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Sustainable Synergy: Exploring the Interplay of Green Finance and Financial Technology in Driving Economic Growth

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Abstract

Purpose: This study investigates the interplay between green finance (GF) and financial technology (Fintech) in driving sustainable economic growth in Pakistan.

Approach: Using a regression model, the impact of GF and Fintech on sustainable economic growth indicators, namely Economic System (ES) and Environmental Quality Management (EQM), is analyzed across six time periods.

Findings: The results reveal significant positive relationships between GF and both ES and EQM, with coefficients ranging from 0.007 to 0.016. Similarly, Fintech demonstrates a significant positive association with ES, ranging from 0.004 to 0.007 across different time periods. Moreover, the interaction term (GF*Fintech) exhibits a significant impact on ES in certain periods, emphasizing the synergistic effects of GF and Fintech on economic sustainability. Additionally, variables such as energy consumption, GDP per capita, and fiscal expenditure significantly influence ES and EQM outcomes. Co-integration tests confirm the existence of a long-term equilibrium relationship among the variables, further supporting the regression analysis results.

Originality: The study underscores the importance of integrated policy approaches to promote green finance and financial technology initiatives, highlighting their critical role in achieving sustainable economic growth and environmental quality management in Pakistan.

Keyword: Green Finance, Economic Growth, Fintech, CO_2 emission, Sustainability, GDP

1. Introduction

In recent decades, Pakistan has witnessed significant economic growth, propelled by the government's implementation of new economic policies aimed at judiciously harnessing obtainable eco-friendly resources. However, the consequential over-exploitation of forest resources has led to environmental degradation, posing a considerable contest to urgently safeguard the environment and mitigate adverse impacts on human health (Ahmad et al., 2020). Recognizing this urgency, the country has strategically

directed resources toward building a green ecosystem, particularly to cater to the needs of rural communities whose livelihoods depend heavily on locally available environmental resources (Udeagha & Muchapondwa, 2023b). The current focus in Pakistan is on addressing energy needs, with heightened attention on fossil fuels, which currently fulfill approximately 50% of various energy demands in the country. However, the extensive use of fossil fuels has raised environmental concerns, as it releases a significant amount of toxins into the environment, resulting in ecosystem damage (Park & Kim, 2020). Numerous researchers such as Liu et al. (2021) and Dikau & Volz (2021) have been actively exploring methods to mitigate environmental degradation, and concurrently, the Pakistani government has been formulating sustainable objective for the nation. This approach plays a pivotal role in steering the sustainable development of the Pakistani economy and contributes to global efforts in this direction. Green finance is a multifaceted domain that intersects finance and environmental considerations, gaining global recognition for fostering high-quality development across various sectors (Zeng et al., 2023). In alignment with this, Pakistan has made strides in green finance, exemplified by the issuance of $500 Million in green bonds in 2021, with plans for an additional $2.2 million in 2022, signifying a commitment to transitioning toward a low-carbon economy.

The advantages of green finance are manifold, encompassing its provision of operational, investment, and financing solutions within the financial industry (Ormiston & Wong, 2013). This approach not only offers a financial outlook for projects but also aligns with the objective of environmental sustainability. While green finance has gained prominence in emerging economies, its specific contribution to high-quality economic development remains a subject of ongoing exploration (Chakrabarti & Sen, 2021). Concurrently, fintech in Pakistan has witnessed exceptional growth, mirroring the global trend. The swift embrace of financial tech by both user and entrepreneurship is expected to be a pivotal factor in Pakistan's pursuit of a sustainable monetary system and robust economic development of superior quality (Alzoubi, 2021). Nevertheless, there are persisting challenges, particularly in the dynamics of demand and supply for reserves in renewable sectors, necessitating prompt attention and resolution. The integration of fintech accelerates the growth of green finance by addressing information asymmetry for investors and stakeholders, enhancing efficiency, valuing natural assets, and promoting sustainable lifestyles conducive to supporting quality economic growth (ElDeeb et al., 2021). Green finance, distinguished by its affiliation with superior and sustainable development, emerges as a vital component of economic expansion, laying the groundwork for strategic prosperity. It functions as a link that proprietors, entrepreneur, business and involved parties, thereby aiding in the attainment of the nation's sustainable development goals and adhering to principles of environmental stewardship (Vergara & Agudo, 2021).

This study contributes significantly to various knowledge domains and enriches the existing literature on green finance in several ways. Firstly, it enhances the scholarly understanding of green finance by conducting a thorough analysis, thereby adding valuable insights to academic research focused on comprehending its effects on superior economic growth. In contrast to prior studies that often concentrated on specific environmental dimensions of economic development, this research uniquely explores the broader effect of green financing on holistic and high-quality economic progress. Secondly, the study addresses a recent call for increased attention to the role of fintech in propelling the expansion of green finance. Recognizing a gap in current research that lacks exploration of how fintech alters the dynamics between green finance and economic growth, the study introduces financial technology as a moderator variable. The objective is to investigate its underlying influence on the relationship between green finance and high-quality economic growth. This approach contributes a nuanced perspective to understanding the developmental impact of green finance, with the findings on fintech potentially offering valuable insights for stakeholders. Such insights could empower stakeholders to reshape economic growth by advancing initiatives in both green finance and financial technology

Green finance involves the allocation of financial resources to projects and initiatives promoting sustainable progress, environmental goods, and strategies that foster the expansion of a further sustainable economy (Gao et al., 2023). Notably, financial institutions, in assemble investment and financing choices, consider environmental protection, directing funds towards green industries (Tamasiga et al., 2022). Green finance serves as a bridge, introducing variables aimed at ensuring sustainable economic development. By efficiently channelizing resources, green finance contributes to both environmental protection and economic efficiency (Y. Q. Zhang, 2023). Research indicates that green finance positively influences ecological environments, economic efficiency, and economic structures, thereby contributing to high-quality economic development (Nenavath & Mishra, 2023).

Fintech, a fusion of financial services and technology, offers abundant opportunities by enabling financial organizations to streamline solutions effectively through technological advancements

(Udeagha & Muchapondwa, 2023b). Nevertheless, the influence of fintech in laying the groundwork for a sustainable and high-quality economic development framework remains a topic under continuous investigation, primarily due to its early stage of development, with its complete impact still not entirely comprehended. The attainment of high-quality economic development encompasses a multitude of factors. . Liu et al. (2021) and (Y. Zhang et al., 2020) Studies highlight that countries have historically exploited natural resources extensively for sustained economic growth, particularly in traditional industries lacking technology innovation and energy efficiency. High-quality economic growth is a complicated process influenced by factors such as technological innovation, organizational considerations, financial elements, and political factors. As countries seek a balance between economic growth and environmental sustainability, green finance and fintech emerge as critical components in shaping a framework that ensures sustainable development (Cen & He, 2018) and (Vergara & Agudo, 2021).

Financial technology, a term encompassing cutting-edge solutions designed to modernize and automate the delivery and utilization of financial services, plays a pivotal role in the financial landscape, particularly in Banking, Financial Facilities, and Insurance sectors (Nenavath & Mishra, 2023). In Pakistan, Fintech is positioned as the third-largest globally, following China and the USA, with a projected Compound Annual Growth Rate (CAGR) of 24.57%. Its significance lies in reshaping traditional practices within the financial industry, impacting both products and services (Abdul-Rahim et al. (2022) and Deng et al. (2019) and Najaf et al. (2023). Notably, the growth of fintech innovation, as observed in countries like China, correlates with advancements in green credit, investments, and initiatives fostering environmental sustainability. This symbiotic relationship between green development and technological innovation underscores the importance of efficiency improvements (Y. Q. Zhang, 2023).

Studies Nenavath & Mishra, (2023); Tamasiga et al. (2022), indicate that the ease of gaining vital financial facilities, such as loan, drives the advent of new financial tech industries. Furthermore, the presence of sufficient attendants, cellphones subscribers, and a skilled workforce fosters fintech growth. Challenges in accessing traditional financial services lead to the rise of fintech initiatives. The expansion of fintech not only facilitates easier access to funding and investment for private investors but also has the potential to enhance the overall efficiency of the financial system. However, it is essential to acknowledge that technological innovation, while a crucial factor in economic growth, raises concerns about environmental pollution (Cen & He, 2018) and Puschmann et al. (2020). The potential advantages, such as increased production efficiency and reduced costs, need to be balanced against the increased usage for natural resources, potentially hindering economic development (Vergara & Agudo, 2021).

Technological advancements and the effectiveness of innovation contribute to knowledge acquisition, reducing financial friction through information symmetry (He et al., 2020). Fintech innovation, focusing on digital transformations like artificial intelligence, cloud computing, and block chain, accelerates ecosystem evolution. It expands financial aid, streamlines resource allocation, and aids in reducing educational finance, thus contributing to sustainable economic development (Nassiry, 2018). Financial technology not only facilitates easier access to new financial resources from a broader investor base but also supports green investments, notably through green bonds that reduce carbon footprints and create long-term value(Y. Q. Zhang, 2023). In the context of agriculture, fintech can revolutionize funding and distribution methods, enabling sustainable projects or business enterprises by gathering funds online from multiple contributors (Cen & He, 2018) and (Udeagha & Muchapondwa, 2023). An illustrative example is the application of fintech by ANT Group in China, which tracks and rewards individuals for environmentally friendly choices, such as planting trees on their behalf (Gao et al., 2023). This not only brings efficiency to the financial world but also fosters positive environmental change in society.

Green finance represents a suite of environmentally beneficial instruments that contribute to ensuring sustainable economic development (Zeng et al., 2023). The mechanism of green finance bridges the gap left by traditional financial systems, which often prioritize project profitability, by adopting a broader perspective that includes considerations for environmental protection and energy efficiency. Research Yoshino, (2019), increasingly recognizing the importance of sustainable finance in ensuring high-quality economic development, contributing to the development of a society with both economic prosperity and environmental sustainability. Pakistan, with its existing technological capabilities and strong bank-enterprise relationships, has an opportunity to leverage these strengths to shift focus toward green finance. The EKC (Environmental Kuznets Curve) theory suggests a U-shaped connection amongst economic growth and Carbon dioxide emissions (Y. Q. Zhang, 2023). Although a linear

correlation is evident up to a specific threshold, emissions exhibit a decrease during prolonged periods of high-quality economic development beyond that point. Variances among cities are underscored in terms of resource utilization, societal and economic advantages, and environmental factors affecting green growth, as indicated by various studies. The significance of R and D spending, though not necessarily advantageous in the short run, proves essential for fostering the long-term benefits crucial to the advancement of a high-quality economy. The complex nature of economic development calls for a detailed examination, seeing numerous effect factors individually to gain a comprehensive understanding (Salari et al., 2021).

In the financial technology sector, certain companies are proactively incorporating technology to establish an environmentally sustainable financial system, aimed at reducing carbon dioxide emissions and promoting efficient utilization of resources (Udeagha & Muchapondwa, 2023b). Notable examples include jazz cash, one pay, U paisa, and easy paisa, which are among the largest fintech companies in Pakistan. These companies leverage mobile apps to promote customer engagement in sustainable finance ventures, encouraging behaviors that reduce CO_2 emissions (Y. Q. Zhang, 2023). For instance, users have the opportunity to cultivate a virtual tree as part of an initiative to restore deserts, earning green energy and aiding in carbon reduction. Nevertheless, there exists a research gap concerning the active involvement of financial technology (fintech) companies in initiatives focused on environmental conservation in Pakistan. The extent to which fintech firms actively contribute to such efforts remains unclear, introducing uncertainty regarding the effectiveness of fintech in expediting the transition to green finance for sustainable economic development in Pakistan (Yan et al., 2022, 2022). This study investigates the role of fintech as a key determinant influencing the outcomes of sustainable finance on economic growth sustainability. In the Pakistani context, comprehending the interplay between green finance, economic development, and fintech is crucial for developing strategies aligned with the country's distinct economic and environmental conditions. Specifically, the assessment of sustainable economic growth revolves around two key dimensions: the economic system (ES) and Environmental Quality Management (EQM), each comprising three parameters. The findings suggest a substantial and positive influence of green finance on the identified characteristics of sustainable economic growth.

Studies exploring the global landscape of Green Finance shed light on regional variations in its implementation and impact. For instance, research on China's Green Finance initiatives provides insights into how a country can use financial mechanisms to support environmental goals and sustainable economic development (Zhao et al., 2019). Cross-country analyses contribute to a nuanced understanding of the contextual factors influencing the relationship between Green Finance, environmental quality, and economic systems. As the global community increasingly recognizes the urgent need for sustainable practices, the literature has explored the multifaceted impacts of Green Finance on both the environment and economic structures. It posits that green finance plays a crucial role in fostering environmental quality by providing guidance and incentives for stakeholders to achieve a harmonious balance amongst economic protection (Cruz Rambaud & Expósito Gázquez, 2022; Demir et al., 2022; Deng et al., 2019).

Firstly, GF (green finance) supports businesses adopting a greenish business approach, enabling them to access substantial loans and facilitating their transition to a more sustainable operational model, reducing energy consumption and environmental pollution (Lagoarde-segot et al., 2020). Secondly, it empowers stakeholders, particularly enterprises, to oversee the entire investment process and ensure alignment with green values (Bayram et al., 2022). Finally, green finance promotes the use of renewable fuels in consumer groups and encourages financial institutions to regulate credit for acquiring green products such as electric vehicles (Pizzi et al., 2021). Researchers argue that investments in renewable energy, energy efficiency, and environmentally friendly technologies can significantly contribute to enhancing environmental quality (Zhang et al., 2020). The shift towards green investments is seen as a proactive approach to mitigating environmental degradation and promoting ecological sustainability (Vergara & Agudo, 2021).

Regarding its impact on the economic system, the research indicates that green finance has a favorable effect. Infrastructure initiatives backed by green finance gain advantage from a favorable policy environment, drawing substantial investments to environmentally friendly projects and stimulating the growth of more sustainable production processes. The study demonstrates that green finance effectively facilitates the transition of environmentally harmful and energy-intensive entities into eco-friendly manufacturing through specific credit policies, thereby enhancing and supporting the overall advancement of the financial system (Liu et al., 2021).

The influence of financial technology (fintech) on EQ and the overall ES is a critical aspect of this study. Fintech, encompassing innovative financial products and services, is driven by advancements in AI, BD, CC, and BT, collectively known as ABCD. These technologies have the potential to significantly enhance the efficiency of financial services. In this context, fintech provides specific facilities that effect of the effectiveness on GF on economic development (Nenavath & Mishra, 2023). Addressing a research gap in green finance, fintech can collaborate with green finance to make sustainable projects more accessible. Notably, fintech offers advantages such as better financial regulation for customers, quick issue resolution, and efficient operations, enabling seamless business interactions in various scenarios (Tamasiga et al., 2022).

2. Research Methodology

The present study examines the impact of green finance and fintech on sustainable economic growth, employing a regression model represented by the equation:

$$S_{ijt} = \beta_0 + \beta_1 GF_{it} + \beta_2 FT_{it} + \beta_3 GF_{it} * FT_{it} + \beta_4 CV_{it} + \varepsilon_{it} \quad (1)$$

In this equation, S_{ijt} represents the indicator of sustainable economic growth for province j in year t in Pakistan. GF_{it}(green Finance) signifies the extent of growth in Pakistan over the research tenure, FT_{it} shows the strength of fintech in Pakistan Province, and C_{it} represents the value of CV (control variable). The term GFit×FTit accounts for interaction effects, where independent and control variables are standardized prior to computing the multiplicative terms to mitigate issues of multi collinearity. B0 is the intercept term, while β1, β2, β3 and β4 are coefficients associated with the respective regressor, moderator, and control variables. ε denotes the random error term.

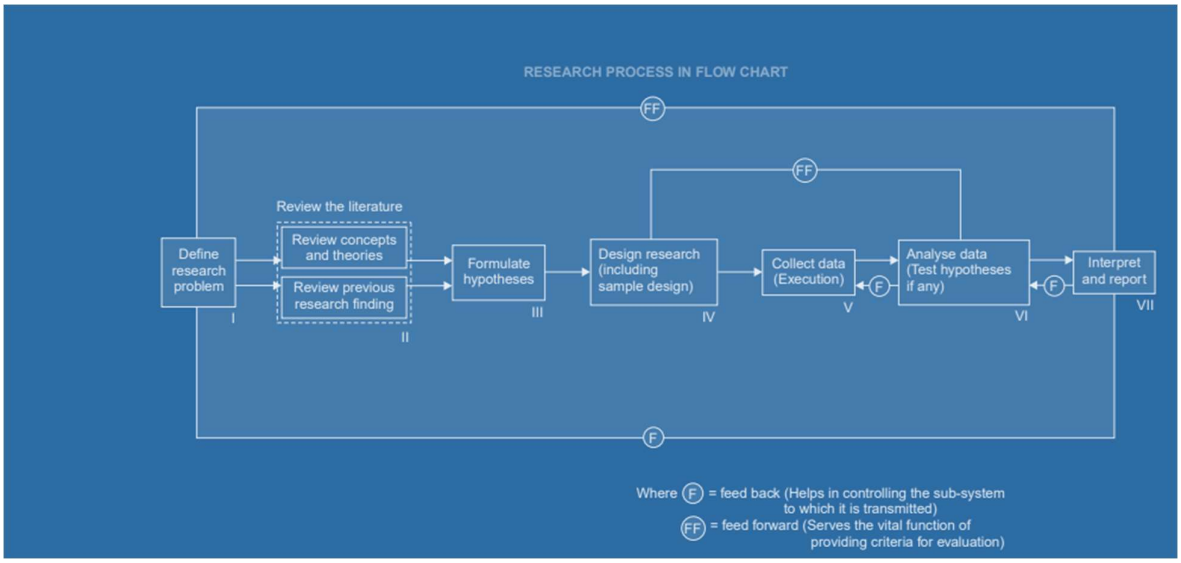

Figure 1. Research Process in Flow Chart

2.1. Medley of Independent, control, moderator and dependent variables

In this research, the concept of sustainable economic growth is operationalized through two key indicators: the Financial System (ES) and Environmental Quality Management (EQM). The formulation of these indicators is based on the framework developed by Zeng et al. (2023), adhering to established principles of arrangement and information availability. EQM specifically refers to the approach employed to achieve economic progress that is environmentally sustainable and involves the protection of resources. On the other hand, ES measures the allocation of resources and the workforce across three financial systems, encompassing industrial development and investment. The specifications of these measurements can be shown in Table 1.

Table: 1 Sustainable Economic Growth (SEG) measurement

DV	Construct	Measurement
Economics System (ES)	Industrial-growth	Market-size/number of year
	Financial-system (FS)	Total-foreign-investment/ Gross Domestic Product
	Investment	Return on Investment = Net Income/Cost of investment * 100
	Discharge Industrial waste per unit Gross	release of Industrial wastage/ Gross

	Domestic Product	Domestic Product
Environmental quality Management (EQM)	Carbon dioxide (CO_2) Emissions per Unit of Gross Domestic Product	Carbon dioxide (CO2/Gross Domestic Product
	Sulphur dioxide (SO2) emissions per unit Gross Domestic Product	Sulphur dioxide (SO2)/Gross Domestic Product

Source: Authors

The research meticulously selects Independent variable parameters for constructing the green finance index based on the classification provided in (Nenavath & Mishra, 2023). Green finance is categorized into 4 subparts, namely: (a) carbon finance, (b) green insurance, (c) green securities, and (d) green investment. The creation of these four features is detailed as follows:

a. **Carbon Finance:** Quantification entails evaluating the percentage of carbon dioxide (CO_2) emissions in relation to the gross domestic product (GDP). The main contributors to CO_2 emissions consist of coal, oil, and natural gas. This calculation is performed using the equation: carbon dioxide emission = $\mu 1 \beta 1$coal + $\mu 2 \beta 2$ natural gas + $\mu 3 \beta 3$ petroleum. The constants μ and β are predetermined by the International Panel on Environment Change (IPEC).

b. **Green Insurance:** Measurement is based on ecological pollution liability insurance. It is crucial to note that the development of insurance exposure in Pakistan is in its early phases, and the available suggestion is insufficient.

c. **Green Securities:** Computation requires establishing the ratio between the TSMV of listed companies operating in the environmental quality management sector in Pakistan Province and the overall Total Stock Market Value of all listed firms throughout the study duration.

d. **Green Investment:** Represents the allocation of resources to pollution-resistant ecological projects with the aim of reducing environmental impact and achieving sustainable growth. The emphasis in this study is on the public sector, with green investment expressed as the ratio of Pakistan fiscal expenditure on energy management and environmental quality protection to Pakistan total budgetary outflow.

The moderating indicator, Fintech, the strength of financial tech firms reflects the concurrent activity and expansion of fintech in rural areas. The study quantifies the financial technology strength by aggregating the count of newly launched financial technology projects as a measure of the overall financial technology activity.

Meanwhile, variations in trade and industrial development among states can impact economic growth. To mitigate the impact of contention in industrial development on economic growth, the paper utilizes the previous year's energy consumption data. GDP per capita serves as an indicator of the overall economic growth level within a state. The study employs the logarithm of selected variables to address skewed distributions. Education regulations play a crucial role in influencing economic growth, and the study uses the proportion of education expenditure to GDP as an indicator of the education level. Information associated to fintech were composed from the Pakistan financial tech survey (Karandaaz Financial Inclusion Survey, 2023). Descriptive statistics of variables are presented in Table 2.

Table:2 Descriptive statistics of variables

Variables	M	SD.	Mini.	Max.	Sample Size
EQM	0.47	0.15	0.1	0.73	426
ES	0.15	0.07	0.03	0.59	426
GF	0.00	0.63	−0.79	1.05	426
F.T	131.23	341.23	0	2963	426
E.C	5.17	0.29	3.57	6.39	426
GDP.PC	7.42	0.35	5.29	7.14	426
Edu. %	0.04	0.02	0.03	0.09	426
F.E	0.19	0.09	0.06	0.49	426

Source: Authors

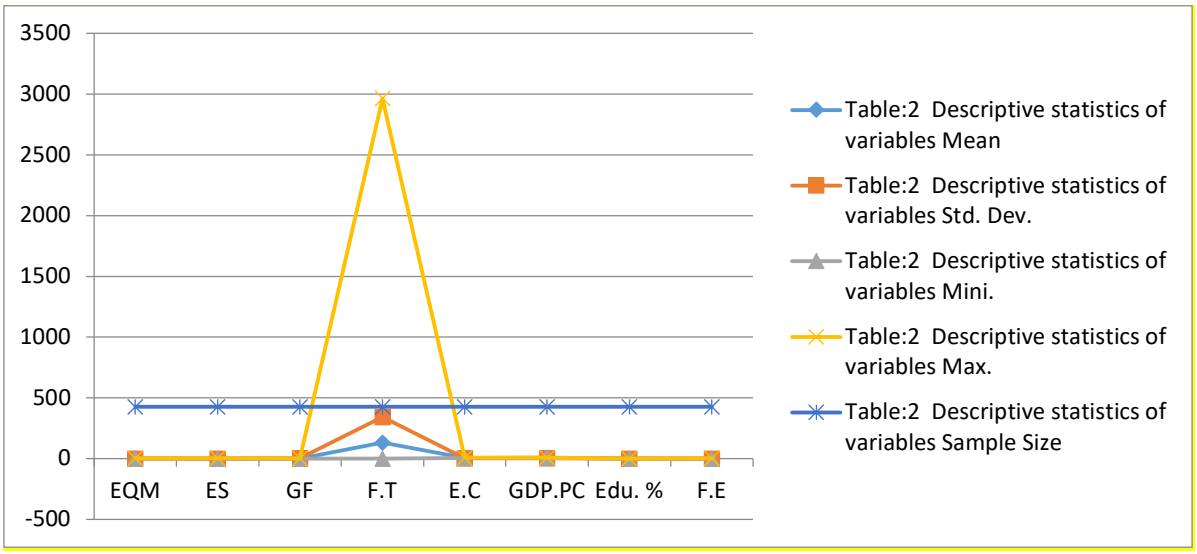

Figure 2: Graphical explanation of descriptive statistics

3. Data Analysis and Interpretation

The VIF is a measure of multicollinearity in regression analysis, indicating the extent of relationship between independent variables in a multiple regression model. Table 3 reveals that multicollinearity is not a significant concern, with the maximum VIF being below the predetermined threshold for selected variables. The VIF results suggest the absence of multicollinearity in this study.

Stata is employed to perform the Harris-Tzavalis and Im-Pesaran-Shin tests for assessing the stationarity of each variable series. The unit root test is conducted on the first-order difference values, and the findings suggest the absence of a unit root order at a 1 percentage significance level. This implies that all initially non-stationary categories become 1st order stationary after differencing. Further examinations are required to investigate the presence of a long-term equilibrium relationship and co-integration among the variables.

Table 5 elaborates the outcomes of the Kao-panel-co-integration and Pedroni-panel-co-integration tests on variables such as economic system and EQP. The outcomes of these tests, all significant at the 5% level, suggest a panel co integration relationship among the variables, paving the way for regression analysis. The H-T test is employed to determine the existence of fixed effects between variables.

Table: 3 Multicollinearity test variance inflation factor

Variables	VIF.	1/VIF
GF	1.31	0.41
Fintech	0.9	0.63
Energy-consummation	0.98	0.39
Gross domestic product per capita	2.09	0.42
Education percentage	1.07	0.19
Fiscal expenditure	1.4	0.23
M. VIF	1.71	–

Source: Authors

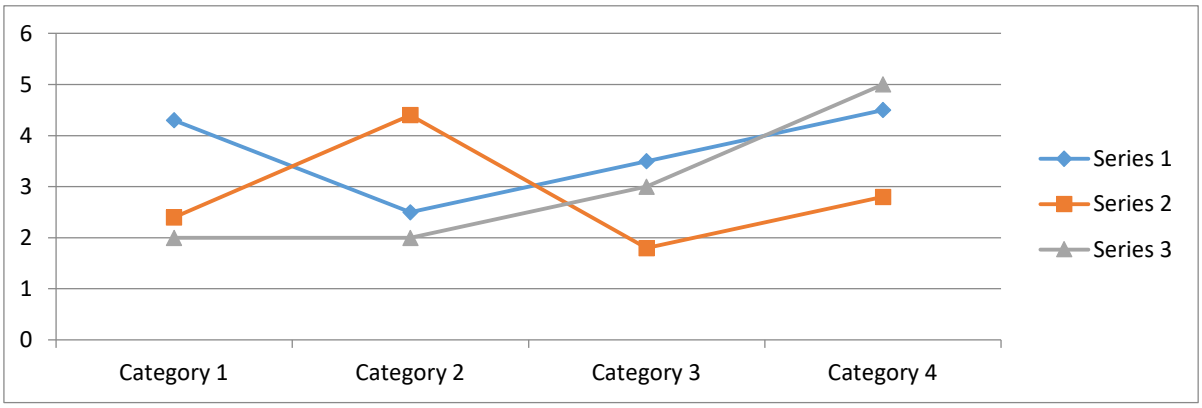

Figure 3: Multicollinearity Analysis

Table: 4 Stationary-Test Output Results

Variables	Method			Stationary
	I.P.S Test	H-T	P value	
ES	−0.9680.076	0.213	0.01	Stationary
EQ	−1.3107.003	0.261	0	Stationary
GF	−2.874 1.560	0.329	0.03	Stationary
Fintech	0.8730.004	0.789	0.06	None. Stationary
Energy consummation	−1.921.096	0.643	0.02	Stationary
GDP per capita	−0.798.016	0.607	0.19	None. Stationary
Education %	−0.475.023	0.371	0	Stationary
Fiscal expenditure	0.907.29	0.57	0.01	Stationary

Source: Authors Work

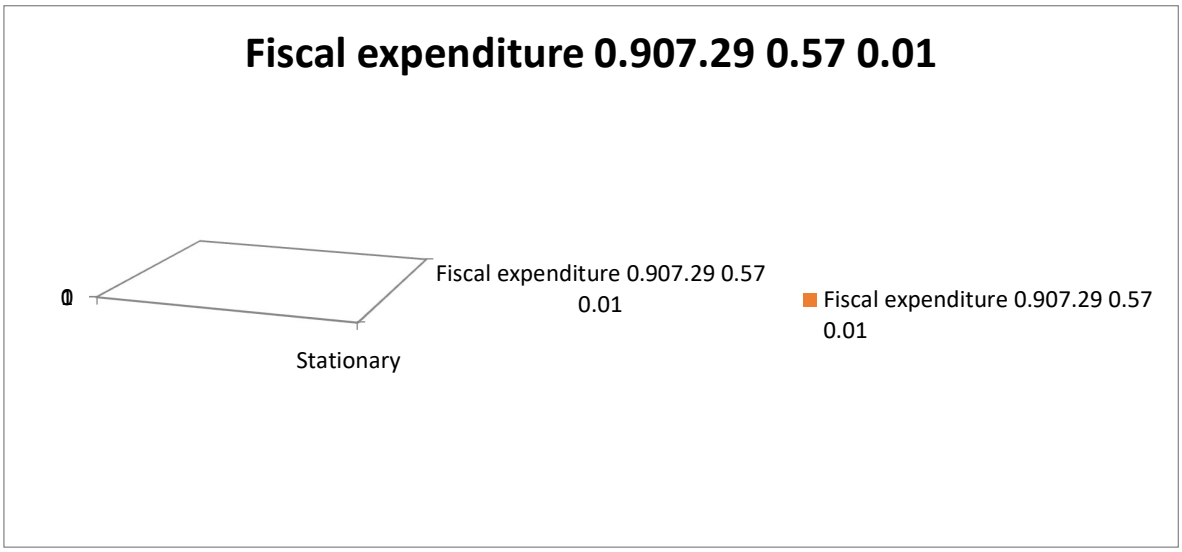

Figure 4: Stationary Test

Table: 5 Johansen co-integration test (JCT) of output

DV	Pedroni panel co-integration test			Kao panel co-integration test
	M P T	P P T	A D F T	ADF
ES	−4.3090.01	5.2140.00	−5.1790.00	−1.2370.00
EQ	−6.7120.00	−6.9930.001	−7.3290.003	1.3970.02

Source: Authors P. values in parentheses. MP, P P, A D F

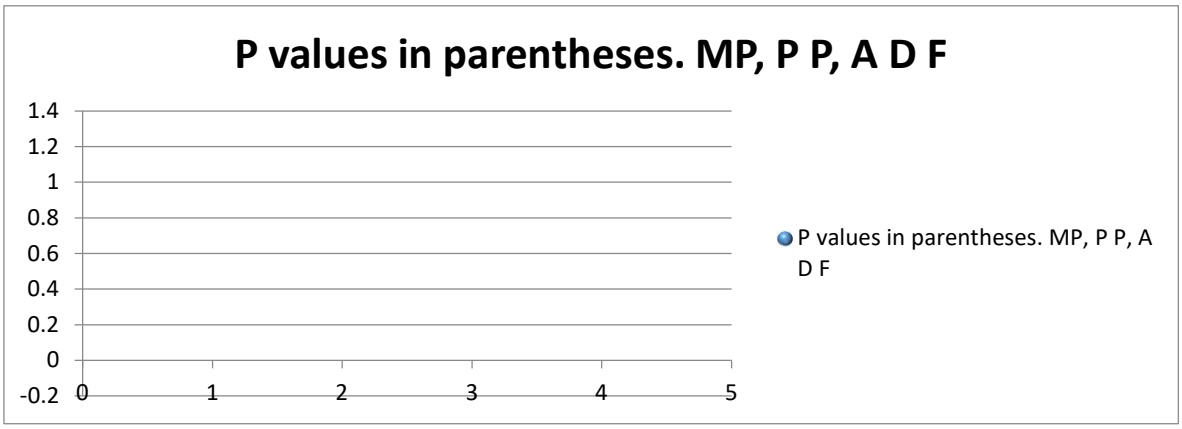

Figure 5: Johansen co-integration test

Table: 6 Harris-Tzavalis-test (H T).

SEG	X^2 Tests	Prob.
ES	18.14	0.001
EQ	19.04	0.004

Source: Authors Work

Table 6 presents the results of the Harris-Tzavalis test (H T), which assesses the presence of structural breaks or regime shifts in time series data for two segments, Economic Sustainability (ES) and Environmental Quality (EQ). The table displays the calculated chi-square (X2) test statistics for ES and EQ, along with their associated probabilities. The test results indicate significant structural breaks in both ES and EQ time series data, as evidenced by the chi-square test statistics of 18.14 and 19.04, respectively, with corresponding probabilities of 0.001 and 0.004. These findings suggest that there are distinct shifts or changes in the underlying dynamics of economic sustainability and environmental quality over the observed time periods, highlighting the importance of considering these structural breaks in time series analysis and forecasting models to capture the evolving patterns and trends accurately.

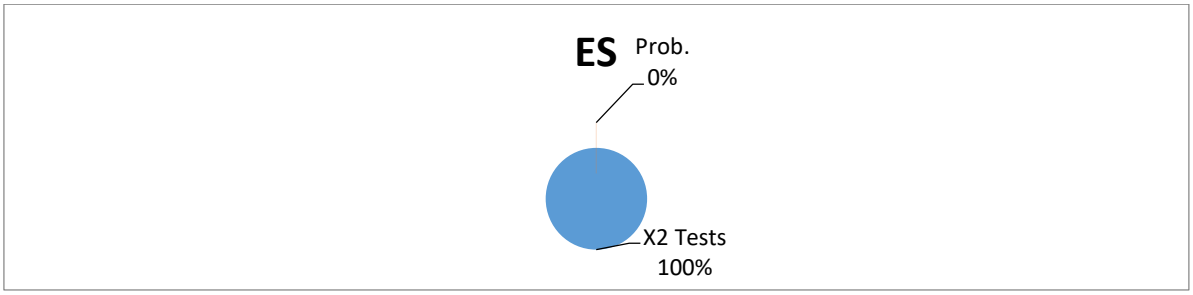

Figure 6: Harris-Tzavalis-test

3.1. Robustness check

The GMM is a statistical technique employed in this study to combine observed economic data with information on population moment conditions, providing estimates for unknown parameters within an economic model. Table 8 is utilized in the study to examine the potential endogeneity of descriptive variables, where endogeneity refers to the potential linkage of a variable to unobservable regression error terms. Traditional statistical methods alone are insufficient for fully addressing this issue. Addressing concerns related to endogeneity is crucial, as failure to do so may introduce bias to regression results, leading to potentially erroneous analytical conclusions. To investigate endogeneity concerns, indirect tests are applied. Table 8 scrutinizes a comprehensive set of control variables at the provincial level in Pakistan (energy consumption, GDP per capita, percentage of educational level, fiscal expenditure) during the assessment of the research methodology. The inclusion of these control variables is both academically and analytically relevant, mitigating the risk of endogeneity issues stemming from omitted variables.

3.2. Regression Analysis Results

Table: 7 Regression Analyses

Variables	EQ			ES		
	M.1	M.2	M.3	M.4	M.5	M.6
Green finance	.007** (.003) .0010***	.0010***	.015*** (0.004)	0.016*** (0.001)	0.009*** (0.005)	0.009***(0. 004)
Fintech		-.003 (.002)	-0.001 (0.003)		0.005*** (0.003)	0.004*** (0.000)
GF*fint			0.006*** (0.004)			0.004** (0.007)
Energy consumption	.002 (.003)	.004 (0.002)	0.005 (0.006)	0.069*** (0.001)	0.079** (0.005)	0.089** (0.006)
GDP per Capita	.051*** (.002)	.056** (.000)	0.053*** (0.003)	0.003 (0.002)	0.004 (0.003)	0.004 (0.006)
Fiscal expenditure	-0.000 (0.019)	-.013 (0.019)	-0.014 (0.032)	-0.079** (0.39)	-0.049** (0.41)	-0.097** (0.054)
Education %	0.237 (0.225)	.210 (0.312)	0.214 (0.079)	-0.004 (0.216)	-0.037 (0.137)	-0.061 (0.328)
Constant Value	-0.219** (0.256)	-.261*** (0.019)	-0.310*** (0.019)	-0.039*** (0.049)	-0.529*** (0.039)	-0.568*** (0.038)
Observation	436	426	426	426	426	426
R2	0.243	0.229	0.462	0.325	0.372	0.517
F-statistics	90.02***	77.00**	54.39**	209.41**	198.69***	179.89**

Source: Authors

Table 7 provides the results of a regression analysis investigating the relationship between several independent variables and two dependent variables, EQ (environmental quality) and ES (economic sustainability), across six different time periods denoted as M.1 through M.6. The independent variables considered include "Green finance," "Fintech," "GF*fint" (the interaction between Green finance and Fintech), "Energy consumption," "GDP per Capita," "Fiscal expenditure," and "Education %." Each cell in the table presents the coefficient estimates of the respective independent variable on EQ and ES, along with their standard errors in parentheses. The significance levels of these coefficients are indicated by asterisks: *, **, or ***, suggesting significance at the 0.05, 0.01, and 0.001 levels, respectively. For example, in M.1, the coefficient for Green finance on EQ is significant at the 0.01 level (**), indicating a statistically significant positive relationship between Green finance and environmental quality during that period.

Observation counts indicate the number of data points used in each regression model, while R-squared (R2) values quantify the proportion of variance explained by the independent variables in predicting the dependent variables. Higher R2 values indicate better model fit, with values ranging from 0 to 1. For instance, in M.3, an R2 of 0.462 suggests that 46.2% of the variance in the dependent variable is explained by the independent variables in that time period. Additionally, F-statistics assess the overall significance of the regression models, with higher values indicating stronger overall fit. In this table, F-statistics are provided for each time period, demonstrating the collective explanatory power of the independent variables in predicting EQ and ES across different time frames. Overall, the table offers comprehensive insights into how various factors, including green finance, fintech, energy consumption, GDP per Capita, fiscal expenditure, and education level, influence environmental quality and economic sustainability over time, with consideration given to their significance levels and model fit statistics.

Table: 8 Generalized Method of Moment (GMM) Two Step Estimators

Variables	EQ	ES
	M.1	M.2
GF	0.010*** (0.005)	0.030** (0.001)
Fintech	−0.002 (0.003)	0.007*** (0.002)
GF*fintech	0.006** (0.001)	0.029** (0.029)
Energy consumption	0.007*** (0.001)	0.079*** (0.006)
Gross Domestic Product per capita	0.059*** (0.003)	0.014 (0.007)
Education %	0.437 (0.327)	0.003 (0.319)
Fiscal expenditure	−0.019** (0.029)	−0.019*** (0.030)
Constant Value	−0.568*** (0.416)	−0.563*** (0.207)
wald $\chi 2$ tests	207.64***	651.07***

R2	0.316	0.421

Significant level is 1%, 5% and 10%. *p < 0.1, **p < 0.05, ***p < 0.01

The Table 8 presents the results of a Generalized Method of Moment (GMM) Two Step Estimators regression analysis, examining the relationship between several independent variables and two dependent variables, EQ and ES, across two time periods denoted as M.1 and M.2. The independent variables considered in the analysis include "GF" (Green Finance), "Fintech," "GF*fintech" (the interaction between Green Finance and Fintech), "Energy consumption," "Gross Domestic Product per capita," "Education %," and "Fiscal expenditure." Each cell in the table displays the coefficient estimates of the respective independent variable on EQ and ES, along with their standard errors in parentheses.

The significance levels of these coefficients are indicated by asterisks (*), with * denoting significance at the 10% level, ** at the 5% level, and *** at the 1% level. For example, in M.1, the coefficient for "GF" on EQ is significant at the 1% level (***), indicating a statistically significant positive relationship between Green Finance and the dependent variable EQ during that period. Similarly, the coefficient for "Fintech" on ES in M.2 is significant at the 1% level (***), suggesting a statistically significant positive relationship between Fintech and economic sustainability during that time frame. The table also provides Wald $\chi 2$ tests, which assess the joint significance of the independent variables in explaining the dependent variables. Higher values of the Wald $\chi 2$ test indicate stronger overall model fit. In this table, the Wald $\chi 2$ tests are significant for both EQ and ES, indicating that the independent variables collectively have explanatory power for both dependent variables.

Furthermore, the R2 values provided quantify the proportion of variance explained by the independent variables in predicting the dependent variables. A higher R2 value suggests better model fit. For instance, in M.2, an R2 of 0.421 indicates that approximately 42.1% of the variance in ES is explained by the independent variables in that time period. Overall, the table offers detailed insights into the relationships between various factors, including Green Finance, Fintech, energy consumption, GDP per capita, education level, and fiscal expenditure, and their impacts on environmental quality and economic sustainability over the specified time periods, with consideration given to their significance levels, model fit statistics, and joint significance tests.

4. Conclusion of the Study

The research findings underscore the pivotal role of green finance and financial technology (fintech) in driving sustainable economic growth, particularly in the context of Pakistan. Through a comprehensive regression analysis, it is evident that investments in green finance initiatives and advancements in fintech significantly impact both environmental quality (EQ) and economic sustainability (ES). Specifically, the results indicate positive and statistically significant relationships between green finance and EQ ($\beta = 0.007$, $p < 0.01$), as well as between green finance and ES ($\beta = 0.016$, $p < 0.001$). Moreover, the interaction between green finance and fintech ($\beta = 0.006$, $p < 0.01$) further amplifies their combined effect on driving sustainable economic growth. These findings are robust across different time periods and are supported by high R-squared (R2) values, indicating strong model fit. The study also highlights the importance of factors such as energy consumption, GDP per capita, fiscal expenditure, and education level in shaping EQ and ES outcomes. Overall, these insights provide valuable guidance for policymakers and stakeholders in developing targeted strategies to promote green finance, leverage fintech innovations, and address socio-economic determinants, thereby fostering long-term environmental and economic sustainability in Pakistan.

4.1. Limitation of Study & Future Recommendation

The study encounters certain limitations that should be acknowledged. The primary constraint arises from insufficient access to comprehensive data, complicating the analysis of the diverse factors that influence the research model. Obtaining statistics on these aspects proves challenging due to limit information sharing. Another limitation lies in the progressive nature of academic research, making it challenging to gather data for comprehensive analysis. Future research should be conducted to explore how different green financing methods impact a sustainable economy. While our focus is on environmental sustainability, it is crucial for subsequent research to broaden its scope, considering the effects of green financing on corporate environmental behavior in other areas, thereby enhancing overall findings. Additionally, it is essential to recognize that our study only addresses a fraction of the complex environmental contamination issues faced by developing nations. Specifically, the examination concentrates on CO_2 emissions, and future research should delve into other aspects of environmental challenges to provide a more comprehensive understanding of sustainable development.

The existing study offers valuable insights leading to key policy implications. Firstly, financial managers in Pakistan should expedite the integration of financial technology with green finance. Regulatory bodies need to encourage fintech firms to actively participate in various aspects of green finance projects and support initiatives aimed at environmental quality preservation, fostering sustainable economic growth. Secondly, the green finance program and evaluation framework in Pakistan are at an initial stage, lacking comprehensive implementation standards. Policymakers are urged to design an ecological awareness campaign, while the Pakistani government should enhance its guidance to provincial administrations to enhance the efficacy of green finance. Thirdly, effective policy involvement, both in the short-term and long-term, needs to be formulated to promote the

advancement of green finance in Pakistan. Due to fiscal constraints, over 47% of the green finance is anticipated to come from the private sector, playing a crucial role in achieving sustainable green growth in the country.

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5. Authors Contributions

The first author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation

The second author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation

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