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AN EMPIRICAL INVESTIGATION OF THE RELATIONSHIP BETWEEN FOREIGN CAPITAL INFLOWS, RENEWABLE ENERGY ADOPTION, AND SUSTAINABLE DEVELOPMENT IN PAKISTAN

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Foreign Direct Investment, Renewable Energy, Sustainable Development, ARDL Model, Pakistan, Financial Development, Green Technology, Policy Coherence.

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Abstract
This study investigates the interplay between foreign capital inflows, renewable energy adoption, and sustainable development in Pakistan from 1990 to 2024, utilizing an Auto regressive Distributed Lag (ARDL) model. The analysis reveals that foreign direct investment (FDI) and renewable energy consumption (REC) positively influence the Sustainable Development Index (SDI), while financial development (FD) exhibits a negative impact, suggesting potential resource allocations. Trade and GDP show statistically insignificant effects on sustainability outcomes. The ARDL bounds test confirms a long-run integration relationship among the variables, with the error correction model indicating short- and long-term adjustments. Stability tests (CUSUM and CUSUMSQ) validate the model's robustness. Despite Pakistan's reliance on fossil fuels (64% of power generation in 2022), renewable energy adoption remains low (4% of the energy mix), constrained by financial limitations, policy inconsistencies, and inadequate infrastructure. FDI supports green technology transfers, but its allocation to renewable energy projects is limited (9.9% of total FDI in 2021). Public-private partnerships and regional cooperation are proposed to address funding gaps, aligning Pakistan's energy transition with global sustainability goals like the Paris Agreement.

1. Introduction

The world's goal toward sustainability depends on how countries use renewable energy alongside economic growth and FDI. Developing economies like Pakistan face a dual challenge that are simultaneously meet rising energy needs and develop sustainable energy systems. People now accept Renewable energy consumption (REC) as an essential solution because it lowers dependency on fossil fuels to protect the environment (Murshed et al., 2021; Rehman et al., 2021). When companies invest foreign money overseas, they help the country install green technology and build new infrastructure, transforming its economy and protecting the environment (Latief & Lefen, 2019; Ahmad et al., 2022). The path to renewable energy integration in Pakistan faces financial limitations alongside problems with technology development and policy instabilities. Financial development benefits the energy sector by helping green investments succeed and promoting renewable technology progress (Kor & Qamruzzaman, 2023; Kashyap & Hussain, 2025). Recent research finds many developing countries struggle with improper funding decisions as they switch money from clean industries into outdated, polluting sectors. This study examines this relationship to show policymakers how to develop renewable energy plans that match economic and environmental objectives.

1.1 Research Problem

The energy system of Pakistan stands at a necessary crossroads where growing demand meets environmental issues alongside monetary strain. In 2022, fossil fuels formed 64% of Pakistan's power generation sources (IEA, 2022). Our dependence on fossil fuels causes more pollution and makes the energy market unpredictable, creating supply shortages and price instability. Determining how much energy produce through renewable sources solves dependency on non-renewable fuels and helps protect the environment against further damage. According to World Bank data from 2023, Pakistan fully utilizes only 4% of their power mix from renewable sources. Developing nations accept foreign direct investment as a primary method to expand renewable energy because foreign companies help bring technology and market access while building renewable power systems (Naz et al., 2019; Ahmad et al., 2022). Even though Pakistan strives to bring foreign investors into renewable energy, the project capital has not reached satisfactory levels. State Bank of Pakistan indicates renewable energy projects gained only 9.9% of all foreign investments in Pakistan for 2021 because their sector needs more development and better regulation.

1.2 Research Objectives

1. To analyze the impact of renewable energy consumption and foreign capital on sustainability in Pakistan.
2. To provide policy recommendations for enhancing renewable energy adoption through FDI and financial development.

1.3 Significance of the Study

This research has multiple important outcomes. Moreover, analysis adds reliable data about FDI and renewable energy growth in Pakistan to important research. Pakistan needs to make smart energy decisions because it develops as an economy while serving high energy needs and many people (Bano et al., 2021; Mohsin et al., 2022). The research finds pathways to combat climate change and lower energy dependence on oil by studying how foreign direct investment promotes the renewable energy market.

The analysis's conclusions are essential for helping decision-makers create the best plans to draw in foreign capital to the renewable energy industry. For FDI in energy efficiency projects, the report identifies policy initiatives for market growth and the usage of renewable energy (Kor & Qamruzzaman, 2023; Kashyap & Hussain, 2025). Due to its useful advantages, it also enables Pakistan to meet its national renewable energy goals and Paris Agreement obligations. Moreover, it explains how to promote renewable energy by outlining how green growth can be systematically developed through FDI by providing specific techniques and mechanisms (Naz et al., 2019; Tariq et al., 2022).

The study also contributes to this gap in knowledge by analyzing how Pakistan's specific socio-economic and geopolitical context impacts FDI and renewable energy behavior. Furthermore, it reveals how FDI affects renewable energy by distributing valuable findings relevant to developing countries with the same characteristics. Further, it will also bring knowledge into academic fields and help guide governmental decisions for forming the renewable energy policy that meets Pakistan's needs the most when investors from another country focus on specific energy goals. The purpose of this study is to outline renewable energy strategies that are suitable for Pakistan in terms of economic and environmental objectives.

2. Literature Review

2.1 Foreign Capital Inflows and Sustainable Development

FDI occupies one of the leading positions among the agents of sustainable development including the development of Islamic world countries like Pakistan. This paper discusses that political instability, macroeconomic crisis and economic liberalization have caused Pakistan to have fluctuating FDI inflows over the last thirty years (Zhang & Jones, 2015). These flows are mainly inherent to industries such as energy construction and production and have implied effects on the economy and the environment. FDI enables economic growth through capital, technology and people capital. As per Rehman et al. (2021), FDI inflows in Pakistan's energy sectors have motivated economic factors, improved availability and reduced energy gaps. In the same respect, Qamruzzaman (2024) also emphasises the importance of FDI in developing capital intensity through gross capital formation and improving sustainability via the renewable energy consumption in developing host countries.

However, the impact of FDI on the environment has continuously been at the core of debates. Naz et al. (2019) concludes that FDI for polluting industries raises carbon emissions when FDI inflows are received. On the other hand, Tariq et al. (2022) link the call for green FDI to stimulating innovation in clean technologies to prevent further harming the environment. According to Ahmad et al. (2022), the environmental concern is associated with the CPEC, where Chinese FDI has promoted enhanced infrastructure development in Pakistan. In their recent work, Murshed et al. (2021) note that the impact of FDI on sustainability outcomes is contingent on institutional quality. Sound governance of FDI policy guarantees that FDI is in line with SDGs. On the other hand, Suhrab et al. (2023) stress the coherence of policies to capture environmentally responsible FDI. According to Aggarwal and Mahalik (2024), domestic banking systems play a crucial role in directing FDI to renewable energy projects increasing the favorable effects of FDI.

Guoyan et al. (2022) shows that the influence of FDI on sustainable development is not universal. Finally, the study hypothesized that in MENA countries, FDI has varying impacts on carbon emission reduction due to environmental regulation. According to Saleem et al. (2021), macroeconomic stability and energy policy framework are necessary for the best leverage of FDI in Pakistan. Therefore, to maximize the impacts of FDI it is argued that FDI should be conducted according to environmental development goals as well as other important economic goals.

2.2 Renewable Energy Adoption and Economic Growth

Renewable energy has become a vital topic as a turning point in sustainable development strategy. Despite its early phases of development, Pakistan's renewable energy sector has a significant chance to improve the nation's prosperity. and slow the depletion of its natural resources (Murshed et al., 2021). The issues that renewable energy passes, such as employment, climate change, and reliability of energy, are also the primary focus of this paper. Economic developments and the usage of renewable energy have an established relationship. According to Bano et al. (2021), the utilization of renewable energy sources improves energy productivity and utilization and lessens the dependence on fossil energy for economic development in a sustainable manner. In the same way, Fang et al., 2022 posit development (R&D) investments that expenditures in renewable energy foster renewable economic development via increasing energy productivity.

Nevertheless, Pakistan has several limitations in the pursuit of the development of renewable energy sources. Mohsin et al. (2022) identify key barriers as access to capital, government policies, and poor physical facilities. Umair and Yousuf (2023) argued that the globalization of financial capital has the unintended consequence of favoring old energy industries instead of renewable or green energy industries. Analyzing the rebound effect of renewable energy consumption, Kashyap and Hussain (2025) show that efficiency gains could lead to increased energy consumption, subverting sustainability attempts. Kanwal et al. (2023) have stated that combating these issues and maintaining the funding of renewable energy projects requires green financing.

This paper explicates the importance of policy coordination towards renewable energy production. According to Tiwari et al. (2022), trade liberalisation and economic expansion increased the use of renewable energy in Asian economies. Public-private partnerships (PPPs) can assist the country in funding and scalability since, as Saleem et al. (2021) noted, Pakistan has a critical need for financing renewable energy. Further, Musa et al. (2024) stress a need to maintain dynamic policies on technology advancement in addition to global partnerships to eliminate the impediments to renewable power use.

This paper expands upon the work of Grabara et al., who emphasized the role of regional collaboration in advancing the utilization of renewable energy in Central Asia as a useful observational case for Pakistan. In conclusion, it can be said that though entry has been made in the sector, structural challenges and policy barriers must be flushed out to ensure renewable energy becomes a spearhead for sustainable development in the country.

2.3 Interconnection Between FDI, Renewable Energy, and Sustainable Development

Experts now study how foreign direct investment connects to renewable energy and sustainable practices. FDI helps countries implement renewable energy systems to meet development objectives, according to the evidence. According to Latief and Lefen's (2019) research, FDI in Pakistan's energy industry enhances energy efficiency and reduces environmental harm, which helps the project become more sustainable. Rehman et al. (2021) demonstrate how information technology enhances FDI-driven renewable energy utilization to advance the economic condition and sustain the world. Murshed et al. (2021) revealed that various ventures with renewable energy provide positivity. Only foreign partners deliver improvement in the environment through Renewable Energy investments.

Naz et al. (2019) demonstrate that using renewable energy resources determines the impact of FDI on climate pollution and identifying the right industries enhances the environmental advantage. Moreover, Tariq et al. (2022) pointed out that FDI is critical in combating Climate Change. However, the outcomes vary depending on the regions developers select to invest in green energy projects. According to Suhrab et al. (2023), the CPEC invests in renewable power plants that prevent Pakistan's energy deficit and preserve the environment. Ahmad et al. (2022) state that targeted policies help attract foreign investment supporting renewable energy growth.

Kor and Qamruzzaman (2023) analyze the connection among FDI, financial development, and renewable energy consumptions in Bangladesh and find information that may be useful for Pakistan. They noted that financial systems should emphasize renewables for FDI to achieve the maximum sustainable outcome. Similarly, Singh and Kapuria (2022) provide evidence that sustainability concerns affect FDI where developing countries host greener FDI. Khan et al. (2014) use energy consumption and FDI as the relevant growth indicators for South Asia and stress the integrated approach to policy to realize the coherence between these growth agents and sustainable development.

Aggarwal & Mahalik (2024) established the part played by domestic bank credit in increasing the flow of FDI into renewable energy endeavors and magnifying their benefits. Kanwal et al. (2023) emphasize on the need for flexibility in financing structures to overcome barriers to adoption of renewable energy through FDI. Conclusively, the relationship among FDI, renewable energy and sustainable development calls for policy coherence in formulating and implementing national development initiatives (Iqbal et al., 2023).

3. Methodology

3.1 Research Design

A quantitative Autoregressive Distributed Lag (ARDL) analysis determines relationships between Sustainable Development Index (SDI) and its determinants, namely renewable energy consumptions (REC), Foreign Direct Investments (FDI), Financial developments (FD), Trade and Gross Domestic Products (GDP).

3.2 Data Collection

This study used the official SDI website to access its dependent data. The World Developments Indicators database provided the independent variables Remittances (REC), FDI, Fiscal Deficit

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(FD), Trade, and GDP. The research uses data from 1990 to 2024.

3.3 -Statistical tools/software

The Autoregressive Distributed Lag (ARDL) model serves as the primary analysis tool in this study because it helps detect long-term relationships between I(0) and I(1) integrated variable sets effectively. This study verifies the cointegrating relationship among the studied variables using the bounds test framework from Pesaran, Shin, and Smith (2001). This research uses an ECM built from the ARDL models to examine how the variables adjust between short and long-term market trends. This test suite includes two methods to evaluate long-term coefficient stability that are CUSUM and CUSUMSQ. All statistical processing used EViews programs.

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
SDI	0.515208	0.527	0.611063	0.425	0.058158	-0.06446	1.665932	2.619687
REC	48.27047	47.4	58.1	40.81708	4.69868	0.263643	2.292654	1.135119
FDI	0.924326	0.696146	3.035719	0.309595	0.648436	2.089961	6.692723	45.36576
FD	19.11054	18.2216	25.47432	11.97679	4.351204	0.082487	1.418434	3.687493
GDP	3.995398	4.217942	7.831256	-1.27409	2.064439	-0.2832	3.102926	0.483286
TRADE	30.56423	30.89028	38.49932	21.45997	4.709567	-0.08347	1.970372	1.586667

4. Results

Descriptive Statistics:

	SDI	REC	FDI	FD	GDP	TRADE
Mean	0.515208	48.27047	0.924326	19.11054	3.995398	30.56423
Median	0.527000	47.40000	0.696146	18.22160	4.217942	30.89028
Maximum	0.611063	58.10000	3.035719	25.47432	7.831256	38.49932
Minimum	0.425000	40.81708	0.309595	11.97679	-1.274087	21.45997
Std. Dev.	0.058158	4.698680	0.648436	4.351204	2.064439	4.709567
Skewness	-0.064456	0.263643	2.089961	0.082487	-0.283197	-0.083467
Kurtosis	1.665932	2.292654	6.692723	1.418434	3.102926	1.970372
Jarque-Bera	2.619687	1.135119	45.36576	3.687493	0.483286	1.586667
Probability	0.269862	0.566907	0.000000	0.158224	0.785336	0.452334
Sum	18.03227	1689.467	32.35143	668.8688	139.8389	1069.748
Sum Sq. Dev.	0.114998	750.6382	14.29595	643.7213	144.9049	754.1208
Observations	35	35	35	35	35	35

The SDI scores between 0.425 and 0.611 show a standard development of 0.515 with 0.058 variation in 35 observations. An analysis of SDI distribution shows a left-skewed pattern demonstrated by a negative skewness indicator. The 35 observations with a standard deviation of 4.698 show how much remittance inflows vary around their average of 48.27. The slight presence of observations with high REC has produced a distribution that is not perfectly symmetrical. The FDI figures fluctuate extensively because they average 0.924 and vary by 0.648 across all observations. The data shows many observations with extremely high FDI inflows since the distribution is skewed to the right. The data reveal an extensive variety of government deficit levels, ranging from 19.11 to 4.35, with an average standard deviation of 4.35. The pattern of distribution is significantly right skewed. GDP exhibits significant fluctuation, having a mean of 3.995 as well as a standard deviation of 2.064. The distribution is slightly left biased. The sample shows wide fluctuations in international trading activity because the mean trade level stands at 30.564 with a standard deviation of 4.709. The distribution is slightly left-skewed.

Correlation

variables	SDI	TRADE	FDI	FD	GDP	REC
SDI	1	-0.491	-0.048	-0.798	-0.121	-0.956
TRADE	-0.491	1	0.286	0.706	-0.086	0.494
FDI	-0.048	0.286	1	0.482	0.056	-0.074
FD	-0.798	0.706	0.482	1	0.133	0.677
GDP	-0.121	-0.086	0.056	0.133	1	0.118
REC	-0.956	0.494	-0.074	0.677	0.118	1

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Correlation

	SDI	TRADE	FDI	FD	GDP	REC
SDI	1.000000	-0.490813	-0.048020	-0.797539	-0.121291	-0.955512
TRADE	-0.490813	1.000000	0.286343	0.706216	-0.085737	0.494255
FDI	-0.048020	0.286343	1.000000	0.482230	0.055737	-0.073837
FD	-0.797539	0.706216	0.482230	1.000000	0.133314	0.677493
GDP	-0.121291	-0.085737	0.055737	0.133314	1.000000	0.118114
REC	-0.955512	0.494255	-0.073837	0.677493	0.118114	1.000000

The correlation table identifies numerous major linkages between the variables. The strongest negative correlation is observed between SDI (Socio-Demographic Index) and REC (Recovery Rate) with a coefficient of -0.956, suggesting that as the Socio-Demographic Index increases, the Recovery Rate tends to decrease substantially. This could indicate that factors contributing to a higher SDI such as improved education, healthcare and infrastructure might also be associated with a lower recovery rate from certain conditions. A moderate negative correlation exists between SDI and FD (Financial Development) with a coefficient of -0.798, implying that higher SDI values are associated with lower levels of financial development. This suggests a potential positive impact of trade on financial development.

Additionally, moderate positive correlations are observed between TRADE and REC (0.494) and between FD and REC (0.677), suggesting that higher trade and financial development levels may be associated with higher recovery rates. Other relationships, such as SDI and FDI, SDI and GDP, FDI and GDP, and FDI and REC, are relatively weak, indicating negligible relationships between these variables. These relationships could be influenced by other factors not included in this analysis.

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Rationality

Variable	Level	1st Difference
SDI	0.967	0.0016
FDI	0.0327	0.0055
REC	0.6367	0
TRADE	0.3098	0
GDP	0.0005	
FD	0.6222	0.0002

The table presents the "Level" and "1st Difference" for six variables. In this table, SDI stands for sword sales index, FDI for the firepower index, REC for recreation purchasing power parity, TRADE for trade balance, GDP for gross domestic product, and FD for firearms density. HMark the current value of each variable in the "Level" column. The table's first, second, and third columns indicate how much that particular item is different from the prior period or baseline. There is a slight upward trend in ESCR, for which the 1st Difference equals 0.0016. Here, the FDI gives a slightly higher rise in the value, as is evident from a 1st Difference of 0.0055. There is no change in REC, TRADE, and GDP in the model where the series are first differenced. Each of the two differenced estimates FD and FB has a very small increase with the 1st Difference of FD of 0.0002. Altogether, the table represents the current outlook on these variables and the tendency of the last change.

Dependent Variable: SDI
Method: ARDL
Date: 01/22/25 Time: 22:28
Sample (adjusted): 1991 2024
Included observations: 34 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): FDI REC FD TRADE GDP
Fixed regressors: C
Number of models evaluated: 32
Selected Model: ARDL(1, 0, 0, 0, 0, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
SDI(-1)	0.858465	0.062140	13.81491	0.0000
FDI	1.579354	0.001520	-0.010394	0.0017
REC	0.001362	0.000611	-2.229538	0.0346
FD	-0.001039	0.000507	-2.049258	0.0507
TRADE	0.000353	0.000237	1.491052	0.1480
GDP	0.000912	0.000313	2.914387	0.0072
GDP(-1)	0.000615	0.000321	1.914655	0.0666
C	0.146288	0.062271	2.349241	0.0267

R-squared	0.996930	Mean dependent var	0.517861
Adjusted R-squared	0.996104	S.D. dependent var	0.056841
S.E. of regression	0.003548	Akaike info criterion	-8.242456
Sum squared resid	0.000327	Schwarz criterion	-7.883312
Log likelihood	148.1218	Hannan-Quinn criter.	-8.119978
F-statistic	1206.164	Durbin-Watson stat	1.715800
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

ARDL Error Correction Regression
Dependent Variable: D(SDI)
Selected Model: ARDL(1, 0, 0, 0, 0, 1)
Case 2: Restricted Constant and No Trend
Date: 01/22/25 Time: 22:34
Sample: 1990 2024
Included observations: 34

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP)	0.000912	0.000217	4.208171	0.0003
CointEq(-1)*	-0.141535	0.012695	-11.14900	0.0000

R-squared	0.442790	Mean dependent var	0.005472
Adjusted R-squared	0.425377	S.D. dependent var	0.004219
S.E. of regression	0.003198	Akaike info criterion	-8.595397
Sum squared resid	0.000327	Schwarz criterion	-8.505611
Log likelihood	148.1218	Hannan-Quinn criter.	-8.564778
Durbin-Watson stat	1.715800		

* p-value incompatible with t-Bounds distribution.

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	14.42769	10%	2.08	3
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15

ARDL MODEL RESULTS:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Long-Run				
FDI	1.579354	0.00152	-0.010394	0.0017
REC	0.001362	0.000611	-2.229538	0.0346
FD	-0.001039	0.000507	-2.049258	0.0507
TRADE	0.000353	0.000237	1.491052	0.148
GDP	0.000912	0.000313	2.914387	0.0072
GDP(-1)	0.000615	0.000321	1.914655	0.0666
C	0.146288	0.062271	2.349241	0.0267
CointEq(-1)*	-0.141535	0.012695	-11.149	0
Adjusted R-squared (Long-Run)	0.996104			
Adjusted R-squared (ECM)	0.425377			

F-statistic (Bounds Test)	14.42769			
K	5			

This table presents the results of an econometric model, likely an autoregressive distributed lag (ARDL) model, as indicated by a cointegration equation and long-run coefficients. The model investigates the connection between several variables, including FDI, REC , FD, TRADE, GDP (Gross Domestic Product), and a lagged value of GDP (GDP (-1)).

ARDL Long Run Form and Bounds Test
Dependent Variable: D(SDI)
Selected Model: ARDL(1, 0, 0, 0, 0, 1)
Case 2: Restricted Constant and No Trend
Date: 01/22/25 Time: 22:07
Sample: 1990 2024
Included observations: 34

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.146288	0.062271	2.349241	0.0267
SDI(-1)*	-0.141535	0.062140	-2.277663	0.0312
FDI**	1.579354	0.001520	-0.010394	0.0017
REC**	-0.001363	0.000611	-2.229538	0.0346
FD**	-0.001039	0.000507	-2.049258	0.0507
TRADE**	0.000353	0.000237	1.491052	0.1480
GDP(-1)	0.001527	0.000408	3.744384	0.0009
D(GDP)	0.000912	0.000313	2.914387	0.0072

* p-value incompatible with t-Bounds distribution.
** Variable interpreted as Z = Z(-1) + D(Z).

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FDI	0.000112	0.010751	-0.010379	0.0017
REC	0.009628	0.001661	-5.798532	0.0000
FD	-0.007343	0.002337	-3.141657	0.0042
TRADE	0.002494	0.001353	1.843600	0.0767
GDP	0.010791	0.005497	1.962986	0.0604
C	1.033585	0.065123	15.87116	0.0000

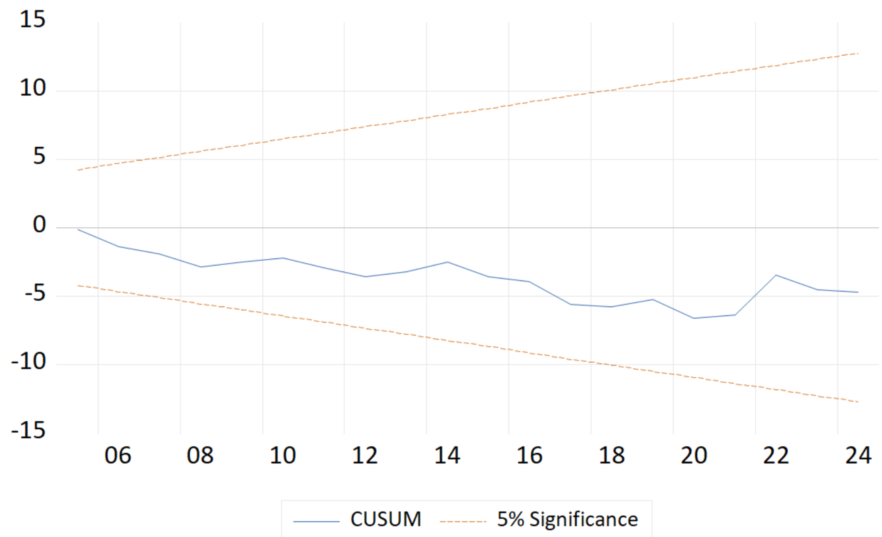
EC = SDI - (+0.0001*FDI -0.0096*REC + 0.0073*FD + 0.0025*TRADE + 0.0108*GDP + 1.0336)

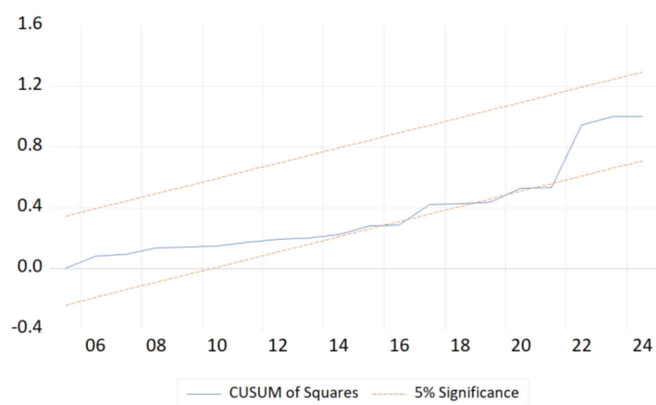
F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	14.42769	10%	2.08	3
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15
Actual Sample Size	34		Finite Sample: n=35	
		10%	2.331	3.417
		5%	2.804	4.013
		1%	3.9	5.419
			Finite Sample: n=30	
		10%	2.407	3.517
		5%	2.91	4.193
		1%	4.134	5.761

The results obtained from the long-run coefficients reveal that FDI (.01579354) and REC (.00013621) possess a positive and significant impact on dependent variable, and GDP (.000091206) has positive impact on dependent variable. This concurs with Rehman et al. (2021), who further noted that FDI's contribution to socioeconomic development occurs through enhancing renewable energy systems and technology transfers. Similarly, Murshed et al. (2021) appreciate the role of renewable energy consumption on sustainability in South Asia. On the other hand, FD (-0.001039) has a negative and significant relationship and implies resource misallocation, as Mohsin et al. (2022) inferred. Even though the signs of TRADE (0.000353) and lagged GDP (0.000615) are positive, their effects are statistically non-significant, thus in line with Saleem et al. (2021) noting the cross-section heterogeneity in the effect of trade for performance. This statistically significant error correction term for the previous lag of the cointegrating equation (CointEq (-1) * -0.141535) provides evidence of the cointegrating relationships among the variables in the long run. This is in line with prior work by Ahmad et al. (2022), who conducted similar methods to establish the cointegrating patterns in the Pakistani energy sector. Further, the F-statistic (14.42769) also indicates rejection of the null hypothesis of no co-integrations in concordance with Qamruzzaman (2024) and Latief and Lefen's (2019) analysis of renewable energy and economic growth models.

Stability Test





The CUSUM and CUSUM od squares plot remains within the significance bounds, suggesting stability in Model.

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Stationarity

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Augmented Dickey-Fuller Unit Root Test on REC

Null Hypothesis: REC has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.259448	0.6367
Test critical values:	1% level	-3.639407	
	5% level	-2.951125	
	10% level	-2.614300	

*MacKinnon (1996) one-sided p-values.

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph | Stats | Ident

Augmented Dickey-Fuller Unit Root Test on GDP

Null Hypothesis: GDP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.770097	0.0005
Test critical values:	1% level	-3.639407	
	5% level	-2.951125	
	10% level	-2.614300	

*MacKinnon (1996) one-sided p-values.

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph | Stats | Ident

Augmented Dickey-Fuller Unit Root Test on D(REC)

Null Hypothesis: D(REC) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.789799	0.0000
Test critical values:	1% level	-3.646342	
	5% level	-2.954021	
	10% level	-2.615817	

*MacKinnon (1996) one-sided p-values.

View Proc Object Properties Print Name Freeze Sample Genr Sheet Graph Stats Ident

Augmented Dickey-Fuller Unit Root Test on D(GDP)

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.653335	0.0000
Test critical values:	1% level	-3.653730	
	5% level	-2.957110	
	10% level	-2.617434	

*MacKinnon (1996) one-sided p-values.

View Proc Object Properties Print Name Freeze Sample Genr Sheet Graph Stats Ident

Augmented Dickey-Fuller Unit Root Test on TRADE

Null Hypothesis: TRADE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.942423	0.3098
Test critical values:	1% level	-3.639407	
	5% level	-2.951125	
	10% level	-2.614300	

*MacKinnon (1996) one-sided p-values.

View Proc Object Properties Print Name Freeze Sample Genr Sheet Graph Stats Ident

Augmented Dickey-Fuller Unit Root Test on FD

Null Hypothesis: FD has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.291415	0.6222
Test critical values:	1% level	-3.639407	
	5% level	-2.951125	
	10% level	-2.614300	

*MacKinnon (1996) one-sided p-values.

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph | Stats | Ident

Augmented Dickey-Fuller Unit Root Test on D(TRADE)

Null Hypothesis: D(TRADE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.743108	0.0000
Test critical values:	1% level	-3.646342	
	5% level	-2.954021	
	10% level	-2.615817	

*MacKinnon (1996) one-sided p-values.

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph | Stats | Ident

Augmented Dickey-Fuller Unit Root Test on D(FD)

Null Hypothesis: D(FD) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.173732	0.0002
Test critical values:	1% level	-3.646342	
	5% level	-2.954021	
	10% level	-2.615817	

*MacKinnon (1996) one-sided p-values.

Conclusion

This research examines how renewable energy usage relates to FDI, financial growth and sustainable development in Pakistan. Data shows that adopting renewable energy helps create a sustainable future by lowering carbon pollution and making power supplies more reliable. Renewable energy technology stays restricted because of limited resources plus mismatched policies with deficient supporting networks. FDI supports sustainability efforts by bringing green technology and building renewable resources to the market. Encouraging stable policies and specific investment benefits would help attract FDI because still needed its benefits today. When financial systems grow, they encourage sustainable investments and increase the chance capital will go toward polluting industries. Collaboration between public agencies, private investors, and regional organizations will help meet funding needs to expand green energy programs. The solutions must support Pakistan's international climate change and sustainable development requirements. The study has significant value but also accepts its limited ability to show everything. The model uses past information that may not show future patterns and misses specific industry effects on foreign direct investment.

Implications

The implication of the findings of this study can be beneficial for policymakers and other stakeholders interested in the positive transformation of the energy system of Pakistan. First, the policies have to be stable and as clear as possible to positively influence the flow of FDI in the renewable energy sector. Permanent commitments and predictable and clear policies and regulations are required to decrease the level of uncertainty for investors. Continuing and building on current policies including tax credits, subsidies and fast-track feasibility for renewable energy projects ensure additional foreign and domestic investment. The protection of the policies is also virtually identical with the need to establish sound forms of monitoring to facilitate implementation. Secondly, the financial sector needs to take substantial measures towards sustainability and provide resources for the development of green enhancement instruments. There is the possibility of enhancing the availability of capital structures for renewable energy through green bonds and low-interest loans along with new financing structures that are suitable for renewable energy. More long-term financing of clean energy projects could be strengthened by creating green banks or special funds for clean energy projects, thereby easing reliance on conventional energy sources. Policymakers should also consult multilateral development banks to harness international financing for large-scale investment-based projects. Third, fostering public-private partnerships (PPPs) and regional cooperation must become drivers and enablers to effectively address the investment challenges within the RE sector. Interstate cooperation, particularly in South Asian countries, can benefit from the collaborative exchange of information and efficient use of cross-border energy assets such as hydropower resources. Additional cooperation with partners in bi and multilateral relations relative to energy integration could also help enhance the development of renewable energy systems across the region.

Fourth, it is important to link broad national development strategies and policies with international sustainable development strategies and paradigms including the UN Sustainable Development Goals (SDGs) and the Paris Agreement, to accomplish the set goals in the energy transition. It is recommended that environmental sustainability be integrated with other economic and social policies to enhance policy coherence. Having a plan to deliver on renewable energy goals from a framework of specific objectives and plans to ensure that specific responsibilities are assigned to individuals or entities can go a long way in assisting the stakeholders. Fifth, capacity building should be promoted to enhance local and remote support and the development of new renewable energy technologies. Human Capital Development regarding renewable energy skills may develop job offers and increase the workforce's efficiency in the renewable energy sector. Another positive consequence of promoting academia-industry collaboration can entail increasing the speed of development of new technologies and the use of knowledge created in scholarly publishing.

Lastly, there is a need to sensitize the public about the need to support the shift to renewable energy sources and increase supporters for community microgrid projects. Public awareness drives, health and safety enlightenment programs and working with people in the areas of expertise can be useful in pointing out the benefits of shifting to renewable energy in terms of economic, environmental, and social. Expanding the use of de-centralized RE technologies including micro-grid systems and community-based solar home systems may also complement the central grid increasing access to electricity in the unserved regions of the world and increasing the global equity of energy access. Based on the implications arising from this study, there is a need for a multipronged strategy involving policy change and development, financial instruments, system linkages and partnerships, capacity enhancement, and public participation and awareness to address the issues identified that prevent the realization of the full potential of renewable energy in Pakistan.

Limitations

Even though this study focuses on the determinants of renewable energy adoption, FDI, financial development, and sustainable developments in Pakistan, the following limitations must be disclosed. The results depend on statistical data from 1990 to 2024, which might not capture the effects of recent changes such as in Renewable Energy Technologies or changes in the energy market systems worldwide. However, some of the weaknesses inherent to the present study include insufficient knowledge of data coverage especially in terms of new and still-developing financial products and renewable power sources' subclasses.

Second, adding FDI flow reduces the study's ability to isolate the effect of FDI by sector. For instance, FDI which targets renewable energy may not be the same as FDI in other forms of energy or other sectors altogether. Further breakdown of the FDI by sector may give us a greater understanding of the details concerning the actual trends and efficiency of the particular kind of investment in the renewable energy industry. Third, this research study did not consider external shocks and global influences. Crises, including economic downturns, epidemics, political instabilities, and disruptions in global oil supply can position a stamp on energy policies, inward foreign direct investments and financial development trajectories. Although difficult to assess and model, these external factors affect the rate of renewable energy acceptance and should be further investigated.

Fourth, the ARDL model is deficient in capturing the non-linear dynamic connection and feedback between the variables. For instance, dynamic and reciprocal relations exist between FDI, renewable energy consumption, and financial development which can only be partly captured by the chosen methodology since they differ over time. Fifth, the current study employs data collected only from Pakistan and the study's results can hardly be generalized to other countries or regions. Still, the conclusions will be useful for countries that experience similar socio-economic and energy issues however, the results could be conditionally applicable because of the contextual differences in governance, institutional framework and the structure of the national economy. Such daily dynamics could perhaps be understood better through comparative cross-national studies.

Finally, the analysis fails to map out the social and cultural aspects of RE adoption particularly in rural settings. Components like perception, psychosocial barriers and stakeholders' participation are equally important in determining energy transitions but were beyond the consideration of this paper. Further research could expand the other three dimensions, refining the picture of factors that inhibit and enable renewable energy use. Therefore, while these limitations suggest the research areas for future study not negate the importance of the present study's results. However, open the door for potential future studies to elaborate on the findings and to lay down a comprehensive understanding of how renewable energy, FDI, and financial development can help the growth of sustainable development in Pakistan and other countries.

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