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RESEARCH ARTICLE

Effect of energy consumption and economic growth on carbon dioxide emissions in Pakistan with dynamic ARDL simulations approach

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Abstract

Environmental degradations are mainly caused by the use of different energy resources for economic growth. This research examined the influence of energy consumption (coal consumption, oil consumption, and gas consumption) and economic growth on environmental degradation in Pakistan. This research used newly developed method dynamic ARDL simulations to scrutinize the actual influence of positive and negative change in the use of coal consumption, oil consumption, and gas consumption for energy and economic growth on environmental degradation in Pakistan. The examined results of dynamic ARDL indicate that economic growth, coal consumption, oil consumption, and natural gas consumption have positive impact on the environmental degradations in Pakistan both in short run and long run. It is suggested that environmental degradations can be reduced by promoting renewable energy sources for energy.

Keywords Economic growth · Energy consumption · CO2 emissions · Dynamic ARDL simulations

Introduction

Environmental degradation is the most complicated problem of industrialized countries and in unindustrialized economies is no more practically effective. High emissions of greenhouse gases (GHGs) are impacting the industrialized and unindustrialized countries across the globe. Countries are utilizing energy and other natural resources to attain maximum economic growth that causes to increase the greenhouse gas emissions. Carbon dioxide emissions are one of the major contributing factors of greenhouse gas emission that causes environmental degradation (Hamilton and Turton 2002; Sarkodie and Strezov 2018a; Owusu and Asumadu-Sarkodie 2016). Hossain (2011) stated that oil, coal, and gas are the main sources of CO2 emissions that negatively influence the environment. Soytas et al. (2007) scrutinized the impact of use of energy and economy development on CO2 emissions in the USA by utilizing Granger causality. The examined result indicates that economic growth does not influence the CO2 discharges while use of energy helps to boost CO2 emission in the long run in USA. They stated that economy growth does not decrease the environmental degradations and can solve the environmental matters. Narayan and Narayan (2010) verified the environmental Kuznets curve (EKC) assumption in emerging economies. The examined results pointed out that with increase of economy growth in 35% countries of developing economies, the environmental degradations decrease with economy development. Apergis et al. (2010) scrutinized the association of use of energy, economy development, and environmental degradations in 19 developed and developing economies by utilizing panel error correct model for checking the association. The examined results specify that use of energy and economy development positively impacts the environmental degradations. Lee and Jung (2018) scrutinized the association of used of energy and economy development in South Korea from 1990 to 2012 by utilizing the autoregressive distributed lag (ARDL) model to inspect the relationship among the study

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variables. The examined results specify that use of energy has an adverse impact on the economy growth. They suggested that strategy creators should focus on economy growth as compared to expanding renewable energy.

Tiwari et al. (2013) examined the influence of use of energy and economy development on CO2 emissions. The examined results indicated that use of energy and trade openness positively impact environmental degradation. The results show that one-way association occurs between economy developments, coal consumption, and environmental degradation while they pointed out unidirectional association from trade openness to economy development, use of energy, and environmental degradations. Shahbaz et al. (2013) scrutinized relation of economy development and financial development with CO2 emissions by utilizing the ARDL model. The examined results show economy development and energy consumption causes to boost the CO2 emissions while financial sector growth and trade openness help to decrease the CO2 emissions. Amri (2017) scrutinized the association of economy development and use of energy with environmental degradations in Algeria. The examined results indicated that the use of energy boosts the CO2 emissions. Pao and Tsai (2010) scrutinized the influence of economy growth and use of energy on environmental degradations in BRIC economies. The investigated results indicate that the use of energy positively influences the CO2 emissions while economic growth negatively impacts environmental degradation. Siddiqui (2004) examined the association of use of energy with economy development in Pakistan. The examined results indicate that the use of energy boosts the economy development in Pakistan. Kasman and Duman (2015) scrutinized the association of use of energy, economy development, and environmental degradations by utilizing panel cointegration for analysis. The examined results indicate that one-way causality runs from use of energy to the environmental degradations and from economy development to energy consumptions. Wang et al. (2011) examined relation of use of energy, economy development, and CO2 emissions in 28 provinces of China by applying panel data for analysis. The examined results specified that use of energy and economy development boosts the environmental degradation. Balsalobre-Lorente et al. (2018) inspected the influence of economy growth, renewable electricity, and natural resources on CO2 emission in EU-5 economies from 1985 to 2016. The examined results verified the N-shape EKC for the study economies. The scrutinized results show renewable energy consumption and natural resource helps to decrease the environmental degradations while economic growth boosts the environmental degradation.

Although numerous researches have scrutinized the relation between energy consumption, economic growth, and CO2 emissions, to the best of our knowledge, all these researches have only used simple ARDL model or other cointegration methods to investigate the short-run and long-run association between variables but in this study, we have applied dynamic autoregressive distributed lag simulations (Jordan and Philips 2018). Dynamic ARDL simulations are proficient to scrutinize the effect of actual changes in the independent variable. No researches in the existing literature have scrutinized the influence of positive and negative changes of energy consumption and economic growth on CO2 emissions in Pakistan by using dynamic ARDL simulations. Finally, this research contributed to the literature by using the novel developed method dynamic ARDL simulations to scrutinize the influence of energy consumption and economic growth on CO2 emissions.

Literature review

Asumadu-Sarkodie and Owusu (2017) analyzed the influence of economy growth, use of electricity, and industrialization on environmental degradations from 1980 to 2011 by utilizing VECM to scrutinize association among the study variables. The examined results indicate economy development, use of electricity, and industrialization positively influence environmental degradations in Sierra Leone. Destek (2017) examined the influence of use of biomass energy on economy development from 1980 to 2010. The examined results indicated that the use of biomass energy positively impacts the economic growth. Fan and Lei (2017) studied the association of environmental degradations with economy development from 1995 to 2014. The examined results indicate that environmental degradations positively impact on the economy development in Beijing. Işik et al. (2017) examined the impact of economy development, financial sector growth, and trade and tourism on environmental degradations from 1970 to 2014 for Greece by utilizing the ARDL model. The examined results of ARDL indicate that economy development, financial sector growth, trade, and tourism have positive impact on the environmental degradations. Tamba et al. (2017) scrutinized the influence of use of energy on economy development from 1975 to 2014 by utilizing VAR model. The examined results indicate that bidirectional association happens between use of energy and economy development in Cameroon. Tamba et al. (2017a) inspected the influence of use of electricity for energy on economy development by utilizing the Johansen cointegration and VAR model. The examined results specify that no causal association exists among the study variables.

Bekun et al. (2018) scrutinized the influence of economy development, environmental degradations, labor force, and capital on energy consumption 1969 to 2016 for South Africa. The examined results pointed out that one-way causality exists among energy use and economy development that verify the energy-led growth hypothesis. EKC hypothesis was also verified because economic growths have association with use of energy. Sarkodie and Strezov (2019a) studied the impact of environmental change susceptibility and adaptation readiness for 192 economies. The examined results indicate that Africa is mostly impacted by the environmental degradation factors as compared to other countries. Mohiuddin et al. (2016) scrutinized the association of use of energy and economy growth with CO2 emission from 1971 to 2013 for Pakistan by utilizing the VAR model for checking. The examined results show that environmental degradations in Pakistan are positively impacted by the use of energy. Sarkodie and Strezov (2019b) scrutinized the influence of FDI, economy development, and use of energy on environmental degradations from 1982 to 2016 by using panel data. The examined results indicated that environmental degradation was positively impacted by energy consumption that verified the pollution haven hypothesis. They suggested that FDI and clean energy technologies help to reduce the environmental degradations. Sarkodie and Strezov (2018b) examined the EKC and Environmental Sustainability curve (ESC) curve hypothesis for four countries from 1971 to 2013. The examined results show that economy growth in developed economies reduces the environmental degradations in developed countries that verify the EKC while the environmental sustainability curve hypothesis specifies that the use of energy and economy development patterns environmental degradations. Destek and Sarkodie (2019) examined the influence of use of energy consumption, financial sector growth, and economy development on ecological footprint in 11 new developed countries from 1977 to 2013. The examined results showed that U-shape association exists among the economy development and ecological footprint while causality results indicated that bidirectional association exists among economy development and ecological footprint. Sarkodie (2018) examined factors that impact the CO2 emissions for 17 African countries by utilizing 1971 to 2013. The author used panel cointegration to scrutinize the relations among the study variables. The examined results specified that association exists among economy development and environmental degradations that verified the EKC in Africa. Bekun et al. (2019) examined the association between use of energy, natural resources, economy development, and CO2 emissions from 1996 to 2014 for different economies. The examined results show that the use of renewable energy helps to reduce environmental degradations; natural resources have positive impact on the environmental degradations while energy consumption positively influences the environmental degradations.

Data and methodology

This research scrutinized the influence of energy consumption and economic growth on CO2 emissions in Pakistan by utilizing annual time series data from 1965 to 2015 sourced from WDI (World Bank 2017) and BP statistical review of world energy 2017. CO2 emissions were measured as metric tons per capita, and economic growth was measured by per capita % of GDP; these two variable data were gathered from WDI (World Bank 2017) while coal consumption was measured by million tons oil equivalent, oil consumption was measured by thousand barrel daily, and natural gas consumption was measured by million tons oil equivalent; these three variable data were from BP statistical review of world energy BP 2017 (https://www.bp.com/). To remove the problem of heteroscedasticity, all series were transformed to logarithmic form. This paper applied the dynamic autoregressive distributed lag simulation methods to examine the actual change caused by independent variable in the dependent variable Jordan and Philips (2018). Before applying dynamic ARDL simulations, we need to conduct a unit root test to examine the stationarity of each variable and the order of integration of the relevant variables. If any variable is non-stationary, it could lead to spurious regression results. We checked the stationarity of each variable with the level and with first difference. If any variable at its level term is non-stationary, it will have a unit root, but if the first differences of the time series are stationary, it means that the time series is integrated of degree one or I(1). Only variable that is stationary at I(0) or I(I) can be used to apply dynamic ARDL simulations. Augmented Dickey-Fuller (Dickey and Fuller 1979) and Phillips-Peron (Phillips and Perron 1988) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests were applied to scrutinize the linear stochastic trend in the series. To examine the association among the study variables, the following general equation is proposed:

$$C02PC_t = \beta_0 + +\beta_1 ECG_t + \beta_2 Oilcm_t + \beta_3 Coalcm_t + \beta_4 Gascm_t + \varepsilon_t \quad (1)$$

In the above equation, β_0 is constant, β_1 to β_4 are the coefficients of independent variables, and ε_t is the error term.

Autoregressive distributed lag bounds test

Bound test was utilized to scrutinize the long-run association among the study variables. Based on the hypothesis, the following ARDL bound test model was applied to examine the long-run association among the study variables:

$$\begin{aligned}\Delta \mathrm{C02PC}_t = {} & \varphi_0 + \varphi_1 \mathrm{C02PC}_{t-i} + \varphi_2 \mathrm{ECG}_{t-i} \\ & + \varphi_3 \mathrm{Oilcm}_{t-i} + \varphi_4 \mathrm{Coalcm}_{t-i} + \varphi_5 \mathrm{Gascm}_{t-i} \\ & + \sum_{i=1}^{q} \beta_1 \Delta \mathrm{C02PC}_{t-i} + \sum_{i=1}^{q} \beta_2 \Delta \mathrm{ECG}_{t-i} \\ & + \sum_{i=1}^{q} \beta_3 \Delta \mathrm{Oilcm}_{t-i} + \sum_{i=1}^{q} \beta_4 \Delta \mathrm{Coalcm}_{t-i} \\ & + \sum_{i=1}^{q} \beta_5 \Delta \mathrm{Gascm}_{t-i} + \varepsilon_t \quad (2)\end{aligned}$$

In Eq. 2, Δ represents the first difference, CO2PC is CO2 emissions per capita, ECG is the economic growth, Oilcm is oil consumption, Coalcm is coal consumption, Gascm is gas consumption, and t-i represents the optimal lags selection based on Akaike information criterion. φ and β are variables that will be examined for checking long-run association among the study variables. Long-run associations exist among the study variables so we estimate the short-run and long-run ARDL model. The null and alternative hypotheses of bound test are the following:

$$H_0 = \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = \varphi_5 = 0$$

$$H_1 \neq \varphi_1 \neq \varphi_2 \neq \varphi_3 \neq \varphi_4 \neq \varphi_5 \neq 0$$

The null hypothesis can be accepted or rejected based on the examined value of F-statistics. Pesaran et al. (2001) stated that long-run association presents among the study variables if the calculated F-statistics values are greater than the upper bounds value; no long run association exists if the calculated F-statistics value is less than the lower bounds value and the decision is inconclusive if the calculated F-statistics value between the lower and upper bounds value.

ARDL model

The ARDL model was suggested by Pesaran et al. (1999); Pesaran et al. (2001). The ARDL model has different advantages as compared to other time series models. Haug (2002) stated that ARDL model can be utilized with short time data. ARDL model can be utilized if the series are stationary at I(0), I(I), or both of them. Different lags can be used for dependent and independent variables. As the estimated results of ARDL bound test indicate that cointegration exists among the study variables. This is the long-run ARDL model:

$$CO2PC_t = \alpha_0 + \sum_{i=1}^{q} \sigma_1 \mathrm{C02PC}_{t-i} + \sum_{i=1}^{q} \sigma_2 \mathrm{ECG}_{t-i} + \sum_{i=1}^{q} \sigma_3 \mathrm{Oilcm}_{t-i} + \sum_{i=1}^{q} \sigma_4 \mathrm{Coalcm}_{t-i} + \sum_{i=1}^{q} \sigma_5 \mathrm{Gascm}_{t-i} + \varepsilon_t \quad (3)$$

In the above equation, σ represents the long-run variation in the study variables. Akaike information criterion was applied to select suitable lags for each variable. For the short-run ARDL model, the following error correction model was applied:

$$CO2PC_t + \alpha_0 + \sum_{i=1}^{q} \beta_1 \Delta \mathrm{C02PC}_{t-i} + \sum_{i=1}^{q} \beta_2 \Delta \mathrm{ECG}_{t-i} + \sum_{i=1}^{q} \beta_3 \Delta \mathrm{Oilcm}_{t-i} + \sum_{i=1}^{q} \beta_4 \Delta \mathrm{Coalcm}_{t-i} + \sum_{i=1}^{q} \beta_5 \Delta \mathrm{Gascm}_{t-i} + \varphi ECT_{t-i} + \varepsilon_t \quad (4)$$

In the above equation, β shows the short-run variation while ECT indicates the error correction term that estimates the speed of adjustment from disequilibrium; normal range of error correction term is from − 1 to 0. Error correction term should be negative and statistically significant that means that any shock is adjusted to equilibrium in the next time period. Stability of model was checked through CUSUM and CUSMSQ (Brown et al. 1975. Serial correlation was check by Breusch–Godfrey Lagrange Multiplier (LM). Heteroscedasticity was checked through Breusch-Pagan-Godfrey (BG), and autoregressive conditional heteroscedasticity (ARCH); Jarque–Bera was used to check the residual normality. Model specification was checked through Ramsey reset test.

Dynamic autoregressive distributed lag simulations

Jordan and Philips (2018) proposed the dynamic ARDL model to remove the complications of the existing ARDL for investigation of the short-run and the long-run association among the study variables. Dynamic ARDL simulations method is efficient to estimate, stimulate, and predict the graph automatically of the actual change in the regressor and its impact on the regressand while the remaining variables in the equation remain constant. To use dynamic ARDL simulations method, the variables would be stationary at I(I) and cointegration among the study variables (Jordan and Philips 2018; Sarkodie et al. 2019). Dynamic ARDL error correction term algorithm used 5000 replications for the vector of variables from multivariate normal distribution. The graphs are used to examine the actual change in the regressor and its impact on the regressand. This is the error correction term forms of ARDL bound test Jordan and Philips 2018; Sarkodie et al. 2019:

$$\Delta CO2PC_y = \alpha_0 + \theta_0 CO2PC_{t-1} + \beta_1 \Delta ECG_t + \theta_1 ECG_{t-1} + \beta_2 \Delta Oilcm_t + \theta_2 Oilcm_{t-1} + \beta_3 \Delta Coalcm_t + \theta_3 Coalcm_{t-1} + \beta_4 \Delta Gascm_t + \theta_4 Gascm_{t-1} + \varepsilon_t \quad (5)$$

Results and discussion

Before applying dynamic ARDL simulations, it is essential to check that any series are not I(2); otherwise, the results will not be valid. Three different unit root tests ADF, PP, and KPSS were applied to check unit root of each series. The examined results show that none of the series are stationary at I(2). The estimated results of the above three unit root tests show that

Table 1 Unit root tests

Variables	ADF		PP		KPSS	
	Level	1st Diff	Level	1st Diff	Level	1st Diff
CO2PC	− 0.3930	− 3.8765***	− 0.3857	− 6.0002***	0.8834***	0.1254*
ECG	− 6.1785***	− 3.8784***	− 6.1921***	− 23.2779***	0.2220	0.5000**
Oilcm	0.1605	− 3.3058**	− 0.3272	− 4.6348***	0.9165***	0.1206*
Coalcm	− 0.1100	− 3.0857**	− 0.3458	− 5.5378***	0.7955***	0.5598**
Gascm	− 1.8191	− 4.9052***	− 2.2741	− 4.7639***	0.9486***	0.3825*

ECG is economic growth, Oilcm is oil consumption for energy, Coalcm is coal consumption for energy, Gascm is gas consumption for energy

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

dynamic ARDL model can be applied with the used series (Table 1).

Autoregressive distributed lag model allow to select different lags for dependent and independent variables. The below table indicates the results of different lags selection criteria test. AIC, SC, and HQ are the famous to select suitable lags for dependent and independent variables (Table 2). We used AIC for lag selection; according to AIC, lag two is suitable for our model because the AIC value is the lowest among the three lag length selection criteria.

ARDL bounds test was used to examine the long-run association among the study series. Table 3 indicates the results of F-statistics. F-statistics is applied to decide the cointegration. The calculated F-statistics value is greater than the upper bounds value at 10%, 5%, and 2.5% level of significance that indicates that cointegration exists among the study variables.

Table 4 indicates the results of different diagnostic statistics. Diagnostic statistics were applied to scrutinize the consistency of the applied model. Results of Breusch-Godfrey LM test indicate that there is no problem of serial correlation in the used model. Heteroscedasticity problem was checked through Breusch-Pagan-Godfrey and ARCH test respectively; scrutinized results show that no problem of heteroscedasticity exists in the model. Ramsey RESET test was utilized to investigate if the model is specified correctly or not; the examined results indicate that the model is correctly specified. Jarque-Bera's results indicate that the residual of the model is normal.

Table 5 indicates the results of dynamic ARDL simulations. The examined results of dynamic ARDL simulations show that economic growth has positive influences on the environmental degradations in Pakistan. The examined results show that 1% growth in economic growth causes to negatively impact the environment and boost the environmental degradations up to 0.0134% and 0.0064% respectively in the long run and short run. Pakistan economy is emerging; for economy growth, different traditional energy sources are used to attain high economy growth with cheap energy resources that have negative effect on the environment and cause the environmental degradations. The examined results are similar with previous researchers. Mikayilov et al. (2018) examined the influence of economic growth on environmental degradations in Azerbaijan. They stated that economic growth in Azerbaijan boosts the environmental degradations. Ang (2007) stated that CO2 emissions are positively impacted by the economic growth in France. Saboori et al. (2012) indicated that economy growth is the main source that causes the degradations of environment. They pointed out U-shape association among economy growth and CO2 emissions. Wang et al. (2011) stated that economy growth positively influences environmental degradations in China. Arouri et al. (2012) stated that economy growth in the long run has positive influence on the CO2 emissions.

Energy consumption is measured by three main sources of energy, i.e., oil consumption, coal consumption, and natural gas consumption. Oil consumption has positive and significant effect on the CO2 emissions. The examined results of oil consumption indicated that in the long run and short run, 1% increase boosts the CO2 emissions up to 0.4469% and 0.1095% respectively. Oil is used for industrial sector as

Table 2 Criteria for lag length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	196.7912	NA	1.96e−10	− 8.161327	− 7.964503	− 8.087261
1	438.8546	422.3234	1.93e−14	− 17.39807	− 16.21712*	− 16.95367
2	477.2843	58.87111*	1.13e−14*	− 17.96955*	− 15.80448	− 17.15482*
3	495.2414	23.68798	1.68e−14	− 17.66985	− 14.52066	− 16.48478

Table 3 ARDL bounds test

Test statistics	Value	K
F-statistics	4.7987	4
Critical bounds value		
Significance	I(0) Bound	I(I) Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

energy in Pakistan that causes the environmental degradations. The examined results of coal consumption indicate positive effect on the environmental degradations. Coal is used as energy for daily life use in Pakistan that has negative effect on the environment. The examined results show that 1% increase in the use of coal consumption boosts the CO2 emissions up to 0.0915 and 0.0433% in the long run and short run, respectively. Gas consumption has indicated positive and significant effect on the CO2 emissions in the long run and short run, respectively. The examined results indicate that 1% increase in the use of natural gas for energy increases the CO2 emissions up to 0.3441% and 0.0253% in the long run and short run, respectively. The examined results of energy consumption are the same as of previous researchers Dogan and Seker (2016) and Jebli et al. (2016). Dogan and Seker (2016) stated that use of energy and trade openness has positive effect on the environmental degradations in the European Union. Jebli et al. (2016) indicated that energy consumption increases the environmental degradations. Jebli and Youssef (2015) stated that use of energy boosts the environmental degradations.

ECT indicates the error correction term that measures the speed of adjustment. The examined results indicate that ECT is negative and statistically significant. The ECT term indicates that 31% disequilibrium is corrected in the long run. R-squared value indicates that 75% variations in regressand are due to the utilized regressors of this study. Estimated *p* value of F-statistics indicates that the model is fit.

Dynamic ARDL simulations automatically plot the predictions of the actual change in the regressors and its impact on the regressand while holding the other regressors constant. We predicated 10% increase and decrease in the independent variables, i.e., economic growth, oil consumption, coal consumption, and gas consumption and its impact on the CO2 emissions in Pakistan.

Table 5 Dynamic ARDL simulations

Variables	Coefficient	St. error	T-value
Cons	− 0.3752*	0.1394	− 2.6900
ECG	0.0134	0.0091	1.4700
Δ*ECG*	0.0064	0.0061	1.0400
Oilcm	0.4469***	0.0818	5.4600
Δ*Oilcm*	0.1095*	0.0475	2.3000
Coalcm	0.0915*	0.0429	2.1300
Δ*Coalcm*	0.0433	0.0379	1.1400
Gascm	0.3441***	0.0776	4.4300
Δ*Gascm*	0.0253	0.0169	1.4900
ECT(−1)	− 0.3148*	0.1365	− 2.3100
R-squared		0.7592	
N		50	
p val of F-stat		0.0000***	
Simulations		5000	

ECG is economic growth, Oilcm is oil consumption for energy, Coalcm is coal consumption for energy, Gascm is gas consumption for energy

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Figure 1 shows impulse response plot that indicate relation of economic growth with CO2 emissions. The graph shows the actual change in the economic growth and its influence on the CO2 emissions. Ten percent increases in economic growth indicate positive influence on environmental degradations in the short run and long run while 10% decrease in economic growth indicates the same effect on the environmental degradations but the effect of 10% increase is high as compared to 10% decrease in economic growth.

Figure 2 indicates the impulse response plot for checking the relationship of coal consumption for energy and CO2 emissions. Coal consumption graph indicates that 10% increases positively affect the environmental degradations while a 10% decrease in coal consumption indicates positive impact in the short run but coal consumption negatively impacts in the long run when the coal consumption is 10% decreased. Use of coal for energy consumption plays a very important role to positively or negatively impact the CO2 emissions.

Table 4 Diagnostic statistics

Diagnostic statistics test	X^2 (*P* value)	Result
Breusch-Godfrey LM	0.4105	No problem of serial correlations
Breusch-Pagan-Godfrey	0.8554	No problem of heteroscedasticity
ARCH	0.9934	No problem of heteroscedasticity
Ramsey RESET test	0.2332	Model is specified correctly
Jarque-Bera	0.1609	Estimated residual are normal

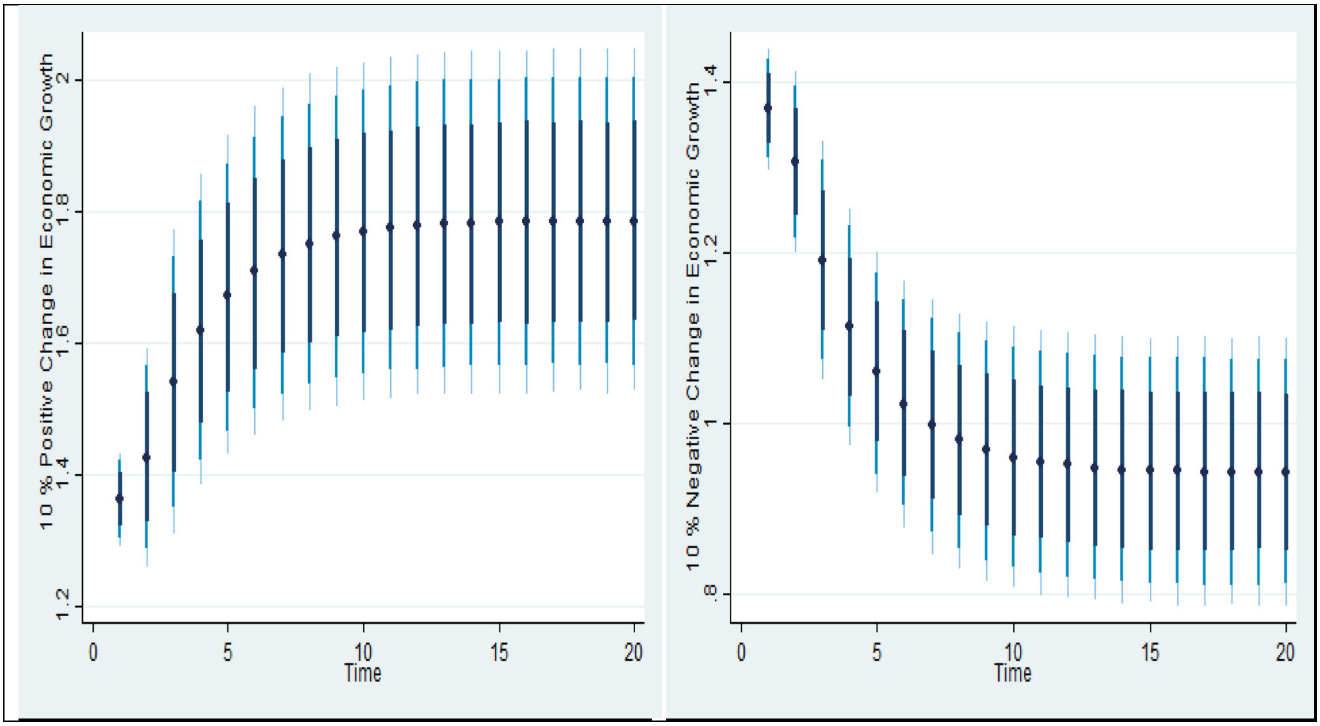

Fig. 1 The above graphs indicate 10 increase and decrease in economic growth and its impact on CO2 emissions. The dots indicate average prediction value while the dark blue to light blue line indicates 75, 90, and 95% confidence interval, respectively

Figure 3 shows the impulse response plot of oil consumption for energy and CO2 emissions in Pakistan. Results of the impulse response plot indicate that 10% increase in oil consumption for energy consumption positively influences the CO2 emissions in Pakistan both in the short run and the long run while 10%

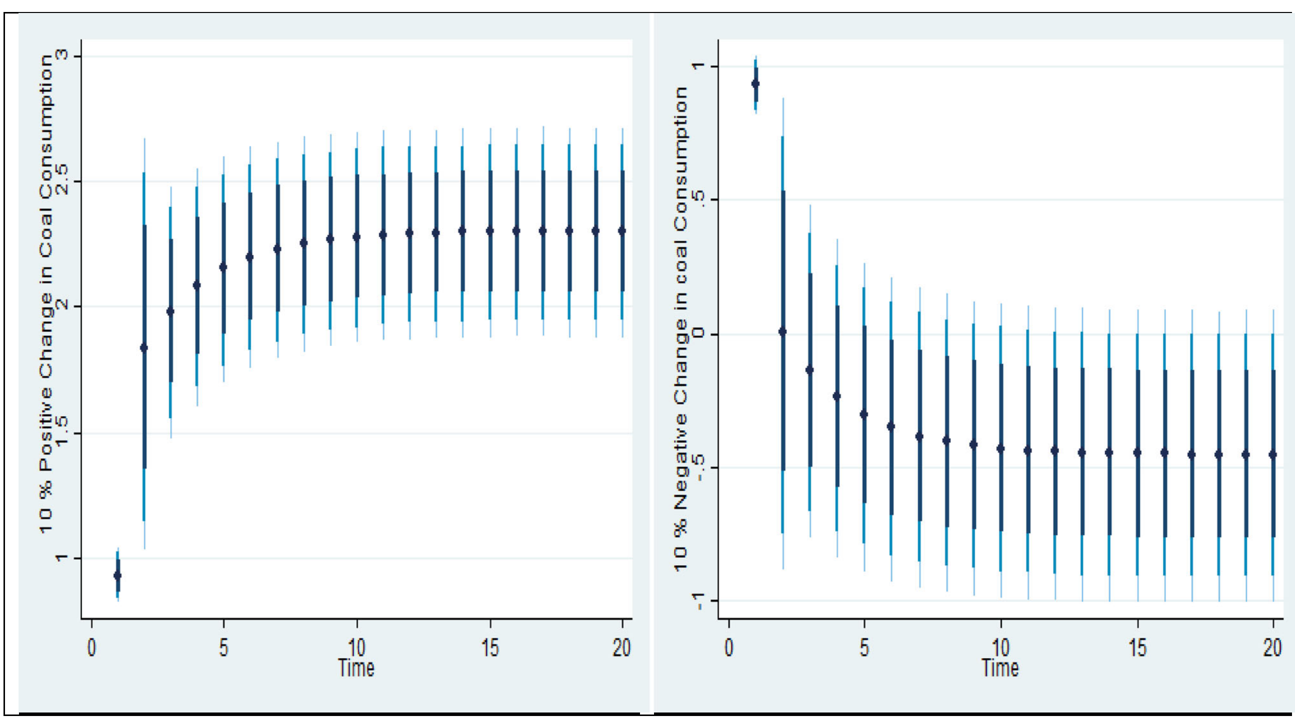

Fig. 2 The above graphs indicate 10 increase and decrease in coal consumption and its impact on CO2 emissions. The dots indicate average prediction value while the dark blue to light blue line indicates 75, 90, and 95% confidence interval, respectively

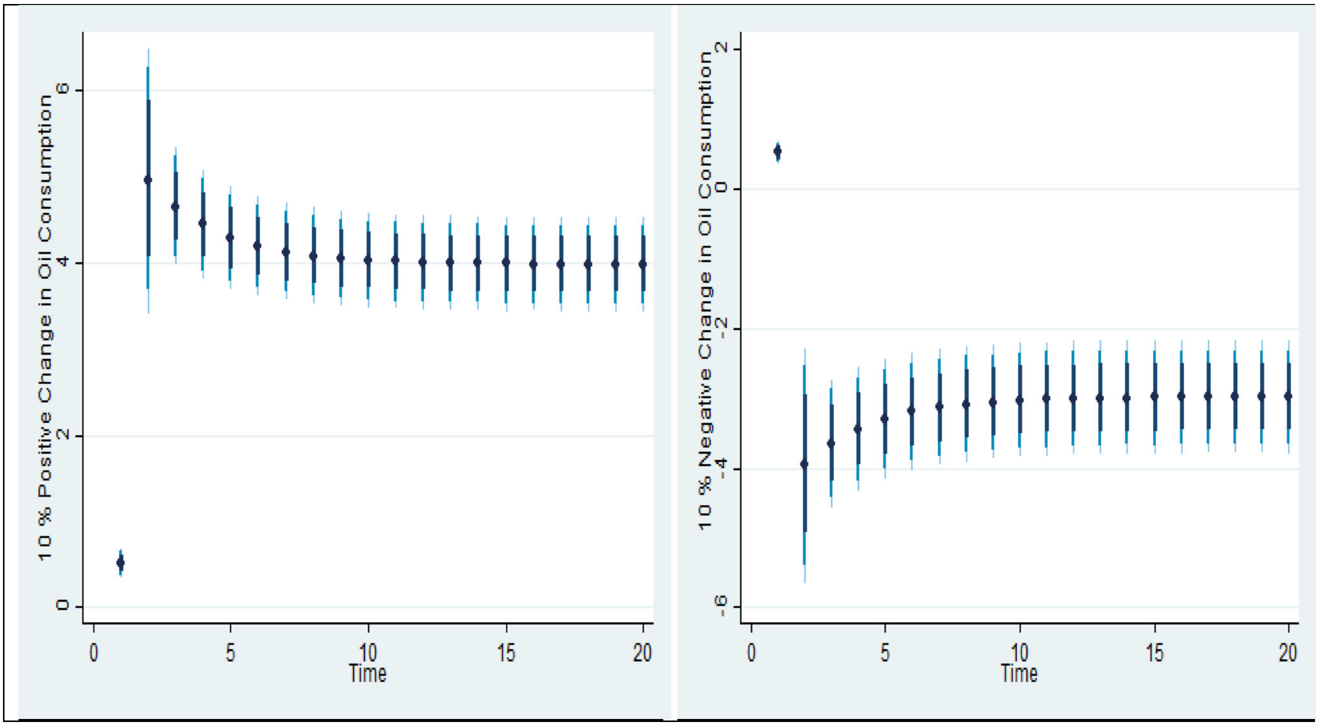

Fig. 3 The above graphs indicate 10 increase and decrease in gas consumption and its impact on CO2 emissions. The dots indicate average prediction value while the dark blue to light blue line indicates 75, 90, and 95% confidence interval, respectively

decrease in oil consumption for energy use shows negative impact on environmental degradations; decrease in oil consumption helps to reduce the environmental degradations.

Figure 4 indicates the association of gas consumption for energy use and CO2 emissions in Pakistan. The examined impulse response graph indicates that 10% increase in use of oil consumption for energy boosts the

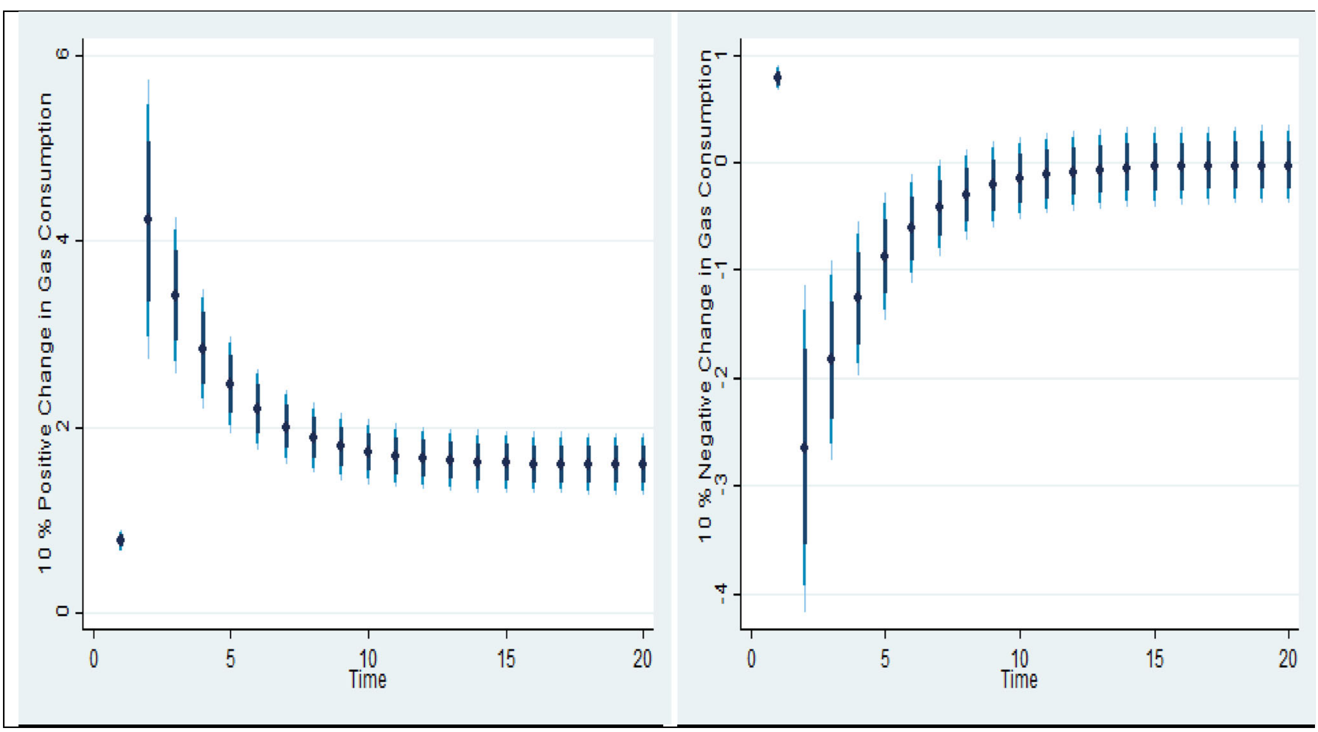

Fig. 4 The above graphs indicate 10 increase and decrease in gas consumption and its impact on CO2 emissions. The dots indicate average prediction value while the dark blue to light blue line indicates 75, 90, and 95% confidence interval respectively

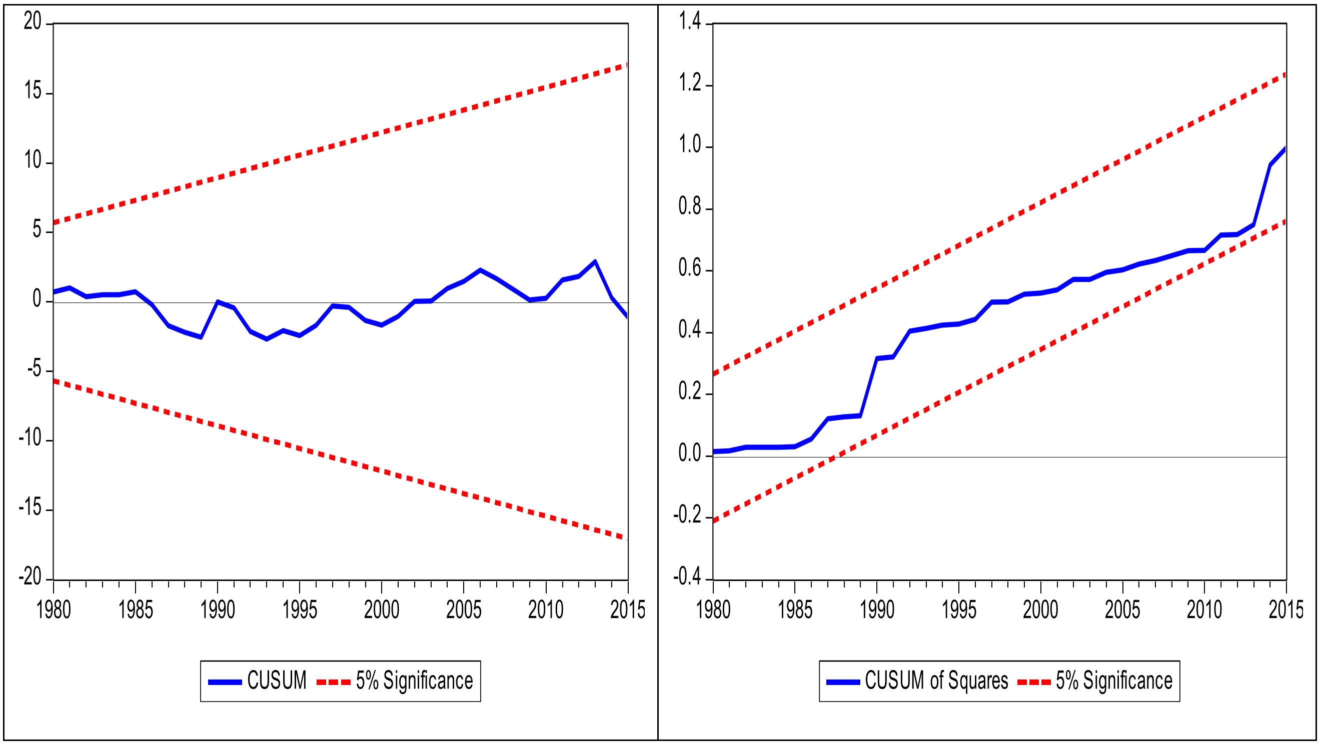

Fig. 5 CUSUM and CUSUM of squares

environmental degradations in the short run and long run while a 10% decrease indicates that in the short run, gas consumption positively influences on environmental degradations, but in the long run, it shows negative influence on the environmental degradations (Fig. 5).

The above graphs are used for CUSUM and CUSUM of squares. CUSUM and CUSUM of squares are utilized to examine if the coefficients are stable or not. CUSUM and CUSUM of squares indicate that the coefficients are stable at 5% level of significance because the blue lines of both graphs are under the red lines that show the stability of the coefficients. The examined graphs indicate that the used models are stable.

Conclusions and recommendations

Environmental degradations are mainly caused by the use of energy for economic growth, and both emerged and emerging economies are facing the problem of environmental degradation. The purpose of this research was to scrutinize the effect of energy consumption and economic growth on CO2 emissions in Pakistan from 1965 to 2015. Dynamic ARDL simulation model was utilized to scrutinize the short-run and the long-run influence of energy consumption and economic growth on CO2 emissions in Pakistan. Simple ARDL model in literature is applied again and again to examine the short-run and long-run association among study variables, but this study utilized dynamic ARDL simulations to examine the actual change (positive and negative) in energy consumption and economic growth and its impact on CO2 emissions. Before utilizing dynamic ARDL simulations, it is necessary to check the stationarity of each series that none of the series are I(2); otherwise, the results will not be valid. Three different unit root tests (ADF, PP, and KPSS) were applied to examine the stationarity of each series. The examined unit root tests indicate that none of the series are stationary at I(2) which confirm that dynamic ARDL simulations can be applied. Different diagnostic tests were applied to check different problems in the used model. Breusch-Godfrey LM test indicates that there is no problem of serial correlation in the used model. The examined results of Breusch-Pagan-Godfrey and ARCH tests indicate that there is no problem heteroscedasticity. Ramsey RESET test results indicate that the model is correctly specified. Jarque-Bera's results indicate that the residual of the model is normal. Results of dynamic ARDL simulations model indicate that coal consumption, oil consumption, gas consumption, and economic growth boost the environmental degradations in Pakistan both in the short run and the long run. Based on the examined results, it is observed that environmental degradations in Pakistan are caused by the use of traditional energy resources for energy consumption. It is recommended that policy makers in Pakistan should adopt such polices that help to reduce the environmental degradations by motivating industrial and household to use renewable energy resources for energy consumption.

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