A Dynamic Linkage between Financial Development, Energy Consumption and Economic Growth: Evidence from an Asymmetric and Nonlinear ARDL Model

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Abstract: Developing countries, including Pakistan, need a considerable effort to withstand economic growth; however, these countries have to cope with greenhouse gases emission and other environmental concerns. Financial advancement gives rise to modern, sometimes even innovative and energy-efficient technologies and, thus, contributes to a decline in energy usage among market entities: organizations and households. The current study explores the nonlinear asymmetric relationship between economic growth (Y) and the selected exogenous variables in Pakistan by incorporating time series data spanning from 1971 to 2016. Economic growth was considered as a target variable, while energy consumption (EC), electric power consumption (EPC), financial development (FD), and energy imports (EM) were considered independent variables. To investigate cointegration among the given variables, a nonlinear ARDL bound testing approach was employed. BDS independence test was used to check the nonlinearity, and a structural break unit root test was used for testing data stationarity. The findings confirm the presence of co-integration in the selected variables. A symmetric unidirectional significant causality exists running from EPC to Y, while a bidirectional symmetric causality was found between FD and Y. In contrast, any negative shocks in EPC, FD, and EM were found to have a positive asymmetric effect on Y. Meanwhile, a neutral effect was found between EC and Y. The outcomes of this study can provide guidelines for future researchers and policymakers.

Keywords: energy consumption; financial development; energy imports; NARDL approach; asymmetries

1. Introduction

To meet global societal needs and economic development, the demand for energy resources and other related services has been increased over the last several decades. Numerous companies are engaged in the international exchange of resources to stimulate sustainable growth, and different economies are promoting foreign direct investment and finance production. The increasing trend in energy resources has resulted in dramatic growth in environmental degradation and greenhouse gas (GHG) emissions [1–4]. Several

studies have pointed out that the growth in CO_2 emissions has been mainly driven by the combustion of fossil energy (two-thirds of global CO_2 emissions) in support of human activities associated with economic growth and development [5–8]. Society is slowly moving towards more sustainable production methods, minimizing waste, reducing vehicle air pollution, distributed energy generation, protecting native forests and green spaces, and reducing greenhouse gas emissions [9].

Although many factors, including financial development, foreign direct investment, and trade liberalization are the prerequisites for economic growth, which is the core ambition of every nation. Energy use has become a new paradigm of discussion between economists and practitioners, and this topic, in particular, has become a focus of serious attention, given the recent progression of the climate agreements [10]. Growing awareness of global warming, unpredictable fossil energy costs, and environmental impacts of carbon emissions, renewable and nuclear energy supplies have emerged as the key pillar of global energy use. Increasing the use of renewable energy and replacing traditional sources with renewable sources is currently an important strategic goal of the economies of many countries. Countries that are able to create a friendly environment for the development of smart organizations constitute clear examples of a dynamically growing commitment to the effective handling of challenges associated with sustainable development issues [11]. The number of research on sustainable development in management science is growing [12,13]. Sustainable development requires methods and tools to measure and compare the impact of human activities on the environment for different solutions [14,15]. Any analysis assessing the impact of natural resources on economic growth has played a key role in creating the analytical framework for sustainable development [16]. Market entities are encouraged to orient their strategies towards sustainable development, which aims at both economic and social well-being on the one hand, equal opportunities for Earth's inhabitants on the other, and environmental integrity on the other hand [17,18]. Moreover, research shows positive attitudes of enterprises towards sustainable development and investments in renewable energy sources (RES) [19].

Socially responsible activities are beneficial for organizations' brand image and also have a positive impact on their innovativeness [20]. Simultaneously corporate social responsibility provides a comprehensive set of appropriate measures necessary to create value in a sustainable enterprise, which consists of achieving economic, ecological, and social goals [18,21].

Nowadays consumers are concerned by the environmental issues and long-term effects of human beings' activities, purchasing behavior is enhanced by the ecological aspects of brands, which is perceived by customers as green brand equity [19,22,23]. Individuals' environmentally positive attitude related to environmental concern, environmental knowledge, and responsibility is the strong determinant of adopting responsible energy [24,25].

Empirical research discussed the causal link between economic development and energy use, and their effect on the environment [26,27]. Economic growth has therefore stressed eco-friendly growing rather than pure growth [28]. Economic intermediation in developing economies could help them introduce new technologies and promote eco-friendly growth, and ultimately improve regional development [29,30]. Moreover, Jensen [31] and World Bank [32] stressed that even if financial growth could drive economic change, it could lead to ecological deprivation through increased industrial pollution. In contrast, it has been documented that higher financial and economic growth rates minimize environmental deterioration [33].

Pakistan is one of those countries facing a shortage of electric power and its role in the growth of renewable and nuclear energy consumption is nominal. Pakistan relies on fossil fuels to meet its energy requirements. Nevertheless, the use of this energy is limited and can generate pollution emissions, which is a concerning issue. Approximately 99 percent of Pakistan's energy supply is supplied by conventional energy sources including natural gas and oil, while the remaining about 1 percent of the energy supply comes from renewable sources. Approximately 140 million people either have no access to

power or are facing more than 12 h' blackout daily. The total average shortfall in the power sector is approximately 4000 MW and approximately two billion ft^3 per day of natural gas. According to the international energy agency (IEA), Pakistan's overall energy production in 2017 was about 70 million tons (oil equivalent). Energy is the pillar of the economy [27], while nuclear and renewable energy may offer a promising future for sustainable development and can also address the power shortage in Pakistan [10].

Taking Pakistan as a case study, this paper aims to fill these gaps in the existing literature by examining the causal links among the endogenous and exogenous variables empirically. Specifically, we employed the NARDL model, proposed by Shin, et al. [34] and the causality test of Hatemi-j [35] and Kim and Perron [36] to analyze the relationships between energy use, electric power consumption, energy imports, and economic growth in Pakistan during 1971 and 2016. The logic behind our use of asymmetry and non-linearity approaches is that the positive and negative changes of one exogenous variable have no influence on another variable in the same way [37,38]. The prevalence of non-linear relationships among variables is affected by social, political, economic, financial, and technological progress. These factors may cause positive or negative changes in exogenous variables that may cause heterogeneous environmental impacts. Furthermore, using unit root test, and Brock, Dechert, and Scheinkman (or BDS) test allows us to (i) account for the integration order and unknown structural breaks, and (ii) capture potential deviations from independence in data series like linear dependency, non-linear dependency or chaos [36]. The findings from this study are envisaged to help policymakers in Pakistan to support modern and pollution-free technologies like renewable and nuclear energy and investment in a green portfolio. In addition, policymakers should concentrate and thoroughly incorporate environmental concerns into their policy agendas to maintain development without environmental degradation.

The previous studies have shown that despite the substantial evidence of improvement in economic growth in Pakistan, the energy use and carbon dioxide discharges have augmented over economic development. How to treat the relationship between energy usage, financial growth, and CO_2 emissions legitimately is a great contest [39,40]. The relationship between energy and economic growth may be very complex because there are many channels of influence between them. For example, financial development may cause a rise in energy consumption. In contrast, financial growth will increase investment and upgrade technology which may also reduce energy use [38,41]. Under these circumstances, it is very important to research how positive and negative shifts under financial growth influence energy consumption. Therefore, we suggest using econometric approaches that account for the evaluation of asymmetry in the analysis of co-integration and causalities among economic growth, financial development, and power usages such as energy consumption and energy imports in Pakistan from 1971 to 2016. Accordingly, Hatemi-J (2012) and Shin et al. (2014) have recently developed these approaches. In addition, we also use Zivot–Andrews structural break trended unit root test to reflect possible unknown structural breaks that may occur in the time series under investigation.

2. Materials and Methods

2.1. Data

This study used secondary data, which was taken from BP Statistical Review of World Energy (2019) and World Development Indicators (WDI, 2019). The main objective of this research is to check the link between economic growth (GDP per capita), energy use (kg of oil equivalent per capita), electric power consumption (kWh per capita), financial development (domestic credit to the private sector in % of GDP) and energy imports for annual data from 1971–2016 for Pakistan's economy. The primary purpose of this study is to examine the significant influences of energy consumption (EC), electric power consumption (EPC), financial development (FD), and energy imports (EM) on economic growth (Y). In addition, all parameters are transformed into appropriate logarithms to achieve accurate

and reliable results [38]. Converting variables into their natural logarithmic allows the interpretation of coefficients as elasticities [42].

2.2. The NARDL Co-Integration

As unpredictable and unexpected incidents, such as financial and economic crises, political instability and revolutions may lead to a lack of linear methods to consider the economic association between time series data. Thus, the current research employed the NARDL methods of Shin et al. (2014) to attain nonlinear asymmetric co-integration among the variables. This methodology encompasses a dynamic model and permits to distinguish between short and long-run asymmetries. The NARDL approach is more robust and advantageous over the Vector Error Correction Model (VECM) and other methods due to its nature of being free from integration order restriction [43]. The other methods of cointegration will only accept the variables with the integration of order 1, while the NARDL can be used irrespective of the nature of variables due to its flexibility [27,44]. Empirically,

$$
\begin{aligned}
\Delta Y_t = {}& \alpha_0 + pY_{t-1} + \theta_1^+ E_{t-1}^+ + \theta_2^- E_{t-1}^- + \theta_3^+ EPC_{t-1}^+ + \theta_4^- EPC_{t-1}^- + \theta_5^+ FD_{t-1}^+ + \theta_6^- FD_{t-1}^- + \theta_7^+ EM_{t-1}^+ + \theta_8^- EM_{t-1}^- \\
& + \sum_{i=1}^{q} \alpha_2 \Delta Y_{t-1}^- + \sum_{i=1}^{q} \alpha_3 \Delta E_{t-1}^+ + \sum_{i=1}^{q} \alpha_4 \Delta E_{t-1}^- + \sum_{i=1}^{q} \alpha_5 \Delta EPC_{t-1}^+ + \sum_{i=1}^{q} \alpha_6 \Delta EPC_{t-1}^- \\
& + \sum_{i=1}^{q} \alpha_7 \Delta FD_{t-1}^+ + \sum_{i=1}^{q} \alpha_8 \Delta FD_{t-1}^- + \sum_{i=1}^{q} \alpha_9 \Delta EM_{t-1}^+ + \sum_{i=1}^{q} \alpha_{10} \Delta EM_{t-1}^- + D_t + \mu_t
\end{aligned}
\tag{1}
$$

where α_i and θ_i symbolize short-run and long-run coefficients, respectively. The long-run parameters here evaluate the amplitude of the adjustment towards the equilibrium, and the coefficients of short-run asymmetries take the instantaneous effect into account. We used the Wald test to analyze the null hypothesis for asymmetries in short-run ($\alpha = \alpha^+ = \alpha^-$) and long-run ($\theta = \theta^+ = \theta^-$) for the given variables i.e., Y_t, EC_t, EPC_t, FD_t and EM_t, which represents economic growth, energy usage, electric power consumption, financial development, and energy imports respectively. Where D_t is the dummy variable representing the structural break date (*t*). Akaike information criteria (AIC) was applied to choose the optimal lags *p* and *q* for all considered variables. The exogenous variables disintegrated into the partial sum of positive and negative as given below.

$$
X_t^+ = \sum_{j=1}^{t} \Delta X_j^+ = \sum_{j=1}^{t} \max(\Delta X_j, 0) \quad \text{And} \quad X_t^- = \sum_{j=1}^{t} \Delta X_j^- = \sum_{j=1}^{t} \min(\Delta X_j, 0)
\tag{2}
$$

where X_t represent the independent variables i.e., Y_t, EC_t, EPC_t, FD_t and EM_t.

According to Shin et al. (2014), the bound test applied in this study to determine the long-term asymmetric co-integration, which considers all the lagged levels of variables. The null hypothesis of $\theta^+ = \theta^- = \theta = 0$ was checked against alternative hypothesis $\theta^+ \neq \theta^- \neq 0$. Rejecting the null hypothesis confirms the long-term association among the variables. The long-run asymmetries are applied here to determine the shocks i.e., $Lmi^+ = \theta^+/\rho$ and $Lmi^- = \theta^-/\rho$. The asymmetric dynamic multiplier effects can be expressed as follows:

$$
\begin{aligned}
m_h^+ = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial EC_t^+} \quad m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial EC_t^-}, \quad m_h^+ = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial EPC_t^+} \quad m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial EPC_t^-} \\
m_h^+ = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial FD_t^+} \quad m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial FD_t^-}, \quad m_h^+ = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial EM_t^+} \quad m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial EM_t^-}
\end{aligned}
\tag{3}
$$

For all $h = 0, 1, 2, 3, \ldots$ where, if $h \to \infty$, then $m_h^+ \to lmi^+$ and $m_h^- \to lmi^-$.

The dynamic multipliers represent the positive and negative shocks in the explanatory variables. We may detect the dynamic changes from the current position to a new equilibrium position, depending on the predicted multipliers.

According to Diks and Panchenko [45], the causality test is applied to obtain the asymmetric causal connection among the variables. Consequently, the unified variables can be given in a random walk process as given below:

$$Y_t = Y_{t-1} + e_{1t} = Y_0 + \sum_{i=1}^{t} e_{1i} \text{ and } X_t = X_{t-1} + e_{2t} = X_0 + \sum_{i=1}^{t} e_{2i} \tag{4}$$

where $t = 1, 2, 3, \ldots, T$, Y_0, and X_0 represent the initial values, while e_{1i} and e_{2i} represent the stochastic term. The positive and negative shocks are given by $e_{1i}^+ = \max(e_{1i,0})$, $e_{2i}^+ = \max(e_{2i,0})$ and $e_{1i}^- = \min(e_{1i,0})$ $e_{2i}^- = \min(e_{2i,0})$ respectively, and can be expressed as given below:

$$Y_t^+ = \sum_{i=1}^{t} e_{1i}^+, \quad Y_t^- = \sum_{i=1}^{t} e_{1i}^- \quad EC_t^+ = \sum_{i=1}^{t} e_{2i}^+, \quad EC_t^- = \sum_{i=1}^{t} e_{2i}^-$$

$$EPC_t^+ = \sum_{i=1}^{t} e_{3i}^+, \quad EPC_t^- = \sum_{i=1}^{t} e_{3i}^- \tag{5}$$

$$FD_t^+ = \sum_{i=1}^{t} e_{4i}^+, \quad FD_t^- = \sum_{i=1}^{t} e_{4i}^- \quad EM_t^+ = \sum_{i=1}^{t} e_{5i}^+, \quad EM_t^- = \sum_{i=1}^{t} e_{5i}^-$$

Hatemi-J's (2012) causality test can be used to examine the asymmetric causal relationship among the variables by incorporating the VAR model. The *HJC* model (Hatemi-j [46] and Hatemi-J [47]) is employed for optimal lag selection as follows:

$$HJC = \ln(|A_j|) + q\left(\frac{n^2 \ln T + 2n^2 \ln(\ln T)}{2T}\right), \text{ where } q = 0, \ldots, p \tag{6}$$

where ln is the natural logarithm, $|A_j|$ is the determinant of the variance-covariance matrix of the error terms in the VAR model using lag order q, while n denotes the number of variables, and 'T' represents the no of observations in the VAR model. Following the selection of the optimum lag order, we defined the null hypothesis of kth element of y_2, which may not influence the wth element of y_1. Wald test is used to examine the null hypothesis of no causality as $H_0 = C\hat{\beta} = 0$.

3. Results

Table 1 shows the descriptive statistics of variables. The Jarque-Bera test findings show that the variables are normally distributed, and there is no outlier in our data. The results show that energy imports (EM) are less volatile than energy consumption and electric power consumption (EPC) while financial development (FD) is more volatile than other variables such as energy consumption, electric power consumption, energy imports, and economic growth. Moreover, the finding reveals that economic growth (Y) has the lowest volatility among all variables. Based on skewness, the results show an asymmetric distribution. Table 1 offers a further overview of the descriptive statistics of the variable.

Table 1. Descriptive statistics of the variables.

Description	Y	EC	EPC	FD	EM
Mean	2.652142	2.596320	2.413474	1.368576	1.308682
Median	2.638874	2.626532	2.526059	1.384041	1.307728
Maximum	3.136230	2.699345	2.668599	1.474013	1.442429
Minimum	2.001027	2.454807	1.958904	1.187128	1.176078
Std. Dev.	0.280861	0.078943	0.235543	0.073336	0.080858
Skewness	−0.080033	−0.482507	−0.652261	−1.007909	−0.194676
Kurtosis	2.553858	1.749091	1.924092	3.425987	1.798896
Jarque−Bera	0.430606	4.784047	5.480430	8.136220	3.055639
Probability	0.806297	0.091444	0.064556	0.017110	0.217008
Sum Sq. Dev.	3.549742	0.280442	2.496620	0.242020	0.294211

NARDL model supports the variables of order I(0), I(1), or both. In order to estimate and conduct the NARDL model, it is imperative to confirm that none of the variables is I(2). Both the Phillips & Perron (PP) test and Dickey-Fuller generalized least square (GLS) test without the structural break were applied to check the presence of unit root over a time series. The findings reveal that all the variables are non-stationary and have a unit root at the level. However, at the first difference, the selected variables are stationary (Table 2). The normal unit root test will yield inaccurate results and misrepresentative [48]. The previous studies demonstrated that, in the existence of structural breakdown, the standard PP and DF-GLS test statistics do not consider the structural break and have low probabilities to reject the null hypothesis; thus, the outcomes seem misleading and fabricated [28]. Such tests may go in favor of the null hypothesis and show that the series is stationary while the given series may have a structural breakdown. The possible bias increases the challenge of designing a test containing knowledge about the series' structural breaks to obtain accurate empirical results. Kim and Perron [36] overcome this problem by addressing structural break-dates, as shown in Table 2. In the proximity of systemic break date, the variables are found as non-stationary during 1981, 2015, 1992, 1976, and 2003 as shown in Table 2. The inclusion of unit root in the variables supports the application of the NARDL model to explore asymmetrical co-integration among the variables.

Table 2. Structural break unit root test.

| Trend & Intercept | PP Test | | DF-GLS Test | | ADF Break Date | | | |
| | | | | | (Level) | | 1st Diff. | |
	Level	1st Diff.	Level	1st Diff.	Statistics	Date	Statistics	Date
Y_t	−2.469	−5.794 ***	−2.261	−5.172 ***	−3.093	1975	−6.039 ***	1981
EC_t	−1.085	−5.168 ***	−1.027	−4.802 ***	−3.657	2007	−5.768 ***	2015
EPC_t	−1.006	−6.549 ***	−0.773	−5.297 ***	−1.765	1981	−7.239 ***	1992
FD_t	−1.686	−5.626 ***	−1.879	−5.197 ***	−5.007 **	2010	−6.473 ***	1976
EM_t	−1.897	−6.182 ***	−1.887	−6.109 ***	−3.726	2002	−7.135 ***	2003

Notes: *** and ** respectively represents 1% and 5%, level of significance.

Moreover, Zivot and Andrews approach [49] is suggested in the proximity of unidentified structural breakpoint in data, which is based on three models i.e., A, B, and C, where models A, B, and C allow one-time spontaneous variation in a variable at trend at the intercept, and both at intercept and trend, respectively. Table 3 shows the outcomes of the Zivot–Andrews test. The finding reveals that all the considered variables are stationary at the trend with break dates of 1987, 1997, 1993, 2007, and 1999. Besides, all of the selected variables except for economic growth and electric power consumption are also stationary at intercept. Moreover, all of the selected variables except for electric power consumption are stationary at both trend and intercept.

Table 3. Zivot–Andrews structural break unit root test.

| Variables | Trend | | Intercept | | Trend & Intercept | |
	Statistic	Break Date	Statistic	Break Date	Statistic	Break Date
Y_t	3.437 (1) **	1987	−3.208 (1)	1992	−3.917 (1) **	1983
E_t	−3.459 (1) **	1997	−3.736 (0) ***	2008	−3.394 (0) **	1987
EPC_t	−3.944 (0) ***	1993	−1.716 (0)	1981	−3.446 (0)	1991
FD_t	−3.414 (0) **	2007	−4.860 (1) ***	2009	−3.857 (0) ***	2003
EM_t	−4.082 (2) ***	1999	−4.090 (2) **	2003	−4.639(2) ***	2003

Notes: *** and ** respectively represents 1% and 5% level of significance.

The unregulated asymmetric analyses of the NARDL model, the long and short-run asymmetries, as shown in Table 4. The null hypothesis of homogenous impact is rejected based on Wald statistics, which point out that various shocks to exogenous variables will bring diverse upshots in endogenous variables. The early literature has indicated that positive and negative shocks had disproportionate effects on their respective dependent variables both in the short and long term [10,26]. Overall results demonstrated in Table 4 are in favor of the NARDL model to express the dynamic association among variables. In any dynamic modeling, the ignorance of asymmetries may lead to the misspecification of the model.

Table 4. Wald test and Diagnostic test.

Variables	Long & Short-Run Asymmetries		Diagnostic Test	
	Long-Run	Short-Run	Tests	Results
EC	10.0711 **	6.8476 **	Heteroscedasticity	8.232
EPC	4.9764 **	11.3644 ***	Functional Form	2.486
FD	0.6306	5.6410 **	Serial Correlation	6.818
EM	3.217 *	10.6320 **	R^2	0.914
F_{PPS}	10.956 ***		Adjusted R^2	0.706
T_{BDM}	−4.729 ***		D-Watson	2.826

Notes: ***, **, and * respectively represents 1%, 5%, and 10% level of significance.

Table 4 also shows the analysis of diagnostic tests. The diagnostic investigations reject the null hypothesis and support the alternative hypothesis suggesting that the variables are homoscedastic, there is no serial correlation, and have the correct functional form (Ramsay Reset test). Furthermore, Figures 1 and 2 show that the recursive residuals of CUSUM and CUSUMSQ test statistics are within critical values at 5% significant, suggesting that the series graphical plots are stable. The Durbin Watson test statistics (2.826) of the estimated model also confirms the nonexistence of autocorrelation. On the basis of Banerjee, et al. [50], the *t*-statistic (TBDM) authenticates the cointegration among the selected variables at a 1% significance level. Likewise, according to Shin, Yu, and Greenwood-Nimmo [34], the F-statistic of the NARDL model (FPSS) validates the presence of asymmetric cointegration among the selected variables suggesting that energy intake, electric power consumption, financial development, and energy imports have a long-term asymmetric relationship.
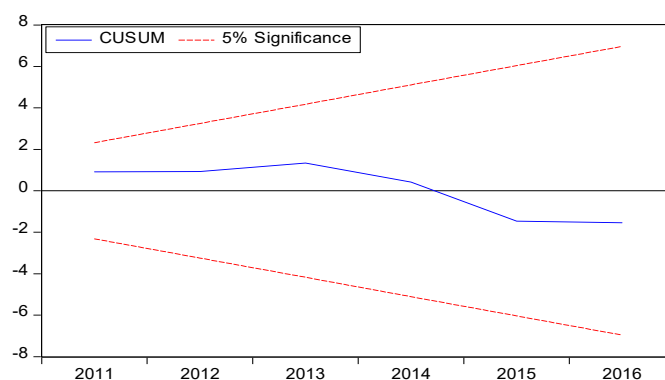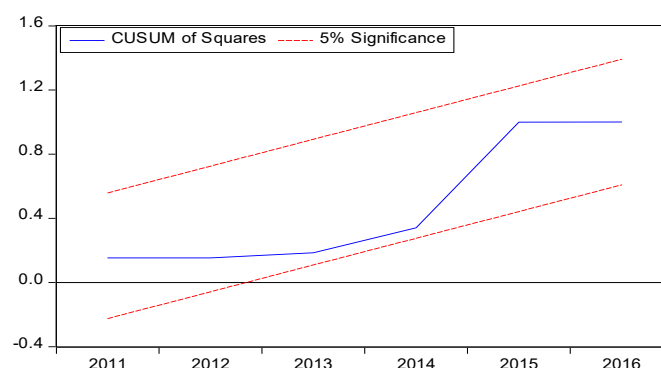

Figure 1. Cumulative sum (CUSUM) test.

Figure 2. Cumulative sum of Square (CUSUMSQ) test.

Table 5 demonstrates the BDS independence test of non-linearity. The BDS test introduced by Broock, et al. [51] is a non-parametric test configured primarily to examine the same and independent distribution identical and independent distribution (IID). BDS test is a general test broadly used to check the model specification when used for residuals from fitted models [52]. The findings reveal that all the selected variables have a non-linear trend in all dimensions. The linearity (null hypothesis) is rejected at a 1% level of significance, while the alternative hypothesis is accepted, suggesting that the included variables are non-linear. Our outcomes show the accuracy and reliability of the estimated results and validate the model selection [38]. More specifically, it is worth mentioning that the specified model of economic growth is appropriate for policymaking in Pakistan.

Table 5. Non-linearity test.

Variables	m = 2	m = 3	m = 4	m = 5	m = 6
Y	0.1603 ***	0.2620 ***	0.3422 ***	0.3973 ***	0.4322 ***
EC	0.2007 ***	0.3413 ***	0.4421 ***	0.5128 ***	0.5604 ***
EPC	0.2047 ***	0.3496 ***	0.4497 ***	0.5181 ***	0.5653 ***
FD	0.1034 ***	0.1439 ***	0.1451 ***	0.1181 ***	0.0646 **
EM	0.1573 ***	0.2650 ***	0.3323 ***	0.3713 ***	0.3883 ***

Notes: *** and ** respectively represents 1% and 5% level of significance.

Table 6 gives an overview for both the long- and short-term NARDL cointegration test Shin et al. (2014). The finding demonstrates that in the long run any positive shock in energy significantly influences the economic growth with a coefficient of 4.780, which reveals that positive shock to energy acting a facilitating role to encourage economic growth in Pakistan. The previous studies also revealed that positive shocks to energy consumption may positively and significantly influence economic growth [38,40]. In contrast, negative shocks have no significant effect on economic growth. The outcomes of [10] demonstrated that shocks to nuclear and renewable energy have a positive and significant influence on economic growth. In the context of the short-run, a rise in the consumption of energy in the current year and preceding years have a significant but negative impact on economic growth (coefficients -4.6219, -6.7646, -7.3947, and -7.4093 at lag 0, 1, 2, and 3, respectively). Meanwhile, negative shocks to energy consumption in an existing year and preceding years have a positive effect on economic growth (with coefficients 6.9595, 27.476, and 22.169 at lag 0, 2, and 3 respectively).

Table 6. Co-integration analysis.

Variable	Coefficient	Std. Error	*t*-Statistic	Prob. *
C	4.049990	1.048192	3.863786	0.0083
Y_{t-1}	−1.456667	0.393101	−3.705581	0.0100
$EC^+{}_{t-1}$	4.780086	2.129562	2.244634	0.0659
$EC^-{}_{t-1}$	−15.53479	8.319582	−1.867256	0.1111
$EPC^+{}_{t-1}$	−1.797265	0.532545	−3.374858	0.0150
$EPC^-{}_{t-1}$	3.159798	1.736601	1.819531	0.1187
$FD^+{}_{t-1}$	2.406176	0.668269	3.600607	0.0114
$FD^-{}_{t-1}$	1.681517	0.943067	1.783030	0.1249
$EM^+{}_{t-1}$	−1.594909	0.541841	−2.943499	0.0258
$EM^-{}_{t-1}$	−3.594752	0.771338	−4.660409	0.0035
D_{1975}	−0.472853	0.109216	−4.329530	0.0049
$DEC^-{}_{t-1}$	9.333762	3.601258	2.591806	0.0411
$DEPC^+{}_{t-3}$	2.717405	0.710681	3.823662	0.0087
$DFD^-{}_t$	1.525884	0.744421	2.049759	0.0863
$DFD^+{}_{t-3}$	−2.676353	0.768715	−3.481594	0.0131
DY_{t-2}	−1.185214	0.296820	−3.993036	0.0072
DY_{t-1}	−0.336336	0.275411	−1.221216	0.2678
$DEPC^-{}_t$	3.902647	1.448316	2.694610	0.0358
$DEM^-{}_t$	1.933691	0.740147	2.612578	0.0400
$DEC^+{}_{t-2}$	−7.394753	2.171339	−3.405619	0.0144
$DEPC^-{}_{t-1}$	3.242940	1.905254	1.702103	0.1396
$DEM^+{}_{t-1}$	−1.113228	0.527357	−2.110957	0.0793
$DEC^-{}_t$	6.959513	2.941017	2.366362	0.0558
$DFD^-{}_{t-2}$	0.880611	0.360691	2.441456	0.0504
$DEPC^-{}_{t-3}$	−6.332501	1.935730	−3.271376	0.0170
$DEPC^-{}_{t-2}$	−3.432552	1.328098	−2.584563	0.0415
$DEC^-{}_{t-2}$	27.47614	6.533294	4.205557	0.0057
$DFD^+{}_{t-2}$	−3.831819	0.986371	−3.884763	0.0081
$DFD^+{}_{t-1}$	−2.705682	0.698677	−3.872580	0.0082
$DFD^-{}_{t-3}$	1.211626	0.337528	3.589702	0.0115
$DEPC^+{}_t$	−1.836759	0.483295	−3.800494	0.0090
$DEC^+{}_t$	−4.621921	1.428418	−3.235692	0.0178
$DEC^+{}_{t-3}$	−7.409318	2.009368	−3.687387	0.0102
$DEM^-{}_{t-1}$	2.380135	0.799388	2.977445	0.0247
$DEC^+{}_{t-1}$	−6.764604	2.510001	−2.695060	0.0358
$DEC^-{}_{t-3}$	22.16880	6.557506	3.380675	0.0148

Notes: * represents 10% level of significance.

The results regarding the long-run association between electric power consumption and economic growth reveal that the significant positive shocks to electric power consumption will negatively influence the economic growth with coefficient −1.7973, while negative shocks to electric power consumption have no considerable impression on economic growth in Pakistan. These findings suggest that a rise in electric power by 1% will hamper economic growth by 1.79% in Pakistan. Meanwhile, the short-run connection of electric power consumption and economic growth shows that positive shocks to electric power consumption in the current period have a significantly negative effect (coefficient −1.8368), while in previous years at lag 3, the positive shocks have a significantly positive influence on economic growth (coefficients 2.7174). The negative shocks to electric power consumption in the current year have a significantly positive effect on economic growth with coefficients 3.9026 at lag 0, while that have negative and significant impacts with coefficients −3.4325 and −6.3325 in preceding years at lag 2 and lag 3, respectively. The findings of Lean and Smyth [53] revealed that there is a long-run unidirectional causality running from electricity consumption to economic growth. While the findings of Akpan and Akpan [54] reported that economic growth is linked with increasing electric power consumption.

Moreover, the results reveal that positive shock to financial development is significantly positive with a coefficient of 2.406, suggesting that a 1% increase in financial development will increase economic growth by 2.406% in Pakistan. However, a negative shock to financial development is non-significant. Meanwhile, the short-run connection shows that positive shocks in financial development have a significant but negative effect on economic growth with coefficients −2.7056, −3.8318, and −2.6763 at lag 1, lag 2, and lag 3, respectively. Whereas any negative shock to financial expansion may significantly cause a positive influence on economic progression with coefficients 1.5258, 0.8806, and 1.2116 with lag 0, lag 2, and lag 3 respectively.

Furthermore, the long-run association between energy imports and economic growth shows that positive and negative shocks to energy imports have a significantly negative influence on economic growth in Pakistan with coefficients −1.5949 and −3.5947, respectively. In the short run, a positive shock in energy import is inversely associated with economic growth having a coefficient of −1.1132 at lag 1. Whereas a negative shock to energy imports in the current and previous years has a significantly positive effect on economic growth with coefficients 1.9337, 2.3801.

Finally, we established dynamic multiplier adjustment of the variables. The cumulative multiplier for energy consumption, electric power consumption, financial development, and energy imports is shown in Figure 3, which displays the outline of adjustment of economic growth towards long-term new equilibrium following the positive or negative shocks in the selected variables. In the case of energy consumption, the dynamic multiplier demonstrates that energy consumption and economic growth are interrelated. The detrimental energy consumption shocks are more prevalent than the positive shocks but have no significant impact on economic growth. Figure 3 also illustrates that electric power consumption is positively associated with economic growth because negative shocks to electric power consumption have a positive effect on economic growth. The significant negative shocks to economic growth are more dominant than the positive shocks.

Similarly, the dynamic multiplier also confirms that financial development is positively associated with economic growth, where the positive shocks to financial development are more dominant than the negative shocks. Finally, Figure 3 indicates that a negative relationship exists between energy imports and economic growth. However, there is a particular feature of the negative shocks in energy imports and they are initially less dominant than the positive shocks and become more prevailing in the lateral situation.

Table 7 display the results of the symmetric and asymmetric bootstrap causalities test. As demonstrated, both symmetric and asymmetric causalities between energy consumption and economic growth were found neutral. The causal association of electric power consumption and economic growth depicts a unidirectional symmetric causality from electric power consumption toward economic growth, meanwhile, a neutral asymmetric causal effect was found between the positive shocks in electric power consumption and economic growth. However, the negative shocks in electric power consumption create a positive shock in economic growth. Moreover, a bidirectional symmetric causality was found between financial development and economic growth. Meanwhile, only a unidirectional asymmetric causality was found running from financial development to economic growth, which shows that a negative shock to financial development will create a positive effect on economic growth. Finally, a neutral symmetric causality was found between energy imports and economic growth. Similarly, asymmetric causality reveals that positive shocks between energy imports and economic growth are not significant. In contrast, negative shocks between energy imports and economic growth are significant at a 10% level of significance (Wald test = 4.088), which indicates any decrease in energy import will boost the economic growth in the country.
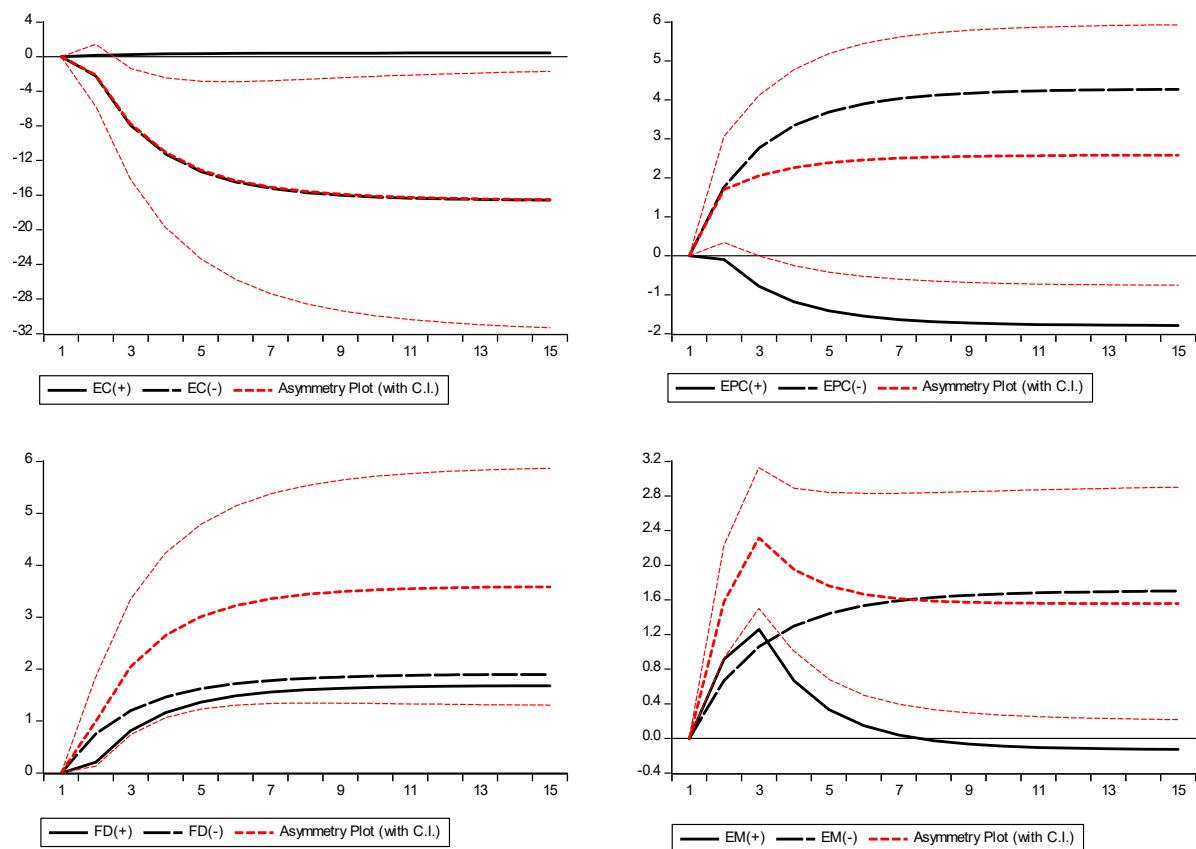
Figure 3. Dynamic multiplier adjustments of energy consumption, electric power consumption, financial development, and energy imports on economic growth.

Table 7. Causality analysis of positive and negative shocks.

Causalities	Wald Test	CV at 1%	CV at 5%	CV at 10%
$Y_t \nRightarrow E_t$	2.408	10.026	4.991	3.303
$Y_t^+ \nRightarrow E_t^+$	2.470	8.689	4.526	3.097
$Y_t^- \nRightarrow E_t^-$	0.006	6.851	4.112	2.934
$E_t \nRightarrow Y_t$	0.119	9.482	5.017	2.934
$E_t^+ \nRightarrow Y_t^+$	0.003	7.988	4.441	3.052
$E_t^- \nRightarrow Y_t^-$	0.462	7.027	4.162	2.974
$Y_t \nRightarrow EPC_t$	8.900	48.804	22.477	15.305
$Y_t^+ \nRightarrow EPC_t^+$	0.029	8.643	4.554	3.049
$Y_t^- \nRightarrow EPC_t^-$	6.681	28.849	16.141	12.086
$EPC_t \Rightarrow Y_t$	27.129 *	60.604	27.384	18.830
$EPC_t^+ \nRightarrow Y_t^+$	0.098	8.387	4.559	3.046
$EPC_t^- \Rightarrow Y_t^-$	26.708 **	27.315	15.261	11.230
$Y_t \Rightarrow FD_t$	5.222 **	9.265	4.947	3.311
$Y_t^+ \nRightarrow FD_t^+$	0.166	8.728	4.350	3.057
$Y_t^- \nRightarrow FD_t^-$	5.483	52.269	25.452	17.515
$FD_t \Rightarrow Y_t$	4.342 *	8.712	4.532	3.099
$FD_t^+ \nRightarrow Y_t^+$	0.611	9.271	4.932	3.260
$FD_t^- \Rightarrow Y_t^-$	43.952 **	57.480	28.153	19.396
$Y_t \nRightarrow EM_t$	0.098	8.641	4.474	3.034
$Y_t^+ \nRightarrow EM_t^+$	1.347	8.461	4.570	3.094
$Y_t^- \nRightarrow EM_t^-$	0.134	7.480	4.285	3.027
$EM_t \Rightarrow Y_t$	0.158	10.464	5.392	3.694
$EM_t^+ \nRightarrow Y_t^+$	0.364	8.572	4.492	3.026
$EM_t^- \Rightarrow Y_t^-$	4.088 *	7.944	4.378	3.025

Notes: **, and * respectively represents 1%, 5%, and 10% level of significance.

4. Conclusions and Discussion

To achieve sustainable economic growth, developing nations, like Pakistan, must make considerable efforts to preserve a good environment without the expense of energy and resources.

The pillar of the environmental policy is sustainable development, oriented towards gradual and consistent rationalization of the use of natural resources, so as to provide the present inhabitants of the Earth with appropriate conditions, as well as future generations. Renewable energy sources (RES), as research shows, are gaining in importance in both developed and developing countries. Earlier studies evidence that enterprises are able to see benefits of investing in RES (so-called RES resonance) both in the area of their corporate social responsibility (CSR) strategy and sustainable development, as well as innovativeness and brand equity [19]. The innovativeness of economic entities, in turn, is an important factor that strengthens the innovativeness of economies and fuels economic growth.

Despite the substantial improvement in economic growth, energy intake and carbon dioxide emissions have grown up in Pakistan. How to justifiably knob the relationship among the selected endogenous and exogenous variables is a considerable challenge. Accordingly, the key purpose of this study was to examine the impact of energy consumption, electric power consumption, financial development, and energy imports on economic growth by employing data set from 1971 to 2016. In this research paper, the asymmetric connection among the designated parameters was investigated by means of the nonlinear ARDL co-integration technique formulated by Shin, Yu, and Greenwood-Nimmo [34] and the causality test of Hatemi-j [35] and Kim and Perron [36]. The outcomes validate the presence of asymmetric co-integration among variables.

The causality test reveals that both symmetric and asymmetric causalities between energy use and economic progression were found neutral. The causal connection between electric power consumption and economic growth confirms a unidirectional symmetric causality from electric power consumption to economic growth. Regarding asymmetric causalities, a neutral effect exists between the positive shocks in electric power consumption and economic growth. However, the negative shocks in electric power consumption were found significant and positive that may influence economic growth positively. Moreover, regarding the causal linkage between financial development and economic growth the findings reveal that there is bidirectional symmetric causality between financial development and economic growth. Meanwhile, only a unidirectional asymmetric causality was found running from financial development to economic growth, which points out that a negative shock to financial development will create a positive effect on economic growth. Finally, a neutral symmetric causality was found between energy imports and economic growth. Similarly, the asymmetric causality reveals that positive shocks between energy imports and economic growth are non-significant. In contrast, negative shocks between energy imports and economic growth are significant at a 10% level of significance, which indicates any decrease in energy imports will boost the economic growth in the country.

The conducted research, the results of which are presented in this paper, have their limitations, which include, above all, the period of the analyzed data. It poses on the other hand also the justification for the continuation of the research. Certainly, in view of the current global problems and trends related to sustainable development, it seems inevitable to pay more attention to renewable energy sources and the attitude of both the government, enterprises, and households towards investing in this field. Examples of developed countries show that sustainable economic growth is possible. However, it requires high environmental awareness, discipline, and commitment of all market entities.

Based on the findings, some critical policy implications emerged. Specifically, the Government of Pakistan and policymakers should pay more attention to the current and future energy crises in the country and overwhelm the shortfall of energy. Moreover, the Pakistani Government should encourage foreign direct investment especially in renewable energy, low Corban-technology, and promote the adoption of green technology in the

agriculture sector, which will not only overwhelmed the energy crises in the country but rather improve the environment as well.

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