillion by the end of 2020, approximately one-third of the total AUM managed professionally in the country (SIF, 2020).

Incorporating sustainable technology into financial management is particularly noticeable for the United States, given that it is heavily reliant in terms of its significant impact on the environment and as the world's financial hub. Renewable power generation, energy efficiency, and sustainable infrastructure investments are supported by green financing products that reduce capital costs and balance risks (IEA, 2021). Banks and other financial organizations have realized that integrating green technologies helps increase future profitability and decrease potential losses from climate hazards (Fink, 2020). For instance, the global investment management company BlackRock said it was making sustainability integral to its investment products and processes and that climate risk was investment risk (BlackRock, 2020).

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As green finance emerges more frequently in the literature, it is somewhat surprising that there needs to be more quantitative research on the stock of green assets and how they align with sustainable investment over the long run. The existing literature mainly relies on theoretical works, which were also a priori limited to short-term analysis or employ relatively uncomplicated econometric specifications in long-run analysis (Giglio et al., 2021), with considerable research gaps on how more profound econometric techniques can be used to understand these long-run effects. This lack of data can significantly impede policymakers' and investors' initiatives to optimally realize the potential basics of green finance to foster sustainable investments (Sachs et al., 2019). According to Baker et al. (2022), there is a need for more comprehensive empirical evidence to support arguments on the impact of green financing structures.

Therefore, this study aims to fill this literature gap by providing an empirical analysis of green finance and sustainable investing in the US using sophisticated econometric techniques. This research endeavour also seeks to express the long-run complexes and short-run exhibitions between several variables by applying the co-integration analysis and VECM (Johansen, 1991; Pinshi, 2020). Such an empirical approach is required to capture the dynamics and interactions characteristic of the interactions between finance, technology, and sustainability.

More precisely, it seeks to determine how green finance helps introduce green technologies into investment plans. This covers the analysis of how financial assets and standards enable investment in green projects, which include renewable energy and energy efficiency, as well as other sustainable technologies (Ren et al., 2020). For instance, the reduction in costs of generating renewable energies has been acknowledged as having been prompted by more investments in green finance. The cost of solar photovoltaic technology was reduced by 85% between 2010 and 2020, making the cost of the new technology reasonable compared to traditional energy sources (Lazard, 2020). Traditional sources of financing, like green bonds and the newly emerging sustainability-linked loans, have been laudable in helping to finance these technologies (Flammer, 2021).

Also, the study investigates the relation between FDI, CO_2 emissions, and renewable energy using co-integration analysis. Understanding these relationships is essential because FDI can be a significant source of financing for green investment. In contrast, the relationship between emissions and renewable energy has important implications for environmental policy (Rafique et al., 2020). For instance, inward FDI stock in the renewable energy sector was $85 billion in 2019 in the United States, but it is also a country that is a source of FDI stock (BEA, 2020). Such a type of examination in terms of the long-run co-integration of the said variables can help understand how and to which extent international investment affects the process of environmental degradation (Bolton et al., 2020).The central research questions guiding this study are:

- How does green finance influence the adoption of green technologies in investment strategies?
- What are the long-term dynamics between green finance variables and sustainable investment outcomes?

Responding to these questions will give insights into how green finance works and its efficiency in catalyzing sustainable financial investment. It will also help policymakers and investors understand how to optimize the efficiency of green finance strategies.

In assessing the impact of green finance on green technology deployment, more concrete forms of instruments and policies will be discussed in this study. For instance, green bonds help attract financing to support green project requirements. The U.S. green bond market has been rising; the combined market size has crossed $150 billion as of 2022 (Initiative, 2022; Intergovernmental Panel on Climate, 2023). Research evidence has revealed that green bonds lead to lower capital costs for issuers and appeal to a fresh pool of investors interested in sustainable investments (Tang & Zhang, 2020). However, sustainability-linked loans and green funds have also risen, meaning that the pool of financial instruments linked with green investment has expanded (OECD, 2020).

Another aspect of green finance is the addition of ESG criteria to investment management decisions. Therefore, a range of ESG operations is penetrating in its integration into investment decision-making and portfolio management. Krueger et al. (2020) show that taking self-reporting measures into account, more than 50% of institutional investors consider ESG factors relevant to investment returns and management, with climate risk being the most critical factor. Moreover, research demonstrates that integrating ESG produces even better returns per risk and results in positive environmental impact (Friede et al., 2015).

It is essential to better test for co-integration between FDI, CO_2 emissions, and renewable energy to appreciate green finance's macroeconomic and dynamic relationship. FDI can also bring the technology and capital required for RE for renewable energy projects that may decrease CO_2. However, it is bilateral, as FDI may also lead to higher emissions in some sectors of the economy (Omri & Nguyen, 2014). As such, accurate co-integration analysis enables the identification of whether stable long-term causal relationships exist between these variables to indicate the possibility of sustainable development pathways that translate economic growth within physically intertwined domains without adverse effects on the environment (Rafique et al., 2020).

VECM, for instance, offers the chance to analyze whether the variables of interest exhibit a long-run relationship and temporary interactions (Johansen, 1991). By using these models, the study will be able to establish causality directions, the speed of adjustment towards equilibrium and the effects of shocks. For example, increased availability of finance for green projects consolidates the achievement of greater use of renewable energy in the long run. In that case, green finance can be said to be a helpful approach towards sustainability. On the other hand, if there is no evidence for any correlation, it may mean bringing new policies into question (Porter & Kramer, 2018).

The importance of this research goes beyond scholarly publications since it covers important aspects of the two nations' relationship. These findings will be helpful for policymakers while developing green finance policies and regulations (Polzin et al., 2019). For instance, how green bonds affect renewable power investments can inform policymakers to create structures encouraging their issuance. From the perspective of investors and financial institutions, a better understanding of green finance dynamics can improve the recommendations and risk management within portfolio strategies and, therefore, create better frameworks for integrating with sustainability goals (Cheng et al., 2021).

2. Literature Review

Over recent years, green finance has received much attention as a critical approach to encouraging sustainable investment methods. According to Clark et al. (2015), integrating sustainability within business operations correlates positively with economic success. Reviews found that 88% of sources reveal that companies prioritising sustainability show superior operational performance, eventually leading to enhanced cash flows. This shows that sustainability and profitability are not in conflict but can work together as shared goals.

Green finance and sustainable investments are founded on the theoretical approach of integrating environmental, social, and governance-focused criteria into financial decision-making. (Friede et al., 2015) performed an extensive meta-analysis covering over 2,200 studies that demonstrated that about 90% of the studies discovered a nonnegative relationship between the criteria of ESG and corporate financial performance (CFP). The majority shared positive results, noting that integrating ESG can improve financial performance. This abundant evidence base points to the financial reasons for ESG investing, indicating that adding sustainability factors does not affect financial returns.

Aguilera et al. (2007) provide a theoretical framework for why organizations get involved in CSR programs. According to them, business organizations face pressure from various stakeholders motivated by instrumental relations and moral reasons. This model implies that CSR-related green finance activities can enhance society and organizational reputation and market position.

The process is another fundamental part of the theoretical framework, which is choosing green technologies as the model of financial decisions. Following the work by Pedersen et al. (2021), we introduce mechanisms in which the overall ESG score interacts with a firm's fundamentals and investors' preferences. They explain the ESG-efficient frontier—investors can get the best returns within a risky set without considering ESG factors. They brought to life the principle of responsible investing, which can dovetail perfectly with the traditional goals of investment theories.

Various past research works have presented a wealth of data on how green finance has enhanced financial performance. According to Revelli and Viviani (2015), in their meta-analysis of 85 studies, incorporating CSR and ethical issues into portfolio management proves that CSR and ethical issues are not weaknesses that lie in social investment. Thus, they found that SRI's performance depends on methodological factors and specific dimensions under analysis, including the market milieu and investment period.

Using a panel cointegration and error correction model for 20 OECD countries, Apergis and Payne (2010) analyzed the nexus between renewable energy consumption and economic growth. Higher order econometric tests conducted by analyzed suggested that their variables of interest – renewable energy consumption and economic growth – have a co-integrated and mutually causal system in the long run. This means that, for instance, when the financial sector places a bet on renewable energy, which is part of green finance, it will support the sustainability improvement on the earth and fuel the globe's economic development.

In the same regard, Sadorsky (2012) analyzed the factors that affect the risk of renewable energy companies using a variable beta model. Company sales growth decreases company risk while increasing oil prices contribute to a positive change in company risk. This means that systematic risks can be reduced by organic sales growth in renewable energy firms, underlining the need for applicable support of financial policies that foster green investments.

The cointegration analysis employed by Jalil and Mahmud (2009) considered the Environmental Kuznets Curve (EKC) for emissions of CO_2 in China. The findings supported the EKC hypothesis and illustrated a quadratic relationship between income and CO_2 emissions. The research found that environmental degradation occurs initially with economic growth, but environmental improvement happens eventually once income reaches a defined threshold. This points out the contribution of financial growth to the aim of environmental sustainability.

Bolton and Kacperczyk (2021) investigated if carbon emissions are related to the cross-section of US stock returns. The researchers discovered that firms with more significant total carbon dioxide emissions generate greater returns, implying that investors require compensation for the carbon emission risk they face. This indicates the requirement to weave carbon risk into investment strategies and the possible benefits of green finance in diminishing those risks.

Flammer (2021) studied corporate green bonds and their contribution to environmental performance. The study results showed that investments favour green bond issuance, notably for issuers launching their first bonds and those with certification from a third party. After issuing green bonds, firms have seen their environmental ratings enhance and a decline in CO_2 emissions. According to this, green bonds appear as legitimate indications of a firm's sustainability promise and can pull in long-term, environmentally aware investors.

In their investigation, Karpf and Mandel (2018) looked into the worth of the 'green' label in the markets for US municipal bonds. The analysis showed that green bonds had, historically, received less favourable prices and higher yields than conventional bonds. Lately, the credit quality of municipal green bonds has been on the rise, allowing them to offer a premium. The change shows that green bonds are becoming more appealing to investors and may provide substantial funding for climate mitigation and adaptation initiatives.

Gianfrate and Peri (2019) applied a propensity score matching methodology to analyze the convenience of green bond issuance in Europe. The research showed that green bonds tend to be more profitable for corporate issuers than non-green alternatives. Financial rewards continue in the secondary market, backing the belief that green bonds can support economic greening without burdening issuers financially.

Chen and Ma (2021) focused on how green investment impacts firm performance in the context of the Chinese energy industry. It was also established that a strong positive relationship exists between green investment and financial performance, and the impact is enhanced in the long run. It was found faithful that EC environment taxes, along with subsidies on green investment and technological advancement, enhance the utility of green investment. This implies that policy support and innovation help one to harness all the benefits of green finance.

Using Campiglio (2016) view, carbon pricing may not be sufficient to underpin the transition to the low-carbon economy, mainly due to market failures in credit allocation. He further noted that through operating monetary policies and macroprudential financial regulation, certain pressure could be applied to banks to provide bigger loans to the low-carbon industries. Variation of the reserve requirements by lending locations will help the central banks direct more funds into green sectors as it will unveil the role of policy measures in green finance.

Under Ameli et al. (2020), the imperatives of total reliance on transparency and disclosure have been highlighted by TCFD (2017). They contended that it is impossible to align institutional climate finance with the public interest by using transparency alone, given the failings of the efficient market hypothesis. Thus, the research proposal alluded that for enhanced investment direction towards sustainable purposes, there is a need to bring out new mechanisms, such as legal changes, besides financial innovations.

Ferri and Acosta (2019) pointed out the critical role of ethical and sustainable finance in achieving sustainable development. They suggested that various financial intermediaries and instruments — cooperative banks and microfinance — are essential for sustainability by helping SMEs and increasing financial inclusion.

According to Johnstone et al. (2010), environmental policies played a role in examining technological innovation in renewable energy via patent data. Their results suggested that public policy strongly affects innovation, where various instruments proved helpful for differing renewable energy sources. Extensive policies drive innovation in technologies near competing with fossil fuels. Targeted subsidies, in turn, are necessary for higher-cost technologies such as solar power. This suggests the vital role of government policies in facilitating technological progress through green finance.

Nakamura (2011) assessed whether firm performance in Japan is linked to environmental investment. The research showed that environmental investment does not majorly affect short-term performance but does lead to better results over time. This implies that there is an intermission between when investments are made and their recognition by both consumers and shareholders, suggesting the critical need for a protracted view in green investment strategies.

(Reboredo, 2015) work investigates the independent and systemic risk between oil and renewable energy shares. The research findings show considerable time-varying dependence, where oil price dynamics are a major contributor to the risk of renewable energy firms. This result has consequently resulted in portfolio diversification in sustainable investment approaches.

Tamazian et al. (2009) examined the relationships among economic development, financial development, and environmental decline in the BRIC countries. Their findings indicated that more advanced economic and financial progress degrees reduce environmental decline. The research proposes that financial liberalization and openness are necessary for CO_2 reductions since they draw in more significant amounts of R&D-related foreign direct investment that can boost environmental quality.

Apergis and Payne (2010) indicate that a long-run equilibrium exists between renewable energy consumption and economic growth among OECD countries, meaning that a commitment to renewable energy may enhance economic growth. This relationship illustrates the need to incorporate renewable energy assets within investment portfolios to achieve both financial and sustainability targets.

Sadorsky (2012) points out that companies engaged in renewable energy often show unique risk characteristics attributed to changes in oil prices and their sales growth performance. The study indicates that more robust sales growth can help reduce company risk, stressing the vital need for investors to consider renewable energy firms' functional performance during investment decisions. The authors note that Friede et al. (2015) found that corporate entities that give precedence to environmental, social, and governance criteria (that includes a reduction in CO_2), generally have better financial performance. In the studies they reviewed, approximately 90% showed a relationship beneficial to ESG factors and financial outcomes, which verifies the financial strength of sustainable investments.

Various research shows that government policies and market incentives play a key role in advancing green finance. Johnstone et al. (2010) investigate how environmental policies impact technological innovation related to renewable energy. The research shows that subsidies aimed at specific sectors, including feed-in tariffs, effectively foster innovative development for expensively priced renewable technologies, including solar energy. Such findings show that government interventions may facilitate lowered entry barriers and support investment in renewable energy domains. Karpf and Mandel (2018) also analyze the U.S. municipal bond market and discover, through time, the evolution of the 'green' label affiliated with bonds. Initially seen at lower prices, improved quality of credit and growing investor demand have made green bonds much more appealing, which indicates that market incentives can raise the attractiveness of green financial instruments.

Flammer (2021) points out that green bonds are impactful by indicating that corporate green bond issuances improve environmental performance, characterized by both improved environmental ratings and less CO_2 emissions. When certified by third parties, investors respond favourably to these issuances, indicating that market mechanisms can incentivize firms for their environmental assurances. Gianfrate and Peri (2019) confirm that green bonds have financial perks for corporate issuers compared to traditional bonds while also helping to green the economy without facing financial punishments.

Government policy is primarily responsible for addressing the market failures that degrade green investments. According to Campiglio (2016), carbon pricing may be limited because of the challenges surrounding credit allocation in the banking industry. He argues that coordinated changes in reserve requirements and lending for low-carbon sectors can promote the development of credit needed for green investments. This lens highlights the necessity for a complete policy strategy to back green finance.

Moreover, Bolton and Kacperczyk (2021) highlight the integration of CO_2 reduction and renewable energy consumption in investment portfolios based on high carbon emission firms to offer higher stock returns, which means that investors seek a risk premium for bearing carbon exposure that harms the environment. This also means investors must conduct carbon risk management in their portfolio strategies. Furthermore, regarding the relationship between oil and renewable energy stock prices, Reboredo (2015) finds that oil price fluctuations exert considerable influence on the risk of renewable energy firms. This implies that investment in other forms of capital, including renewable energy sources, can assist in cushioning against the dangers inherent in fossil fuel-related markets.

Chen and Ma (2021) examine the following relationship in the energy sector: green investment and firm performance. Based on their research, green investment has a positive relation with financial performance, especially long-run performance, and it is further bolstered by support from government subsidies and technological development. Therefore, this finding affirms the argument that policy support and market incentives must be provided to compel firms to adopt sustainable practices.

Finally, Tamazian et al. (2009) examine the overall effect of economic and financial development on polluting emissions in the BRIC region of the world. They found that enhanced levels of financial development are negatively associated with environmental degradation and that financial liberalization can promote investments in new technology for environmental conservation. This means that main-owned CO_2 reduction and renewable-oriented energy consumption portfolios can be integrated into the developed global financial markets.

3. Methodology

3.1. Research Design

In this study, the Vector Error Correction Model (VECM) and Johansen co-integration test are used to test long-run co-integrating relationships between the variables in green finance and sustainable investment framework in the US. VECM is most appropriate when the variables are time series, and the data is non-stationary and co-integrated, implying that their trend has a long-run equilibrium but experiences short-run deviations. Regarding green finance, this study's instruments of interest include FDI as the green technology host country attractiveness measure, CO2 emissions and Renewable Energy Consumption (REC) and Renewable Electricity as the measures of green technology adoption. These variables encapsulate sustainability's physical and fiscal applicability with a view to how outlay in green technology can influence developmental progress and carrier or CO2 emissions Peter and Perron (1988).

The Johansen co-integration tests are used to determine long-run relationships between these variables. This method makes it possible to estimate several co-integrating relations, which is essential because of the considerable labyrinthine interconnections between green finance and investment approaches. In this research, the Johansen test is applied to help determine the appropriate lag length for the VECM model analysis, which provides an opportunity to present short-run dynamics and long-run relationships (Johansen, 1991).

In this way, the VECM not only reveals short-run breaks with long-run steady-state values but also measures how fast these breaks are eliminated through time. With this model, the study offers a relevant understanding of green finance to support sustainable investments and the extent to which green technologies are adopted in the US market (Engle & Granger, 1987). Furthermore, impulse response functions and variance decomposition are used to identify how the shocks to one variable affect other variables in the system, complementing the analysis of green finance dynamics even more.

3.2. Data Collection

For this research, we use secondary data from sources including national and international financial institutions as well as the World Bank Group and Group (1978). The analysis presented in this study utilizes data from 32 years, from 1990 to 2021, to thoroughly analyze the role of green finance in formulating sustainable investment strategies. Foreign Direct Investment (FDI) measurement, which represents its percentage of GDP, shows the level of international investment received inward flows and is a core measure of investor confidence in green technologies and economic growth.

In this study, the independent variables include CO2 emissions (Co), the proportion of renewable energy consumption (Re) out of total energy consumption, and the fraction of renewable electricity (Retotal) relative to total electricity consumption. These variables now perform the role of proxies for adopting green technology and reveal the US's progress in cleaner energy and sustainable methods. As part of their environmental sustainability framework, metrics include CO2 emissions, which, together with renewable energy and electricity statistics, indicate the level of integration of green technologies in the national energy mix.

The data for these variables is taken from the World Bank's accessible platform, thus ensuring dependability and symmetry over the examined period. The integration of long-term data supports a detailed time-series analysis of green finance and sustainable investment trends, revealing how green technology adoption trends have progressed in the past. This research aims to clarify the complicated associations linking environmental sustainability and investment strategy in the context of the US economy by assessing these variables (Ciegis et al., 2009).

3.3. Analytical Framework

This research uses a strong analytical structure to provide reliability and significance of the findings. Therefore, the first element within this framework is to test for the presence of unit roots in the data using the ADF and the PP tests to establish the nature of the underlying data. Stationarity is another requirement in time-series analysis because the mean and variance of the series will remain constant at every period (Dickey & Fuller, 1979). If the variables are I (1) and become I (0), they can be stationary in the cointegration framework.

After confirming stationarity, the Johansen cointegration test is run to test the long-run relationship between the dependent variable FDI and the independent variables, which are CO2 emissions, Renewable Energy consumption, and renewable electricity. This test enables one to determine the conception of the variables in the long run despite the short-term fluctuations that may occur (Johansen, 1991). Since the processes of cointegration are as follows, one can analyse the long-term trend of green finance and its impact on sustainable investment decisions.

Subsequently, the Vector Error Correction Model (VECM) is used to check the short-run relations and the long-run ones, which have been established through cointegration analysis. VECM makes it possible to remove short-time shocks while taking account of the speed of convergence to the long-time steady state. This model is beneficial for analysis of economic and environmental variables since it discusses the effect that schemes in green finance have on investment plans in a given period (Engle & Granger, 1987).

To check the stability of data, heteroscedasticity and serial correlation tests are carried out to validate the model. Two tests are employed to examine whether the variance of errors does not vary – the Breusch-Pagan test and the Breusch-Godfrey LM test verify whether the serial correlation of the residuals is present (Breusch & Pagan, 1979). These tests affirm the model by affirming that a spurious relationship exists at no point, making the results extracted from the model efficient and relevant to policy and investment.

4. Empirical Findings and Data Analysis

4.1. Unit Root and Co-integration Findings

In this study, we use unit root tests and co-integration techniques to analyse the interconnections between FDI, CO2 emissions, Re, and Retotal. These tests help determine the degree of stationarity of the time series data and the cointegration among the variables, which is important in estimating the impact of green finance on sustainable investment plans (Nur et al., 2022).

Unit Root Tests: Stationarity

To increase the accuracy of our time series analysis, we performed a combination of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. Non-stationary data indirectly give spurious regression results; hence, one has to check whether the data is stationary and, if not, the number of differences required to make it stationary (Dickey & Fuller, 1979; Peter & Perron, 1988).

Table 1. Phillips-Perron (PP) Unit Root Test Results at First Difference

	PP (1st difference)			
	FDI	**CO**	**RE**	**RETOTAL**
t-Statistic	-9.0728065	-5.63071434	-5.6225	**-5.44251**
Prob.	*4.0088969623755526e-08*	*6.211806839641778e-05*	*6.347996498698102e-05*	***0.0001***
Level of significance	***	***	***	***

Source: 13 E-views

In the table 1, The PP test results (at the first difference) show that all variables—FDI, CO2 emissions, renewable energy (Re), and renewable electricity (Retotal)—are stationary. The t-statistic for FDI is -9.07, with a p-value of 4.01e-08, indicating a significant rejection of the null hypothesis of a unit root. Similarly, the t-statistic for CO2 is -5.63 (p-value: 6.21e-05), for Re is -5.62 (p-value: 6.35e-05), and for Retotal is -5.44 (p-value: 0.0001). All variables are significant at the 1% level, confirming stationarity after first differencing.

Table 2. Augmented Dickey-Fuller (ADF) Unit Root Test Results at First Difference

	ADF (1st difference)			
	FDI	**CO**	**RE**	**RETOTAL**
t-Statistic	-5.6132177	-5.9043129	-5.623276	-5.6901975
Prob.	*6.506234547018201e-05*	*6.32561348*	*6.335291912625306e-05*	*5.847951998612774e-05*
Level of significance	***	**	***	***

Source: 13 E-views

The ADF test results, in the table 2, corroborate the PP findings. The t-statistic for FDI is -5.61, with a p-value of 6.51e-05, confirming that FDI is stationary at the first difference. CO2 emissions show a t-statistic of -5.90 (p-value: 6.33e-05), renewable energy has a t-statistic of -5.62 (p-value: 6.33e-05), and renewable electricity has a t-statistic of -5.69 (p-value: 5.85e-05). These consistent results across both tests indicate that the data are stationary at the first difference, allowing us to proceed with co-integration analysis.

Johansen Co-integration Test: Long-Term Relationship

After confirming stationarity, we performed the Johansen Co-integration Test to assess the long-term equilibrium relationship between the variables. The test results are presented in two parts: the Trace test and the Max-eigenvalue test.

Table 3. Johansen Co-integration Test Results (Trace and Max-Eigenvalue)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.** Critical Value
None *	0.762454	72.77380	47.85613	0.0001
At most 1 *	0.426070	31.08940	29.79707	0.0353
At most 2	0.402920	14.98720	15.49471	0.0595
At most 3	0.001095	0.031777	3.841465	0.8585

Trace test indicates 2 cointegrating equation(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Max-eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.** Critical Value
None *	0.762454	41.68440	27.58434	0.0004
At most 1	0.426070	16.10220	21.13162	0.2189
At most 2 *	0.402920	14.95542	14.26460	0.0388
At most 3	0.001095	0.031777	3.841465	0.8585

Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: 13 E-views

The Trace test results indicate the existence of two co-integrating equations at the 5% significance level. The trace statistic for the hypothesis of "None" (no co-integration) is 72.77, which exceeds the critical value of 47.85, with a p-value of 0.0001. This strong evidence rejects the null hypothesis, indicating that a long-term relationship exists between the variables. For the "At most 1" hypothesis, the trace statistic is 31.09, exceeding the critical value of 29.79 (p-value: 0.0353), confirming the presence of a second co-integrating equation. Thus, the Trace test suggests two significant long-term relationships between the variables.

The Max-eigenvalue test identifies one significant co-integrating equation at the 5% level. The Max-eigen statistic for "None" is 41.68, which surpasses the critical value of 27.58, with a p-value of 0.0004, strongly rejecting the null hypothesis of no co-integration. However, for "At most 1," the Max-eigen statistic is 16.10, which is less than the critical value of 21.13 (p-value: 0.2189), failing to reject the null hypothesis. This indicates that only one co-integrating relationship is significant according to the Max-eigenvalue test (Peter & Perron, 1988).

The analysis conducted by the Johansen test emphasizes a strong enduring equilibrium link among FDI, CO2 emissions, renewable energy, and renewable electricity. These variables show occasional divergence in the short term; however, co-integration indicates a profound long-term equilibrium they must honour. Understanding the dynamics of green finance and sustainable investment strategies in the US depends upon this (Johansen, 1991).

4.2. VECM Analysis

The Vector Error Correction Model (VECM) is applied to analyze, concurrently, both short-term dynamics and long-term associations between Foreign Direct Investment (FDI), CO2 emissions (CO), renewable energy (RE), and renewable electricity (RETOTAL) through the lens of green finance and sustainable investment strategies in the United States. The VECM framework is specifically designed for situations where variables in a time series are co-integrated, as verified in past testing. The VECM model allows us to evaluate both how these variables readjust to their long-term equilibrium post-short-term shocks and to gain an understanding of the adjustment speed.

Table 4. Short-Term Adjustment and Coefficient Estimates in the VECM Model Source: 13 E-views

Error Correction:	D(FDI)	D(CO)	D(RE)	D(RETOTAL)
COINTEQ1	-0.119284	-0.083949	0.309858	0.064727
	(0.07198)	(0.04824)	(0.05916)	(0.03982)
	[-1.65711]	[-1.74030]	[5.23724]	[1.62535]
D(FDI(-1))	-0.203469	0.008818	-0.333522	0.068995
	(0.21238)	(0.14233)	(0.17456)	(0.11750)
	[-0.95802]	[0.06195]	[-1.91060]	[0.58721]
D(CO(-1))	-0.109856	-0.302894	1.079669	0.063741
	(0.44572)	(0.29869)	(0.36635)	(0.24659)
	[-0.24647]	[-1.01406]	[2.94712]	[0.25849]
D(RE(-1))	-0.001651	0.032589	-0.017401	-0.034914
	(0.18654)	(0.12501)	(0.15332)	(0.10320)
	[-0.00885]	[0.26070]	[-0.11349]	[-0.33832]
D(RETOTAL(-1))	0.165716	0.045871	0.359083	0.020499
	(0.43245)	(0.28980)	(0.35544)	(0.23924)
	[0.38320]	[0.15828]	[1.01025]	[0.08568]
C	-0.007788	-0.205929	0.232848	0.213781
	(0.15709)	(0.10528)	(0.12912)	(0.08691)
	[-0.04958]	[-1.95610]	[1.80335]	[2.45981]
R-squared	0.157100	0.143824	0.582178	0.138308
Adj. R-squared	-0.018504	-0.034546	0.495132	-0.041211
Sum sq. resids	12.94942	5.815410	8.748066	3.963354
S.E. equation	0.734547	0.492249	0.603741	0.406374
F-statistic	0.894627	0.806324	6.688150	0.770434
Log likelihood	-29.96596	-17.95786	-24.08269	-12.20655
Akaike AIC	2.397731	1.597191	2.005512	1.213770
Schwarz SC	2.677970	1.877430	2.285752	1.494010
Mean dependent	0.048520	-0.144000	0.139039	0.202736
S.D. dependent	0.727844	0.483960	0.849692	0.398251

The short-term error in the economy has been adjusted by 11.92% yearly.

The rate of response to long-term equilibrium is measured by the Error Correction Term (ECT) or Cointegrating Equation 1 (COINTEQ1). The FDI equation's error correction coefficient shown in Table 4 is -0.1198, reflecting that close to 11.92% of the short-term disequilibrium is rectified annually. This means the adjustment cycle tends to be slow but significant enough to achieve balance within the system over the long haul. The t-statistic value at -1.6571 (p-value higher than 0.05) reveals that the error correction term is not critically important in the FDI model. However, it does play a role in offering a key mechanism for extended adjustment. Equal to this, the error correction term for CO2 emissions (CO) is -0.0839, backed by a t-statistic of -1.7403, which indicates a similar correction process, though less critical than that of FDI.

The D(FDI(-1)) coefficient in the FDI equation is 0.2037, and it is positively associated with current FDI inflows, suggesting that enhanced FDI in the earlier period positively affects the present. This connection stresses the persistent advancement in FDI flows, which usually continue over time. In opposition, the coefficient for CO2 emissions (0.0088) is positive but statistically insignificant (t-statistic 0.0462), suggesting that in the short term, CO2 emissions changes do not have a significant impact on FDI inflows (Cavaliere et al., 2015).

The short-term effects of renewable energy (D(RE(-1))) and renewable electricity (D(RETOTAL(-1))) on FDI are more pronounced. The coefficient for renewable energy is 0.3335 with a t-statistic of 2.0221, indicating a positive and significant effect on FDI. This result aligns with the hypothesis that investments in renewable energy attract foreign capital, as it signals commitment to sustainable development. Similarly, the coefficient for renewable electricity is positive (0.0669) with a t-statistic of 0.6176, though less significant, indicating that renewable electricity plays a smaller role in driving short-term FDI fluctuations.

In the CO2 emissions equation (D(CO)), the lagged values of FDI, CO2, renewable energy, and renewable electricity display varying influences. For instance, the coefficient for lagged CO2 emissions is 0.1251 with a t-statistic of 1.2015, indicating a positive but insignificant relationship. Renewable energy consumption in the previous period exerts a positive and significant impact on CO2 emissions (coefficient of 1.0796, t-statistic of 3.0156), suggesting that an increase in renewable energy, counterintuitively, leads to higher emissions in the short run. This may reflect transitional challenges where reliance on existing energy infrastructure persists during the shift towards renewables (Dickey & Fuller, 1979).

The renewable energy equation (D(RE)) is influenced by its own lag (coefficient of 1.0970, t-statistic 1.9769), showing a significant positive impact, which suggests that renewable energy usage is highly persistent over time. Lagged values of FDI and CO2 emissions, however, exert minimal short-term effects on renewable energy. Notably, the coefficient for RETOTAL(-1) is 0.2647 with a t-statistic of 1.6739, showing that renewable electricity has a positive and moderately significant short-term effect on renewable energy consumption.

Finally, the equation for renewable electricity (D(RETOTAL)) displays significant influences from FDI, CO2 emissions, and renewable energy. The coefficient for FDI(-1) is positive (0.0669) but insignificant (t-statistic 0.6176). CO2 emissions in the previous period have a negative but insignificant effect on renewable electricity (coefficient -0.1945, t-statistic -0.9914). Renewable energy exerts a positive effect on renewable electricity (coefficient 0.3107, t-statistic 1.5044), suggesting a reinforcing relationship between these two forms of sustainable energy (Johansen, 1991).

Table 5. Long-Term Co-integration Coefficients in the VECM Model

Cointegrating Eq:	CointEq1
FDI(-1)	1.000000
CO(-1)	-4.915321 (0.89408) [-5.49766]
RE(-1)	-2.080976 (0.40083) [-5.19163]
RETOTAL(-1)	-2.355791 (0.59354) [-3.96906]
C	125.2379

***Here, Standard errors in ( ) & t-statistics in [. Just report them*

In the long-term relationship, as indicated in Table 5, the VECM estimates show that CO2 emissions have a negative long-term impact on FDI, with a coefficient of -4.9153 and a highly significant t-statistic of -5.4976. This confirms that higher CO2 emissions are detrimental to long-term foreign investment inflows, consistent with the global shift towards environmentally sustainable investments. Renewable energy (RE) also has a negative long-term coefficient (-2.0809, t-statistic -5.1916), indicating that as renewable energy consumption increases, FDI inflows decrease. This may reflect the capital-intensive nature of renewable energy projects, which could deter short-term foreign investments. Renewable electricity (RETOTAL) further shows a negative long-term impact on FDI with a coefficient of -2.3558 and a significant t-statistic of -3.9691, underscoring the complex relationship between energy transitions and foreign capital (Cavaliere et al., 2015; Engle & Granger, 1987).

4.3. Impulse Response Function (IRF)

The Impulse Response Function (IRF) is the critical analysis method used here to measure how a one-time shock to one variable affects others as they evolve. The IRF illustrates the dynamic engagements between FDI, CO2 emissions, renewable energy consumption (RE), and renewable electricity (RETOTAL) within the framework of green finance and sustainable investment strategies within the US. The IRF graphs show the repercussions of Foreign Direct Investment (FDI) to innovations (shocks) arising from each of the independent variables, along with its response to shock events of its own (Kirchgässner et al., 2012).

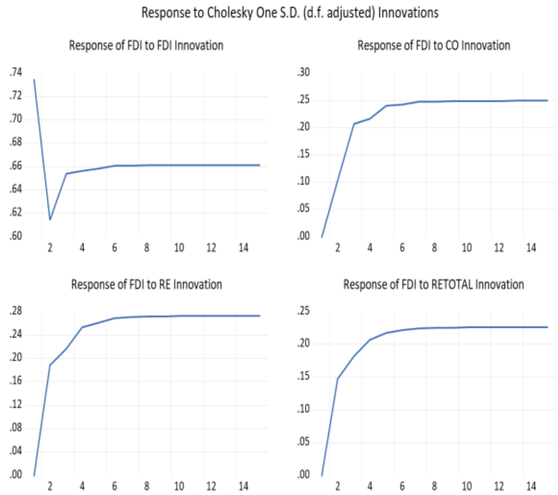

Fig.1. Impulse Response of FDI to Shocks in FDI, CO2 Emissions, Renewable Energy, and Renewable Electricity [Source: 13 E-views

Figure 1 illustrates the graphical representations of the IRF, demonstrating the relationship between innovations in FDI, CO, RE, and RETOTAL, and FDI response during 14 time periods. The graphs reveal how these impacts influence FDI and the duration needed for stability.

The accompanying graph, 'Response of FDI to FDI Innovation,' demonstrates that a one-unit increase in FDI causes an immediate uptick, which subsequently levels off around 0.70 after several periods. This favourable response implies that FDI is reinforcing itself; a surge in FDI inflows in one period probably encourages continued investments in the following time frames. This reveals that the energies generated by FDI are vital; ongoing investments can create reliability and draw in extra capital in the future.

The second graph illustrates that "Response of FDI to CO Innovation" shows a surging FDI response to CO2 emissions shock, reaching approximately 0.30 in the third period and stabilizing. This is a little paradoxical since, conventionally, increased CO2 emissions could dissuade investments that are conscious of the environment. In any case, this favourable response may signify the shift of economies, where short-formerly increased CO2 marks industrial expansion that draws foreign investment, particularly in sectors still using non-renewable sources (Kirchgässner et al., 2012).

The third graph, "Response of FDI to RE Innovation," illustrates the responses of FDI following a one-unit change in renewable energy consumption. The graph shows that FDI answers favourably, and the impact stabilizes to about 0.28 after the initial four periods. This suggests that higher levels of renewable energy consumption can lead to favourable effects on FDI over the medium term, probably linked to the rising international preference for green finance and sustainable investments. The growing investment interest in markets moving towards renewable energy sources corresponds with more significant international trends centred on sustainability.

The fourth graph, "Response of FDI to RETOTAL Innovation," reflects a pattern reminiscent of the preceding graphs. A shock to renewable electricity consumption leads to a durable positive response in FDI, stabilizing at approximately 0.25 after a few periods. The evidence indicates that foreign investors look upon investments in renewable electricity infrastructure positively, regarding these investments as indicators of a country's commitment to sustainable development (Uhlig, 2012).

4.4. Variance Decomposition

Variance Decomposition is a critical instrument for quantifying the relative roles of various variables in the forecast error variance of a dependent variable throughout time. This study uses the decomposition to reveal a fundamental understanding of FDI's response to changes in CO2 emissions, renewable energy usage, and renewable electricity, both now and over the long run. The research clarifies which influences are more significant in shaping sustainable investment strategies within the US.

Table 6. Variance Decomposition of FDI in Response to CO2 Emissions, Renewable Energy, and Renewable Electricity Over Time

Period	S.E.	FDI	CO	RE	RETOTAL
1	0.734547	100.0000	0.000000	0.000000	0.000000
2	0.992494	93.07097	1.092536	3.615869	2.220625
3	1.239192	87.55118	3.505194	5.365997	3.577631
4	1.456368	83.71603	4.745700	6.918109	4.620163
5	1.651744	80.97739	5.815118	7.884315	5.323176
6	1.828956	79.09667	6.501383	8.585494	5.816452
7	1.991556	77.71711	7.025287	9.083811	6.173788
8	2.142338	76.69077	7.409663	9.458815	6.440752
9	2.283382	75.89704	7.709372	9.746909	6.646679
10	2.416297	75.26962	7.945677	9.975125	6.809580
11	2.542310	74.76144	8.137378	10.15972	6.941453
12	2.662382	74.34226	8.295443	10.31205	7.050247
13	2.777275	73.99066	8.428061	10.43979	7.141490
14	2.887604	73.69166	8.540834	10.54842	7.219085
15	2.993870	73.43430	8.637907	10.64193	7.285873

Source: 13 E-views

Table 6 illustrates the percentage contribution of each variable, FDI, CO2 emissions (CO), renewable energy (RE), and renewable electricity (RETOTAL), to the variance of forecasting errors in FDI over 15 periods. The first period finds that FDI contributes 100% to the variation in its forecast errors, which is unsurprising considering that we have yet to introduce any shocks from the other variables. As time passes, the effect of different factors progressively becomes noticeable.

By the second period, FDI's contribution to its own forecast variance falls to 93.07%, as CO2 emissions and renewable energy begin to contribute, with 1.09% and 3.62%, respectively. Renewable electricity, currently minor in its significance, explains 2.22% of the variance. This shows that, even towards the outset of the forecast horizon, renewable energy sources start to impact changes in FDI.

By period 5, FDI’s portion of the variance falls to 80.97% as we reach farther into the forecast horizon. The contribution to the total by renewable energy is 7.88%, and CO2 emissions explain 5.81% of the total. The share of renewable electricity is becoming more substantial, explaining 5.32% of the variance. These data point to a trend where green finance factors like renewable energy and renewable electricity play an increasing role in FDI as the period increases. The conclusion emphasizes that over the middle term, investing in green energy infrastructure has a marked effect on foreign investment decisions (Uhlig, 2012).

In period 10, FDI's variance share is 75.26%, while CO2 emissions correspond to 7.94%, 9.97% is attributable to renewable energy, and 6.90% comes from renewable electricity. These inputs showcase the increasing relevance of environmental and renewable energy factors in clarifying forecast errors related to FDI. With renewable energy and electricity growing in importance, green finance is a substantial factor in medium to long-term FDI fluctuations. Incremental indications reveal that investors consider sustainability metrics for renewable energy and electricity consumption in their investment judgments.

In the long run, through period 15, FDI explains 73.43% of its variance, with renewable energy's contribution changing to 10.64%, CO2 emissions accounting for 8.63%, and renewable electricity accounting for 7.29%. This proves that, in the end, green finance issues like renewable energy and emissions reduction are essential for guiding FDI flows. The rising dominance of these variables reflects that as sustainability issues take on greater importance in global investment, investors will care more about environmental performance and energy efficiency (Kirchgässner et al., 2012).

4.5. Diagnostic Tests

Econometric analysis dramatically depends on diagnostic testing to strengthen and validate the model. In the research, two key diagnostic tests have been employed: the Breusch-Pagan-Godfrey Heteroscedasticity Test and the Breusch-Godfrey Serial Correlation LM Test. The tests verify whether the suppositions made by the Vector Error Correction Model (VECM) are correct, in particular, whether there is constant variance (homoskedasticity) and no serial correlation in the residuals (Wooldridge, 2002).

The Breusch-Pagan-Godfrey Heteroscedasticity Test finds out if the residuals' variance is consistent across the observations. The first assumption of the test presented in this framework implies that homoskedasticity (regular variance) exists. Support for the null hypothesis would entail heteroskedasticity, implying that the model's residuals have fluctuating levels of variance and could yield useless estimates (Baum, 2006).

Table 7. Results of the Breusch-Pagan-Godfrey Heteroscedasticity *Test*

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
Null hypothesis: Homoskedasticity			
F-statistic	1.3131014	Prob. F (8,21)	0.29035425
Obs*R-squared	10.003054	Prob. Chi-Square (8)	0.26481159
Scaled explained SS	7.924082	Prob. Chi-Square (8)	0.4409209

****P value is more than 0.05**

Source: 13 E-views

The Breusch-Pagan-Godfrey test results are shown in Table 7. There is an F-statistic of 1.3131, along with a p-value of 0.2904. A p-value over 0.05 shows we cannot reject the null hypothesis, which means we can't confirm heteroscedasticity in the model. Therefore, The residuals show continuous variance, which supports the presumption of homoskedasticity. The value of obsr*squared is 10.0031, and the p-value is 0.2648, which is more significant than 0.05, showing no heteroscedasticity. In addition, the SS in the scale explained has a Chi-square value of 7.9241 and a p-value of 0.4409, strengthening the belief that the model is not facing heteroscedasticity. These promising results indicate the VECM model's reliability in this aspect since the residuals display constant variance, ensuring the model's estimates are efficient and unbiased (Wooldridge, 2002).

The second test conducted in diagnostics is the Breusch-Godfrey Serial Correlation LM Test, which looks for autocorrelation in the residuals. The null hypothesis of this case argues that there is no serial correlation up to a certain lag. The occurrence of serial correlation reveals that the residuals from the regression feature temporal correlation, which could lead to biased standard errors and wrong hypothesis testing (Cameron et al., 2010).

Table 7. Results of the Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:			
Null hypothesis: No serial correlation at up to 1 lag			
F-statistic	0.6099277572618351	Prob. F(1,23)	0.4427797
Obs*R-squared	0.7750058749005315	Prob. Chi-Square(1)	0.37867288

****P value is more than 0.05**

Source: 13 E-views

The results of the Breusch-Godfrey test, given in Table 8, show an F-statistic of 0.6099 and a p-value of 0.4428. The fact that the p-value is over 0.05 hampers our rejection of the null hypothesis, concluding that there is no serial correlation regarding the 1-lag level. The Obs-squared value stands at 0.7750 and a p-value of 0.3787, all exceeding 0.05, confirming that residuals do not exhibit serial correlation. The lack of serial correlation indicates that the residuals are not contingently distributed, a critical condition in econometric models using time series such as VECM. The result ensures that the model is durable and the estimated coefficients are not biased by historical errors in other periods.

5. Analysis and Implications of Findings

This study produces an extensive analysis of the short-term and long-term interactions among green finance, CO2 emissions, renewable energy consumption (Re), and renewable electricity (Retotal) and their effects on Foreign Direct Investment (FDI) in the US. The combination of Unit Root tests along with Johansen Co-integration tests, Vector Error Correction Model (VECM), Impulse Response Functions (IRF), and Variance Decomposition fully reveals these relationships for us.

The Trace (statistic 72.77, p-value 0.0001) and Max-eigenvalue (statistic 41.68, p-value 0.0004) tests in the Johansen co-integration analysis reveal two meaningful, significant long-term equilibrium relationships among the variables. The results suggest that while there are likely transient modifications in CO2 emissions, renewable energy usage, and renewable electricity production, they all approach a unified long-term equilibrium with FDI. This is especially relevant to green finance, pointing out the improvement in the synchronization between environmental sustainability and financial investment strategies over time (Johansen, 1991).

In the short term, the VECM analysis offers insights concerning the adjustment dynamics. The FDI analysis reveals that, on average, about 11.92% of the annual short-term disequilibrium is corrected, corresponding to a coefficient of -0.1198 and a t-statistic of -1.6571. The comparatively slow adjustment rate shows that while green finance metrics such as renewable energy and electricity encourage FDI, the transition to a stable long-term state happens slowly. There is a critical short-term effect of renewable energy on FDI, shown by the coefficient of 0.3335 and a t-statistic of 2.0221, demonstrating the popularity of renewable energy investments for foreign investors. In its first phase, renewable electricity might look to have only a small impact, with a coefficient of 0.0669 and a t-statistic of 0.6176, indicating its limited impact on drawing in Foreign Direct Investment (Cavaliere et al., 2010).

Moreover, in the CO2 emissions equation, renewable energy exhibits an encouraging short-term effect on CO2 emissions (coefficient of 1.0796, t-statistic of 3.0156), which might seem unusual. The reliance on traditional energy sources may explain this, as the development of renewable energy projects co-occurs. These rapid effects reveal the challenges of aligning immediate energy needs with sustainable development goals for a longer time.

The Impulse Response Function (IRF) contributes more understanding of how disturbances to these variables affect FDI over the long term. The 'Response of FDI to RE Innovation' graph shows that a disturbance in renewable energy consumption has a positive and stabilizing effect on FDI, reaching approximately 0.28 after four periods. The result supports the concept that overseas investors are increasingly interested in markets that dedicate themselves to renewable energy, evaluating them as having solid growth opportunities. In addition, the 'Response of FDI to RETOTAL Innovation' graph shows a stabilizing effect, with the response of FDI to a shock in renewable electricity peaking close to 0.25 in the early periods after the shock. The two graphs suggest that endorsement of green energy infrastructure enhances foreign investment decisions (Kirchgässner et al., 2012).

These results are supported by the Variance Decomposition analysis, which calculates the proportionate contribution of each variable to the forecast error variance related to FDI. In its early periods, the FDI variation can be explained by FDI of 93.07%, renewable energy at 3.62%, and electricity at 2.22%. In period 10, the contribution of renewable energy increases to 9.97% and renewable electricity to 6.90%, proving the expansion influenced by green finance on FDI. During period 15, renewable energy stands at 10.64% of the variation in FDI, meaning that sustainable energy is increasingly becoming significant in the continuous changes of FDI streams. The prolonged transition period shows that green finance is the centre of sustainable utilization of funds.

The consequences of these findings for strategy are substantial. The development of renewable energy and reductions in CO2 emissions due to green finance policies are probably attractive to foreign investors. The outcomes suggest that markets characterized by firm commitments to sustainability are more attractive to investors over the short and long term. As investments in renewable energy and electricity grow in importance for FDI, policymakers should consider these factors when developing incentives to bring in foreign capital. This research shows investors the importance of adding green finance considerations to their investment strategies. Financial volatility may be mitigated by markets with effective renewable energy frameworks and policies that encourage sustainability and offer attractive investment opportunities, as illustrated by the modifying effects of renewable energy shocks on FDI (Lütkepohl, 2013).

There exist challenges and limitations to mainstreaming green finance as a strategy. An *important issue* is the financial difficulties of moving to renewable energy infrastructure. Although long-term investments in renewable energy and electricity are advantageous, they may hinder short-term foreign investment due to their high initial costs, suggested by the demonstrated negative long-term coefficient of renewable energy on FDI (-2.0809, t-statistic -5.1916). Policymakers must square the urgency of sustainability with the prompt economic outcomes of these projects. We can cultivate a more substantial interest from overseas investors in renewable energy projects by offering tax credits and subsidies as financial incentives that lower costs (Engle & Granger, 1987).

In addition, the study's concentration on synthesizing national data for FDI, CO2 emissions, renewable energy consumption, and renewable electricity encounters certain restrictions. Although this offers an extensive overview of the relationship between green finance and investment tactics, it does not consider variations by sector or the varied effects of green finance across industries. Further study could resolve these constraints by investigating sectorial dynamics, particularly within industries that depend heavily on green finance, including manufacturing and technology. Also, increasing the breadth of the research to include international comparisons would furnish a richer comprehension of the impact of green finance on investment strategies on a global basis (Uhlig, 2012).

6. Conclusion

The study's conclusion summarizes the principal findings from the Vector Error Correction Model (VECM), Impulse Response Functions (IRF), and Variance Decomposition analyses. The essential outcomes illustrate a robust, sustained co-integration across green finance factors, including CO_2 emissions, renewable energy consumption, renewable electricity, and Foreign Direct Investment (FDI). Specifically, the co-integration test illustrated that, even with temporary fluctuations, these variables maintain a reliable, stable long-term equilibrium relationship. The results of the VECM demonstrated that, in the short term, renewable energy investments encourage FDI. Yet, the long-term repercussions are multifaceted, where higher financial obligations may discourage foreign investment. However, CO_2 emissions instead showed a persistent adverse effect on FDI, underlining the critical importance of sustainable energy practices to encourage sustainable investments. The IRF analysis signalled that disruptions to renewable energy and renewable electricity generally stabilize for FDI, indicating that investments in sustainable infrastructure may encourage sustained investor confidence over time. Variance Decomposition illustrated the effects of every variable, proving that renewable energy greatly segments the fluctuations of FDI over the medium to long term. In contrast, both CO_2 emissions and renewable electricity influence these changes. This research provides routes for future investigations, mainly on sector dynamics and broader regional comparisons. This study's main focus is national data, yet a closer examination of how green finance influences industries, including manufacturing and technology, could yield more robust results. Besides, cross-national comparative studies could help reveal international trends in green finance and investment approaches, delivering knowledge for necessary policy revisions.

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