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Greening Growth: The Environmental Implications of Technology Innovation, Green Finance, and Foreign Direct Investment in Pakistan

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ABSTRACT

This research delves deeply into the intricate interplay among technology innovation, green finance, foreign direct investment (FDI), GDP, and their collective impact on the environment. Employing the Autoregressive Distributed Lag (ARDL) model over the timeframe spanning 1990 to 2021, the study aims to unveil nuanced insights into the intricate relationships that shape the environmental landscape. The study's findings offer an insightful perspective on the connections between these pivotal variables and their repercussions on environmental metrics. Specifically, the outcomes reveal a negative correlation between technology innovation, green finance, and CO2 emissions, as well as ecological footprints. This suggests a noteworthy linkage between technological advancements and the adoption of sustainable financial mechanisms with reduced carbon emissions and a less burdensome ecological footprint. These trends underline their potential to contribute positively to the well-being of the environment. In contrast, the study uncovers a positive correlation between FDI, GDP, and both CO2 emissions and ecological footprints. This observation underscores the intricate dynamics at play, wherein foreign direct investment and economic growth appear to exert pressures that escalate carbon emissions and environmental impact. This intricate relationship brings into focus the potential trade-offs between advancing economic development and preserving the environment, necessitating a thoughtful equilibrium for sustainable progress. The implications of these revelations hold substantial weight for policymakers and government officials in Pakistan. By illuminating the nuanced interconnections among technology innovation, green finance, FDI, and environmental indicators, this research equips decision-makers with invaluable insights to formulate effective policies.

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1. Introduction

In the ever-evolving tapestry of modern society, technology innovation has emerged as an undeniable catalyst, shaping every facet of our lives, from communication and healthcare to transportation and entertainment. This transformative power of technology has ushered in unparalleled convenience and efficiency, revolutionizing our interaction with the world. However, amidst these transformative triumphs, a growing shadow of concern has emerged – the impact of these innovations on the environment. As we find ourselves at the pivotal juncture of progress and preservation, it becomes paramount to unravel the intricate layers of technology's impact on the environment and to craft strategies that channel its potential toward fostering a sustainable future. The relationship between technology and the environment is a nuanced interplay of benefits and challenges. On one hand, technological innovation heralds a wave of solutions brimming with potential to mitigate pressing environmental concerns (Ali et al., 2022; Faheem et al, 2023). Notably, renewable energy technologies present alternatives to fossil fuels, tapping into sources like solar, wind, and water power. This transition not only slashes greenhouse gas emissions but also charts a course toward cleaner energy ecosystems. Electric vehicles stand as another emblem of progress, poised to metamorphose the transportation landscape by diminishing air pollution and reducing our carbon footprint (Farooq et al., 2023; Faheem et al., 2021).

Beyond this, the realm of technology-driven data collection and analysis opens the door to refined environmental monitoring and assessment (Ahmed et al., 2023). A symphony of sensor networks, satellite imagery, and advanced analytics furnishes scientists and decision-makers with real-time ecological insights, fostering informed judgments and targeted interventions. Here, technology evolves into a potent instrument for deciphering the intricate dance of ecosystems, tracking shifts in biodiversity, and orchestrating effective responses to natural calamities (Ullah et al., 2023). Yet, even as technology surges forward with unprecedented velocity, it carries its own ecological balance sheet. The manufacturing, utilization, and disposal of electronic devices generate electronic waste (e-waste), an escalating environmental concern. Mismanagement of e-waste translates into the contamination of soil, water, and air, while imperiling human health. Moreover, energy-intensive technological processes, like data centers and cryptocurrency mining, wield a hefty ecological toll through augmented energy consumption and ensuing carbon emissions. The dawn of the digital era, with its proliferation of smartphones, computers, and digital devices, casts a latent environmental shadow. Data centers, bastions of the digital realm, sustaining the deluge of information we both create and consume, demand prodigious amounts of energy for their operations and cooling systems. These energy requirements, oftentimes met by non-renewable sources, can exert undue strain on local power grids (Anwar et al., 2016; Ahmad et al., 2021; Chaudhry et al., 2021; Farooq et al., 2023; Uche et al., 2023).

Green finance, an innovative financing approach that places environmental sustainability at its core, is swiftly reshaping the financial landscape, bearing significant implications for our planet (Farooq et al., 2020). With its central goal of directing capital toward initiatives and projects with positive environmental outcomes, green finance is not only revolutionizing investment strategies and resource allocation but also playing a pivotal role in addressing urgent environmental challenges. One of the most substantial effects of green finance lies in its power to propel sustainable development and alleviate environmental degradation. By channeling funds toward endeavors that promote renewable energy, energy efficiency, sustainable agriculture, and clean technologies, green finance operates as a catalyst, diminishing carbon emissions and mitigating the impact of climate change. For instance, the funding of renewable energy initiatives, such as solar and wind farms, not only diminishes dependency on fossil fuels but also expedites the transition toward a low-carbon economy. Furthermore, green finance assumes a critical mantle in fostering innovation. The financial incentives extended to

businesses and organizations committed to environmentally friendly projects stimulate the advancement of research and development in clean technologies. This, in turn, gives rise to innovative solutions for enhancing energy efficiency, curbing waste, and managing resources sustainably. This innovative drive ripples across industries, nurturing a culture of innovation essential for addressing intricate environmental challenges.

Beyond its positive influence on environmental outcomes, green finance contributes to economic resilience and the mitigation of risks (Taneja & Ozen., 2023). As businesses and investors incorporate environmental considerations into their decision-making processes, they are better poised to anticipate and adapt to environmental risks. This proactive stance not only shields investments against potential losses resulting from environmental shocks but also encourages the adoption of sustainable business practices that can augment long-term profitability. Additionally, green finance champions transparency and accountability. The integration of environmental criteria into investment decisions demands heightened disclosure and reporting on environmental performance. This fosters a culture of transparency within businesses and financial institutions, enabling stakeholders to accurately assess the environmental ramifications of their investments. Consequently, companies are incentivized to enhance their environmental practices to attract green investments and showcase their dedication to sustainability. The reach of green finance transcends a single sector; its impact reverberates throughout economies, societies, and ecosystems. By mobilizing private capital in support of sustainable initiatives, green finance complements governmental endeavors to attain environmental targets outlined in international agreements like the Paris Agreement. It aligns financial objectives with environmental imperatives, fostering a harmonious synthesis of economic growth and ecological well-being (Triki et al., 2023; Anwer et al., 2023; Ahmad et al., 2023; Farooq et al., 2023; Chaudhry et al., 2021).

In the intricate realm of globalization and interconnected economies, Foreign Direct Investment (FDI) emerges as a formidable agent transcending geographic confines, orchestrating transformative shifts in worldwide economies and industries (Chaudhry et al., 2020). Amid the fervent pursuit of economic expansion, technological progress, and elevated employment prospects, FDI emerges as a conduit through which capital, proficiency, and inventive ideas traverse borders. Nevertheless, amid this pursuit of economic ascendancy, the environmental implications of FDI have garnered considerable attention and sparked lively debates. The nexus between FDI and the environment weaves a complex narrative, encompassing a spectrum of outcomes that span from constructive contributions to pressing apprehensions. This dynamic interplay prompts us to embark on a comprehensive exploration of the intricate impact of FDI on the environment, scrutinizing its potential to ignite environmental sustainability, propel resource depletion, usher in cleaner technological frontiers, and heighten the levels of pollution. In this expedition, our endeavor is to meticulously unravel the intricate threads that tether FDI and the dynamics of the environment, paving the way for a nuanced comprehension of how economic ambitions intersect with the ecological mandates on the global stage.

At the core of FDI's potential constructive influence rests its capability to nurture environmental sustainability. Foreign investors frequently import advanced technologies, managerial acumen, and exemplar practices from their home nations (Jan et al., 2023; Tanveer et al., 2023; Chaudhry et al., 2021). These transmissions of knowledge can potentially galvanize the adoption of ecologically benign production methods, resource-efficient methodologies, and sustainable business paradigms in the host nations. Consequently, FDI holds the potential to contribute to the curtailment of carbon emissions, the containment of pollution, and the advocacy of judicious resource management, thereby aligning economic growth with the stewardship of the environment. However, the symbiotic bond between FDI and environmental advancement is not devoid of intricacies. The pursuit of economic advantages, often

linked with augmented production and heightened consumption, can yield resource-intensive industries that exert strains on ecosystems, culminating in concerns of resource overexploitation. The establishment of extensive FDI ventures, such as mining enterprises or intensive agricultural setups, can act as catalysts for deforestation, habitat degradation, and soil erosion, thereby fundamentally reshaping local ecosystems (Wang et al., 2023; Tanveer et al., 2023). In this radiance, the ecological footprint of FDI extends beyond the immediate sphere of economics, fomenting deliberations on the equilibrium between development and preservation.

Moreover, the advent of FDI also introduces a dual narrative in the domain of technological advancements. On one hand, multinational corporations investing in host nations might bring forth advanced technologies that champion energy efficiency, waste abatement, and the adoption of renewable energy sources. This infusion of innovation has the potential to expedite the transition toward sustainable practices and cultivate a culture of environmental consciousness. However, the converse can also hold true, where industries tethered to antiquated or environmentally detrimental technologies may relocate to regions boasting less stringent environmental regulations. This migration exacerbates pollution levels, subsequently impairing air and water quality. In steering through this intricate terrain, governmental bodies and regulatory entities assume pivotal roles. Devising policies that incentivize environmentally conscious FDI while discouraging practices that run counter to environmental well-being becomes paramount (Kiani et al., 2023; Chaudhry et al., 2021; Tanveer et al., 2021; Umar et al., 2021). The establishment of robust benchmarks for environmental standards, coupled with mechanisms for vigilant monitoring and stringent enforcement, stands as a safeguard ensuring that FDI adheres to principles of sustainability. Similarly, the fostering of alliances between foreign investors, local communities, and environmental advocacy groups can give rise to an all-encompassing strategy that mitigates adverse repercussions and leverages the potential of FDI for constructive transformation.

The research impact of technology innovation, green finance, GDP and FDI on Environment in Pakistan" significantly contributes to our understanding in the following ways: The utilization of the Autoregressive Distributed Lag (ARDL) model for analyzing data spanning from 1990 to 2021 yields valuable insights into both the enduring relationships and fleeting dynamics of the studied variables. The ARDL model's aptitude for handling variables with mixed orders of integration proves fitting, offering a robust framework to assess the intricate connections between technology innovation, green finance, foreign direct investment (FDI), and the environment. (ii) Against the backdrop of the contemporary global context, this research addresses a pressing concern, shedding light on the pivotal roles played by technological advancement, sustainable financial mechanisms, and transnational investments in shaping economic growth and safeguarding environmental integrity. (iii) By centering on Pakistan, the study acknowledges the distinctive socio-economic and environmental milieu of the nation. The insights gained provide a tailored perspective capable of guiding policy formulations and strategic decisions aimed at harmonizing economic development with the preservation of the environment. (iv) The research underscores the pivotal significance of technology innovation. As a catalytic force capable of reshaping production processes, consumption patterns, and the utilization of resources, technology innovation's interactions with green finance and FDI are scrutinized. The collective influence of these factors on Pakistan's environmental trajectory is deciphered, contributing to an enhanced understanding of the intricate relationships at play. (v) The inclusion of green finance as a distinct element augments the research's contributions. Through a meticulous investigation of the interplay between green financing initiatives and their outcomes within Pakistan, the study casts light on the efficacy of such financial mechanisms in propelling sustainable practices and aligning economic growth with the imperative of environmental well-being. (vi) The ramifications of the research extend

beyond its immediate focus, permeating the broader discourse in the realm of environmental economics and sustainability. By unraveling the complex web of connections between economic advancement and environmental welfare, the findings enrich our comprehension of this nuanced interrelationship.

2. Literature Review

Ahmed et al. (2023) investigated the impact on china economic growth of technological innovation. Study used auto regressive distributive lag model and data was used over forty years almost. The results of this study were showed that technology innovation has positive impact on economic growth of selected economy. Ullah et al. (2023) studied that environment is a big problem nowadays in the world. Study checked the impact of public investment and technology on the environment of Pakistan. In this study was used (NARDL) asymmetric technique to check the association among the variables. Data was used over the time period from 1971 to 2021. The finding of this study were showed that there is the asymmetric relationship among the ICT, public investment, economic expansion and environment in Pakistan. Uche et al. (2023) examined that in underdeveloped countries foreign direct investment have a great role. Study found that foreign direct investment have positive relation with environment. For this panel auto regressive distributive lag model technique was used in the study. Study defined also that in the BRICS economies carbon emissions are systematic with the passage of time foreign direct invest, technological innovation and environment also cleaned the environment. And also found the in the traditional method foreign direct investment, technological innovation and environment have positive and negative both impacts

Jan et al. (2023) checked the relationship between financial development, trade, economic growth, foreign direct investment and innovation on environment in Pakistan. This study was used dynamic auto regressive distributive lag model to check the relationship among the variables. Results of the study were found that negative effect of urbanization, energy consumption, and economic growth on carbon emissions. Kiani et al. (2023) explored the technological impact on environment over the time period from 1991 to 2018 for selected countries. Auto regressive distributive lag model results were showed that in the long time period technological innovation have positive impact and in the short time have negative impact on environment. Ali et al. (2022) looked that in Pakistan remittances, technological innovation, natural resource and economic growth effect on the environment. In this study urbanization and energy consumption were used as dependent variables and all other were used as independent variables. The data was used over the time period from 1990 to 2019 and autoregressive distributive lag model was used to check the association among the variables. ARDL results were explained remittances have positive relationship with environment. Results also showed that carbon emissions, economic growth, urbanization and technology have negative impact on environment.

Usman et al. (2022) used autoregressive distributive lag model and data from 1991 to 2020. In this study nuclear energy, renewable energy, technology innovation environment variables for selected country Pakistan. Finding of this study showed that in long time period nuclear energy have negative impact and technological innovation decrease pollution in the long time period. Ullah et al. (2021) revealed that the role of technology in the economic development has very important role. Study was used annual data time period from 1990 to 2018. ARDL (auto regressive distributive lag) model was used to check the relationship between the variables. The results were showed that trade mark has symmetric impact on environment in long and short time period. Li and Ali (2023) aimed to study that how green finance decrease the carbon emission in China economy. The study was used Delphi and fuzzy analytical Hierarchy method to check the correlation among the selected the variables. The results were showed that political instability have a great crucial role in the green finance in China. The role of green finance to reduce the carbon emission very important.

Taneja and Ozen (2023) studied the association of green finance and energy consumption on environment in Asian countries. In this study panel (ARDL) technique was used to check the results of long and short time period. The results of this study were showed that green finance have negative impact on CO2. In the Asian Countries green finance and renewable energy reduce the carbon emission. Triki et al. (2023) influenced the performance of green finance and banks activities. In this study for the improvement of environment factor analysis technique was used. The results founded that banks and green financing have great impact on environment. Environment reduced with the use of green financing in the selected economies. Jahangir et al. (2023) studied the Saudi Arabia economies with the role of green finance and other variables like renewable energy, environmental quality and public health. The study was used data over the time period from 1980 to 2020. ARDL (auto regressive distributive lag) model technique was used to c heck the association among the variables. The finding of the study was revealed that all variables have impact on environment and also decrease the environments impact.

Du and Wang (2023) investigated the ASEAN countries impacts of clean energy, grean finance, economic growth, urbanization and foreign direct investment on environment. The study used twenty years data from 2000 to 2020. The results of ARDL were showed that clean energy and green finance have positive relationship with environment and also increased environmental quality. Economic growth and urbanization process increase the pollutions. Dai et al. (2022) identified China economy and the role of green finance, geopolitical risk, natural resource and environment. The data was used in this study time period from 1995 to 2020. Quantile auto regressive distributive lag model was used. The outcomes of the study showed that variables natural resources, agriculture development and geopolitical risk have positive impact on environment. Wu et al. (2023) explored the impacts population growth, foreign direct investment, trade openness and industries value added on environment in Pakistan India, Bangladesh, Bhutan, Sri Lanka and Nepal economies. The study was used data of Pakistan and all others economies from 1990 to 2021. Panel Autoregressive Distributed Lag model was used to check the relationship between variables in this study. Study was founded that industry value added and CO2 have a negative relation and positive impact of Foreign direct investment on environment. Wang et al. (2023) studied the China economy and check the relationship of economic growth, environment, foreign direct investment on economic efficiency. Study was used China data time period from 2009 to 2021. SBM (super-efficient model) was used to check the China economy impacts of selected variables. Results were showed that in the China economy environment have different affects at different places or different regions.

3. Methodology

The analysis employs ARDL model to investigate the relationship between the dependent variable, which is environmental impact, and the independent variables: technological innovation, green finance, GDP and FDI. The model is specified as follows:

$$CO_2 = \beta_0 + \beta_1(TECN) + \beta_2(GFIN) + \beta_3(FDI) + \beta_3(GDP) + \varepsilon$$

Where:
Environment = ENV; Technological Innovation = TECN; Green Finance =GFIN; FDI = Foreign direct investment; GDP = Gross domestic product

Variable Measurement & Data Source		
Measurement	Data Source	
CO2 emissions (kt)	WDI	Environment (CO_2)
Renewable energy consumption (% of total final energy consumption)	WDI	Green Finance (GFIN)
Patent applications, residents	WDI	Technology Innovation (TECN)
Foreign direct investment, net inflows (% of GDP)	WDI	Foreign Direct Investment (FDI)
GDP (constant 2015 US$)	WDI	Gross Domestic Product (GDP)

Descriptive statistics encompass a range of summary measures that are employed to depict and succinctly outline the essential attributes of a dataset. They offer a condensed perspective of the dataset's central tendencies, diversities, and distribution configurations. These statistics encompass metrics such as mean, median, mode, standard deviation, variance, minimum, maximum, and percentiles. In the realm of effective econometric analysis, descriptive statistics form the bedrock. They play a pivotal role in facilitating comprehension of the data, evaluation of its quality, assessment of model assumptions, selection of variables, and formulation of hypotheses. Through their initial portrayal of the data's characteristics, descriptive statistics aptly steer researchers toward suitable econometric techniques, thereby bolstering the soundness and dependability of subsequent analyses and conclusions (Farooq et al., 2022; Chaudhry et al., 2022; Faheem et al., 2022).

The correlation matrix holds a crucial significance within econometric analysis as it serves to illuminate the interconnections between variables and assists in the process of selecting and defining variables for modeling (Chaudhry et al., 2022; Faheem et al., 2022). It establishes a fundamental basis for generating hypotheses, conducting diagnostic assessments, testing assumptions, and exploring the dataset. Through the revelation of the inherent structure of the data, correlation matrices contribute to fortifying the accuracy and dependability of econometric analyses (Faheem et al., 2021).

Stationarity pertains to a characteristic of time series data wherein its statistical attributes remain consistent over time. Essentially, it implies that the data's mean, variance, and autocorrelation remain unaltered as time progresses. In the realm of econometric analysis, stationarity holds immense importance as numerous statistical techniques and models rely on or are optimized for stationary data. The Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test are instrumental tools employed to ascertain whether a given time series dataset exhibits stationarity or not (Farooq et al., 2022; Tanveer et al., 2022; Faheem et al., 2022).

Cointegration reveals meaningful, enduring relationships among non-stationary time series variables (Tanveer et al., 2022). The F-Bound test plays a crucial role in this context by enabling the detection of cointegration. This, in turn, assists in selecting appropriate models, preventing inaccurate regressions, and enhancing the precision of econometric analyses. As a result, it becomes a vital tool for researchers and analysts working in this field.

The Autoregressive Distributed Lag (ARDL) estimation technique is a statistical method utilized in econometrics to explore enduring connections between variables within a time series framework. It proves especially effective in scenarios where both the dependent and independent variables display varying integration orders, indicating non-stationary behavior. The ARDL approach entails constructing autoregressive models for both the dependent variable and lagged independent variables. This strategy

facilitates the examination of immediate short-term dynamics as well as lasting equilibrium relationships among the variables. The ARDL estimation method is favored in particular situations due to its array of benefits: (i) ARDL adeptly manages cases in which variables possess distinct integration orders (such as one variable being of order 1 and another of order 0). This adaptability renders it suitable for a diverse array of economic scenarios. (ii) ARDL tackles endogeneity concerns by incorporating lagged values of independent variables. This step assists in reducing potential bias in estimations. (iii) ARDL demonstrates solid performance even when dealing with relatively modest sample sizes. This proves advantageous when confronted with restricted data availability. (iv)ARDL estimation empowers researchers to analyze extended relationships between variables. This proves essential for comprehending the interactions of economic variables over prolonged periods. (v)ARDL allows for model selection based on information criteria, aiding in the identification of appropriate lag lengths and variables for inclusion in analyses. (vi) ARDL furnishes a framework for dynamic multiplier analysis, permitting researchers to scrutinize the effects of shocks and variable alterations over time. (vii) ARDL estimation maintains robustness against various types of heteroscedasticities and autocorrelation, common characteristics of economic time series data (Chaudhry et al., 2021; Farooq et al., 2021; Faheem et al., 2022). The following table shows the descriptive statistics and correlation matrix that description of variables and association of variables.

Descriptive Statistics & Correlation Matrix					
	CO2	TECN	GFIN	FDI	GDP
Mean	124443.8	116.6516	49.31987	1.040954	1.99E+11
Median	121608.7	91.00000	47.96000	0.735837	1.88E+11
Maximum	198738.8	387.2000	58.09000	3.668323	3.41E+11
Minimum	59026.00	16.00000	42.10000	0.375528	9.95E+10
Std. Dev.	42045.09	104.2243	4.063479	0.825176	7.45E+10
Skewness	0.159102	1.150201	0.420858	2.160517	0.428144
Kurtosis	1.831746	3.351020	2.501282	6.617068	1.910253
CO2	1	0.89	-0.93	0.05	0.98
TECN		1	-0.71	-0.05	0.94
GFIN			1	-0.23	-0.86
FDI				1	-0.048
GDP					1

The results of unit roots shows that all variables are integrated at first order of integration that leads to apply ARDL estimation.

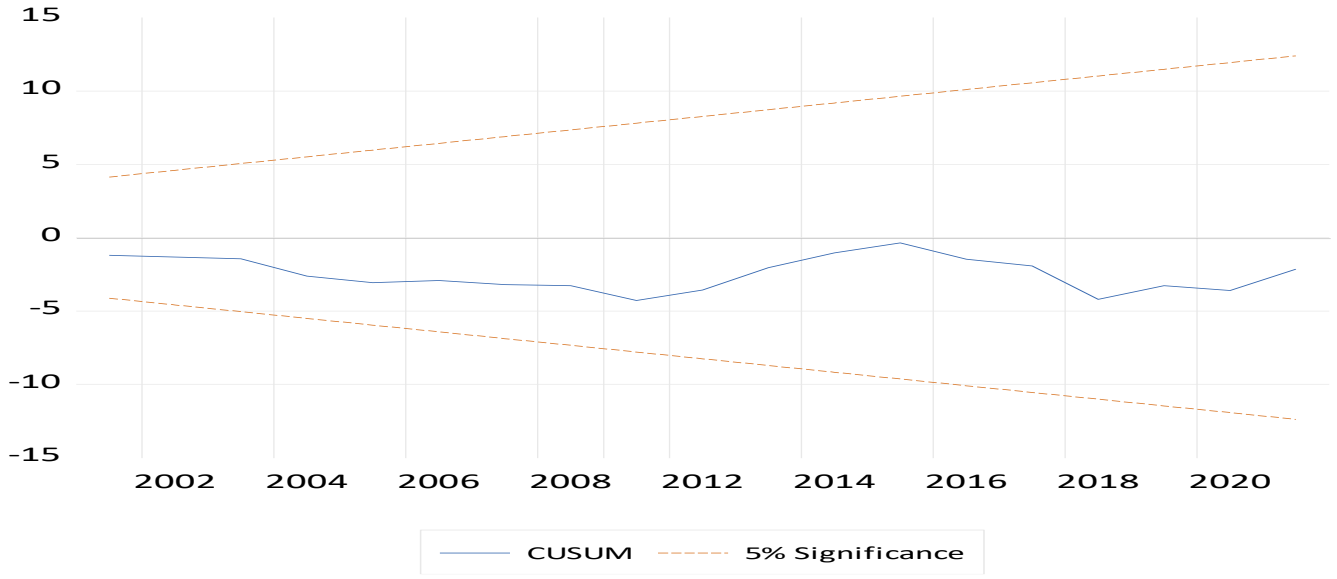
4. Results & Discussion

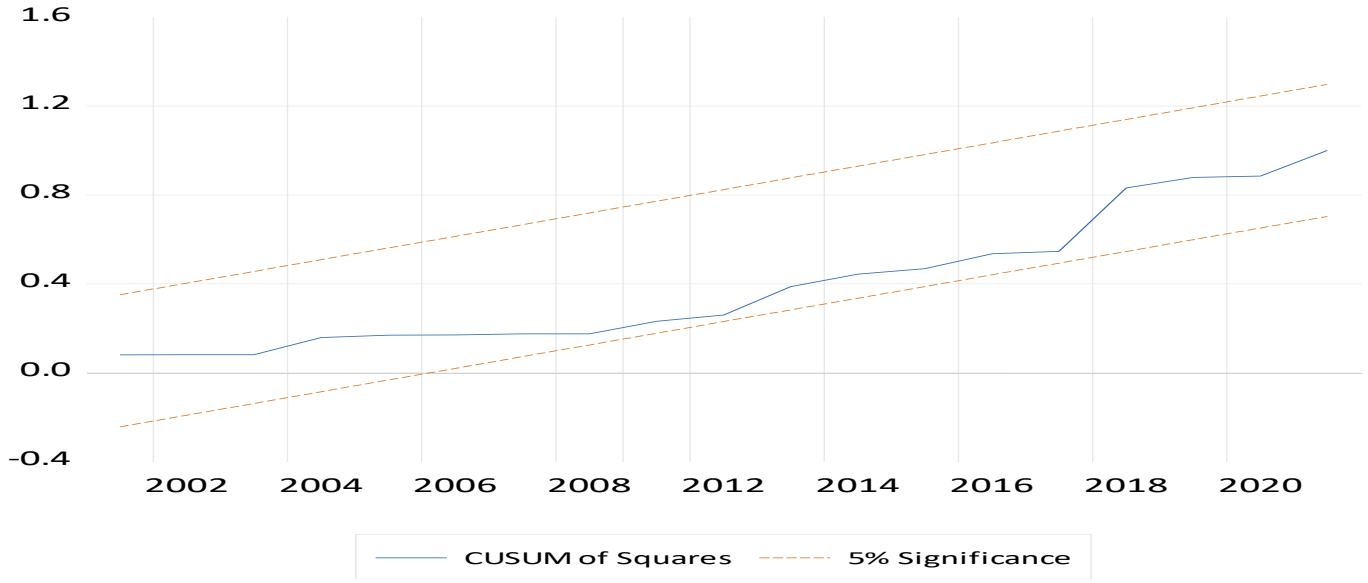
Table: Unit Root Test						
		CO2	TECN	GFIN	FDI	GDP
ADF	I(0)	-0.731	3.504	-2.149	-2.012	2.677
	I(1)	-4.619***	-4.444***	-4.254***	-3.613**	-3.682***
PP	I(0)	-0.739	3.345	-2.133	-2.055	2.63
	I(1)	-4.623***	-6.481***	-4.279***	-3.473**	-3.764***

Table: F-Bound Test					
F-Stat:6.61		1%	2.5%	5%	10%
	I(0)	3.74	3.25	2.86	2.45
	I(1)	5.06	4.49	4.01	3.52

The following table shows association of the variables in short and long run. The results report TECN and GFIN are negatively associated with CO2 emission while other variables FDI & GDP are positively associated with CO2 in both short and long run. The lower part of the table shows diagnostic test that reports our model is free from all problems.

Table: ARDL Results	
Long Run	Coefficient [t-ratio]
TECN	-0.87*** [-3.59]
GFIN	-0.02** [-2.53]
FDI	0.34* [1.98]
GDP	0.59*** [8.03]
C	2.65 [1.09]
Short Run	
D(CO2(-1))	0.56*** [4.51]
D(TECN)	-0.03* [-1.82]
D(GFIN)	-0.78** [-2.46]
D(FDI)	0.68*** [3.50]
D(GDP)	0.07* [2.35]
ECM(-1)	-0.81*** [-3.60]
Diagnostic Tests	
R^2	0.99
D.W	1.98
J.B	0.27(0.87)
Hetero	0.94(0.53)
LM	1.95(0.18)
Ramsey RESET	1.52(0.26)





5. Conclusion & Policy Suggestions

To conclude, this study, which investigates the impact of technology innovation, green finance, and foreign direct investment (FDI) on the environment, utilizing the ARDL model for the period spanning from 1990 to 2021, has yielded insightful revelations about the intricate relationships among these variables and their collective ramifications. The findings have illuminated both positive and negative associations, thereby presenting a comprehensive panorama of the intricate interplay between economic advancement and the imperative of environmental preservation. The study's revelation of the inverse correlation between technology innovation and green finance with CO_2 emissions and ecological footprints accentuates the potential of innovation and sustainable financial mechanisms to make positive contributions to environmental well-being. This accentuates the significance of cultivating an innovation-driven culture and embracing green financial practices as effective means to mitigate carbon emissions and alleviate ecological burdens. On the contrary, the observed positive links between FDI, GDP, and CO_2 emissions, as well as ecological footprints, underline the necessity for circumspect approaches to economic growth. While FDI and economic development are pivotal drivers, they concurrently possess the capacity to escalate environmental strains. This underscores the

paramount importance for policymakers to meticulously balance aspirations for economic expansion with commitments to environmental preservation.

The implications of the study's findings bear substantial weight for policymakers and government authorities in Pakistan, as they navigate the intricate terrain of technology innovation, green finance, and FDI within the context of environmental sustainability: (i) Encouraging and supporting technology innovation can lead to reduced carbon emissions and a diminished ecological footprint. Policymakers can stimulate research and development in clean technologies, thereby cultivating an environment conducive to eco-friendly innovation. (ii) The study emphasizes the value of green finance in mitigating carbon emissions and ecological impact. Policymakers can formulate policies that further incentivize investments in sustainable projects and encourage the adoption of green financial practices. (iii) While FDI and economic growth are indispensable, it's imperative to acknowledge their potential environmental consequences. Policymakers can introduce measures that ensure FDI aligns with sustainable practices, thereby accounting for both economic and ecological aspects. (iv) Given the diverse associations uncovered, policymakers can implement robust monitoring and reporting mechanisms for CO2 emissions, ecological footprints, FDI, and GDP. This data-driven approach can facilitate timely interventions and informed policy adjustments.

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