



# The trade-off between economic growth and environmental quality: does economic freedom asymmetric matter for Pakistan?

Muhammad Tariq Majeed<sup>1</sup> · Zhiyuan Yu<sup>2</sup> · Adnan Maqbool<sup>3</sup> · Mesfin Genie<sup>4</sup> · Sana Ullah<sup>1</sup> · Waheed Ahmad<sup>1</sup>

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## Abstract

This empirical study investigates the dynamic effects of economic freedom on economic growth and air quality for Pakistan over the period 1990–2019. The ARDL results suggest that economic freedom and other variables do not have any visible impact on economic growth and pollution in the short-run. However, in the long-run, economic freedom significantly mitigates air pollution whereas inflation instability increases emissions. The NARDL results show that a partial sum of positive change in economic freedom is negatively linked with economic growth in the short term but has positive effect in the long term. However, the negative change in economic freedom has negative but insignificant impact on growth confirming asymmetric effects. The results for the pollution model show that a partial sum of positive change in economic freedom has positive impact on emissions both in the short and long-runs, whereas a negative change has no significant effect in the short-run and has negative impact in the long-run. Thus, economic freedom supports economic activities that, in turn, escalate emissions in the atmosphere.

**Keywords** Economic freedom · Economic growth · Air quality · Pakistan

## Introduction

The interconnection between economic freedom and economic growth is well debated since the seminal work of Adam Smith. Generally, it is perceived that free economies are more productive, and economic freedom plays a pivotal role in the process of economic growth (Wiseman 2017). In the recent era, there is an ongoing debate on the role and significance of economic freedom to achieve maximum wellbeing for the poor segment of the population living in developing countries. Besides, it is generally argued that economic freedom is a

prerequisite for an economy to utilize its scarce resources efficiently.

It is a well-observed fact that economic freedom is an important channel to utilize resources optimally by creating a favorable environment for different stakeholders in the economy (Corbi 2007). Economic freedom grants individuals' personal freedom to consume and produce. There are three important ways, through which economic freedom can enhance economic growth. (i) Competitive markets perform their functions in a better way and thus allow new businesses to enter the market. (ii) Economic freedom also encourages

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✉ Zhiyuan Yu  
379460230@qq.com

✉ Sana Ullah  
sana\_ullah133@yahoo.com

Muhammad Tariq Majeed  
tariq@qau.edu.pk

Adnan Maqbool  
adnanpak@yahoo.com

Mesfin Genie  
mesfin.genie@abdn.ac.uk

Waheed Ahmad  
awaheed@eco.qau.edu.pk

<sup>1</sup> School of Economics, Quaid-i-Azam University, Islamabad, Pakistan

<sup>2</sup> Department of Economics and Management, Taiyuan Institute of Technology, Taiyuan 030008, China

<sup>3</sup> Department of Management Sciences, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, Pakistan

<sup>4</sup> Department of Economics, University of Aberdeen, Aberdeen, UK

entrepreneurship. Through this channel, many business persons can start their own business and thus also help to generate employment opportunities. (iii) Economic freedom creates a favorable environment for investment. On the contrary, a complicated tax system, lack of information for the new entrants, and insecure property rights discourage investors to start new businesses in the economy and weaken the growth trajectory of a country.

The previous literature supports the fact that economic freedom is one of the important channels to enhance the growth process (Azman-Saini et al. 2010; Gravel and Tarroux 2011; Cebula 2011; De Soysa and Vadlammanati 2013; Wiseman 2017; Kešeljević 2018; Nadeem et al. 2019). For developing countries, the idea of economic freedom to promote growth is even more important for the sake of the largely poor and marginalized segment of the population. The role of economic freedom to enhance the growth process is broadly based on four important principles of economic freedom that are government size, open market, rule of law, and regulatory efficiency. Also, better property rights enable individuals to earn more; fewer restrictions on entrepreneurial activities also encourage new businesses to join the market. Norton (1998) is of the view that better property rights are interconnected with higher levels of human development which in turn serve as a strong channel to uplift the world's marginalized population. de Haan and Siermann (1998) also described that economic freedom is an important channel to enhance growth which increases total factor productivity and human capital accumulation. The same study revealed that economic freedom enables countries to increase their steady-state levels of income. However, the linkage between economic freedom and economic growth is highly influenced by the choice of the indicators, by which we measure economic freedom. Esposto and Zaleski (1999) highlighted that economic freedom influences the quality of life over time and across nations.

In this era, climate change has become one of the most sorted out areas for policymakers throughout the world. Therefore, it is an interesting debate to inspect the link between economic freedom and different indicators of environmental quality including air pollution. We can discuss the influence of economic freedom on the environment in three different ways. First, the efficiency effect postulates that economic freedom is an important tool to enhance market efficiency; so, there must be a negative correlation between economic freedom and CO<sub>2</sub> emissions. Economic freedom also promotes the efficient use of resources, and firms can meet consumers' demands in a better way. However, this effect is relevant in the presence of effective environmental regulations. The second, effect is the trade regulation effect as such trade liberalization is concerned with efficient resource allocation due to the higher level of competition in the international market. But here, we cannot rule out the existence of the "pollution haven" effect. In most cases, trade liberalization

promotes an increased level of specialization and also capital-intensive production, that too at the cost of lax environmental regulations. Therefore, it generally increases CO<sub>2</sub> emissions (Majeed and Mazhar 2020). However, under this effect, there are two more kinds of effects we observe, either the efficiency effect, which helps to undermine the CO<sub>2</sub> emissions, or the "pollution haven" effect which upsurges the CO<sub>2</sub> emissions. Therefore, the outcome with respect to CO<sub>2</sub> is ambiguous. The third effect in this regard is called the stability effect. Under economic freedom, an increase in price stability encourages efficient investment and consumption decisions, which stabilize the economy in the long-run. Thus, a stable macroeconomic system positively enhances environmental quality. The stability effect is also directly associated with secure property rights in the economy. Hence, a stable economy along with secure property rights may increase the level of emissions in the economy. To sum up, economic freedom can increase or decrease CO<sub>2</sub> emissions; it depends on the composition of goods and also whether the firms are engaged in pollution-intensive production or using clean technology in the production process.

According to the Heritage Foundation, Pakistan's economic freedom score is 54.8, and also, it occupies 135th position in 2020. By looking at the numbers, we can conclude that Pakistan's position in terms of economic freedom is not promising. There are many reasons behind this scenario for Pakistan. The most prominent includes the government's inability to implement rule of law at the grass-root level, complex labor laws, and regularity inefficiencies. Due to red-tapism, and longer procedures, and unclear rules and regulations, it is quite difficult for anyone to start a new business in Pakistan. Moreover, most of the workers are working in the informal sector, and therefore, underemployment is one of the stylized facts of the labor market in the case of Pakistan. Due to inconsistent policies, the investment regime is also inefficient. Even though many commercial banks are operated by the private sector, still, the banking sector is not free from state interference. In Pakistan, the tax system is also very complex. Therefore, due to putting so much effort, the government is still not able to increase the tax to GDP ratio sufficiently.

In the existing literature, the impact of economic freedom is a well-debated topic; however, most of the existing literature is focused on economic freedom and growth linkage. For example, Azid and Mahmood (2009), Zaman et al. (2011a, b), Nasir and Hassan (2011), and Shahbaz (2013) explored economic freedom and growth linkages. However, we could not find any notable work concerning the impact of economic freedom on environmental quality. Even though, in the recent era, the impact of economic freedom on air pollution is gaining enough importance. Besides, there is limited literature available on economic freedom and growth nexus for Pakistan (Azid and Mahmood 2009; Zaman et al. 2011a, b; Sheikh et al. 2018). However, we could not find any empirical study

which has explored the economic freedom, growth, and air pollution nexus simultaneously for the case of Pakistan. Therefore, this study contributes to the economic literature in three important ways. First, it is the first attempt to assess the impact of economic freedom on growth and air quality in the case of Pakistan. Second, this study applies the conventional ARDL model as well as the asymmetric ARDL approach and explores the positive as well as negative impacts of economic freedom on growth as well as on air pollution. Third, we will also find out the asymmetric causality between these variables. Fourth, the study will offer a few implications, which will be generalized in the case of other countries in the region.

## Literature review

### Economic freedom and economic growth

From the theoretical perspective, it is a well-known fact that economic freedom is one of the significant pillars of economic growth. The beneficial effects of economic freedom can be transmitted into economic growth through many channels. There is enormous literature available on the effect of economic freedom on economic growth for different regions around the world. For example, in this regard, Goldsmith (1995) and Gwartney et al. (1996) noted that economic freedom is positively connected with economic growth. Specifically, Islam (1996) is of the view that economic freedom has a positive effect on economic growth for high-income countries only; in comparison, the study could not prove the positive link between economic freedom and growth in the case of low-income countries. Meanwhile, less economic freedom is negatively affecting the level of income per capita for the sample of low-income countries; however, this is not valid for the sample of middle and high-income countries.

In the comparatively recent wave of literature, researchers around the world found a positive link between economic freedom and economic growth, for example, Sturm and De Haan (2001), Doucouliagos and Ulubasoglu (2004), Corbi (2007), Faria and Montesinos (2009), Azid and Mahmood (2009), and Compton et al. (2011a, b). Moreover, Sheikh et al. (2018) also assessed the positive link between economic freedom and economic growth for Pakistan and India. Similarly, in another study, Akin et al. (2014) divided 94 selected countries into five different income groups and pointed out that economic freedom is positively linked with economic growth across all income groups. Also, Kovačević and Borović (2014) assessed the positive but insignificant impact of economic freedom on economic growth for a panel of former socialist countries. For Bangladesh, during the time

period 1995 to 2015, Tanin and Masih (2017) showed a positive association between economic freedom and growth.

The impact of economic freedom on growth is highly influenced by the choice of economic freedom measures used in the analysis for a particular country or region. The existing literature also assessed the negative or mixed impacts of different categories of economic freedom on economic growth for different countries around the world, for example, Borović (2014) elaborated that two mechanisms of economic freedom, namely, rule of law and open market, have a negative impact on economic growth. In another study for the selected South Asian countries, Anwar and Quaratulain (2017) also highlighted that trade freedom is negatively linked with economic freedom, in the long-run; however, business freedom, monetary freedom, and freedom from corruption exert positive impacts on economic growth for the selected panel of South Asian countries. Similarly, Haydaroglu (2016) explored the same linkage for BRICS countries and assessed the positive association between economic freedom and growth; however, one component of economic freedom, namely, the size of government, is negatively impacting the economic growth process in these countries. Santiago et al. (2020) also observed the negative impacts of economic freedom on the economic growth for Caribbean and Latin American countries in the long-run. In another study, Erdem and Tugcu (2012) also proved the negative link between economic freedom and economic growth for the OECD economies during the time period 1995 to 2009. Gorlach and Le Roux (2013) used the GMM method of estimation and assessed the impact of economic freedom on economic growth in the Southern African Development Community. The study used five different components of economic freedom i.e., trade freedom, monetary freedom, government size, regulation, and security of property rights. According to the empirical results of the study, the overall economic freedom index is exerting a positive impact on economic growth.

### Economic freedom and CO<sub>2</sub> emissions

Our prime objective is to assess the effect of economic freedom on economic growth and air pollution in the case of Pakistan. In this section, we will sum up the existing literature which interconnects economic freedom to environmental quality. Theoretically, economic freedom can trigger or suppress CO<sub>2</sub> emissions in several ways. Coase (n.d.) explained the absence of transaction costs and well-defined property rights mostly correlated with negative externalities such as air pollution. There are two kinds of agents in the economy, those who are hurt by these externalities and also those who are getting benefits from these pollution activities. They negotiate until they can attain an efficient distribution of property rights to the environmental resource. However, in the real world, the cost component of resolving

this kind of dispute is higher. Therefore, at this stage, well-developed institutions play an important role to resolve these disputes among different stakeholders in the economy as well as help to attain an efficient distribution of the resources among them. Besides, not only the strong property rights but also the efficient environmental regulations play an important role in suppressing the level of air pollution and thus enhancing environmental quality. There are different components of economic freedom such as trade openness, competitive market, government size, and composition, and all of them are either directly or indirectly associated with environmental quality. For instance, in several studies, trade openness is positively linked with CO<sub>2</sub> emissions. Antweiler et al. (2001) and Tahir et al. (2020) explained that trade openness can cause an increase or decrease in CO<sub>2</sub> emissions through technique and scale effect. Also, government size is also one of the important determinants of the increase in CO<sub>2</sub> emissions (Bernauer and Koubi 2009). Meanwhile, it is also observed from the literature that state-owned firms are proved to be dirtier as compared to their private counterparts (Meyer and Pac 2013).

We could not get many studies in the previous literature on economic freedom and environmental quality nexus. Few studies have shown the positive effect of economic freedom on CO<sub>2</sub> emissions. Adesina and Mwamba (2019) have explored the same linkage for 24 African countries and revealed that economic freedom is positively linked with CO<sub>2</sub> emissions in the selected sample. Bjørnskov (2020) is of the view that economic freedom is negatively associated with the level of CO<sub>2</sub> emissions. Similarly, the literature provides evidence that economic freedom and CO<sub>2</sub> emission are a country-specific phenomenon. For example, in an interesting study, Joshi and Beck (2018) revealed that economic freedom is depressing the level of CO<sub>2</sub> emission in the case of OECD countries. However, in the case of non-OECD countries, this relationship is positive. Bae et al. (2017) explored the same relationship for 15 countries and postulated that economic freedom is upsurging CO<sub>2</sub> emissions through the GDP growth channel. Wood and Herzog (2014) also explained the negative impact of economic freedom on air quality. You and Lv (2018) elaborated that economic freedom in terms of globalization is positively enhancing environmental quality. However, Amoah et al. (2020) offered an interesting perspective in the case of 32 African economies and elaborated that economic and trade freedom helps to upsurge the share of renewable energy in the total energy mix. Therefore, the study concluded that economic and trade freedom is helping to improve the environmental quality in the selected countries.

Moreover, the previous literature also found out mixed evidence for different countries based on different income groups. Bjørnskov (2020) further segregated their sample

concerning different income levels and found out that economic freedom is negatively associated with CO<sub>2</sub> emissions in upper-middle-income counties in comparison to other income groups included in the sample. Similarly, Chang and Wang (2012) elaborated that economic freedom helps to decrease CO<sub>2</sub> emissions in low-income countries. Carlsson and Lundström (2001) also found out a negative link between economic freedom and CO<sub>2</sub> for low-income countries and the opposite for high-income countries.

We have summed up the existing literature based on the effect of economic freedom on economic growth and environmental quality as well. Most of the empirical literature supports the positive link between economic freedom and economic growth. Besides, economic freedom is also positively impacting different components of economic growth such as education, wages, employment, poverty, and income inequality. After having a careful look at the applicable literature, we could not find even a single study, which is based on the in-depth analysis of economic freedom concerning air pollution in the case of Pakistan. Furthermore, this study is different from any existing work on economic freedom and growth and air pollution nexus in the way that it applied the asymmetric ARDL approach to find out the nonlinear influence of economic freedom on growth and air pollution.

### Model, methodology, and data

Previous literature has identified that economic freedom to be the main determinant of economic growth and air quality. Therefore, we follow the theoretical as well empirical studies and rely upon the following economic growth and carbon emissions models:

$$EG_t = \varphi_0 + \varphi_1 EF_t + \varphi_2 PR_t + \varphi_3 INFinstab_t + \varepsilon_t \tag{1a}$$

$$CO_{2,t} = \varphi_0 + \varphi_1 EF_t + \varphi_2 PR_t + \varphi_3 INFinstab_t + \varepsilon_t \tag{1b}$$

where subscripts *t* indicates years,  $\varphi_0$ ,  $\varphi_1$ ,  $\varphi_2$ , and  $\varphi_3$  are parameters for estimation;  $EG_t$  denotes economic growth,  $CO_{2,t}$  denotes carbon emissions,  $EF_t$  denotes economic freedom,  $PR_t$  denotes political regime, and  $INFinstab_t$  denotes an inflation instability, and  $\varepsilon_t$  is a random term, respectively. Similarly, Eqs. (1a) and (1b) are supposed to depend on that economic freedom, political regime, and inflation instability. Since increased economic freedom leads to more economic growth, we expect an estimate of  $\varphi_1$  to be positive. Similarly, increased economic freedom leads to more pollution in an economy; we expect estimates of  $\varphi_1$  to be positive in the environmental pollution model. As the literature reveals the

estimate of  $\varphi_2$  and  $\varphi_3$  to be positive in the model (1a), we expect estimate of  $\varphi_2$  and  $\varphi_3$  to be negative in the model (1b). Equations (1a) and (1b) give the long-run estimates by using any method. Pesaran et al. (2001) introduced an error-correction modeling framework so that we can also add the short-run impacts of exogenous variables. Therefore, a new format of the equations is as:

$$\begin{aligned} \Delta EG_t = & \omega_0 + \sum_{k=1}^n \beta_{1k} \Delta EG_{t-k} + \sum_{k=0}^n \beta_{1k} \Delta EF_{t-k} \\ & + \sum_{k=0}^n \beta_{1k} \Delta PR_{t-k} + \sum_{k=0}^n \beta_{1k} \text{INFinstab}_{t-k} \\ & + \omega_1 EG_{t-1} + \omega_2 EF_{t-1} + \omega_3 PR_{t-1} \\ & + \omega_4 \text{INFinstab}_{t-1} + \varepsilon_t \end{aligned} \quad (2a)$$

$$\begin{aligned} \Delta CO_{2,t} = & \omega_0 + \sum_{k=1}^n \beta_{1k} \Delta CO_{2,t-k} + \sum_{k=0}^n \beta_{1k} \Delta EF_{t-k} \\ & + \sum_{k=0}^n \beta_{1k} \Delta PR_{t-k} + \sum_{k=0}^n \beta_{1k} \text{INFinstab}_{t-k} \\ & + \omega_1 CO_{2,t-1} + \omega_2 EF_{t-1} + \omega_3 PR_{t-1} \\ & + \omega_4 \text{INFinstab}_{t-1} + \varepsilon_t \end{aligned} \quad (2b)$$

Equations (2a) and (2b) are assessed via OLS; short-run impacts are reflected and noted in the estimates of “delta” variables, and long-run effects are reported by the estimates of estimates of  $\omega_2 - \omega_4$  that must be normalized on  $\omega_1$  in Eqs. (2a) and (2b). The linear ARDL specification is for the first time introduced by Pesaran et al. (2001) and becomes the workhorse of time series modeling. For the validity of long-run coefficient estimates to be important, Pesaran et al. (2001) suggest  $F$  test and ECM or  $t$ -test. Since macroeconomic variables could be combination of  $I(0)$  and  $I(1)$ , both tests have new critical values in estimation. We extended the empirical literature so that we can explore the asymmetry analysis. The modification in linear modeling is for the first time introduced by Shin et al. (2014). The concept of the partial sum is used to decompose  $\Delta EF$  into two new time-series variables as follows:

$$EF^+_t = \sum_{n=1}^t \Delta EF^+_t = \sum_{n=1}^t \max(\Delta EF^+_t, 0) \quad (3a)$$

$$EF^-_t = \sum_{n=1}^t \Delta EF^-_t = \sum_{n=1}^t \min(\Delta EF^-_t, 0) \quad (3b)$$

where  $EF^+_t$  is the new time-series variable of positive changes in economic freedom which infers only increased economic freedom. Similarly,  $EF^-_t$  is the new time-series variable of negative changes in economic freedom which infers only decreased economic freedom. In the next step, we move back to Eqs. (2a) and (2b) to replace  $EF_t$  by  $EF^+_t$  and  $EF^-_t$ . The extended error-correction models are:

$$\begin{aligned} \Delta EG_t = & \alpha_0 + \sum_{k=1}^n \beta_{1k} \Delta EG_{t-k} + \sum_{k=0}^n \pi_{1k} \Delta EF^+_{t-k} \\ & + \sum_{k=0}^n \delta_{1k} \Delta EF^-_{t-k} + \sum_{k=0}^n \eta_{1k} \Delta PR_{t-k} \\ & + \sum_{k=0}^n \mu_{1k} \text{INFinstab}_{t-k} + \omega_1 EG_{t-1} + \omega_2 EF^+_{t-1} \\ & + \omega_3 EF^-_{t-1} + \omega_4 PR_{t-1} + \omega_5 \text{INFinstab}_{t-1} \\ & + \varepsilon_t \end{aligned} \quad (4a)$$

$$\begin{aligned} \Delta CO_{2,t} = & \alpha_0 + \sum_{k=1}^n \beta_{1k} \Delta CO_{2,t-k} + \sum_{k=0}^n \pi_{1k} \Delta EF^+_{t-k} \\ & + \sum_{k=0}^n \delta_{1k} \Delta EF^-_{t-k} + \sum_{k=0}^n \eta_{1k} \Delta PR_{t-k} \\ & + \sum_{k=0}^n \mu_{1k} \text{INFinstab}_{t-k} + \omega_1 CO_{2,t-1} \\ & + \omega_2 EF^+_{t-1} + \omega_3 EF^-_{t-1} + \omega_4 PR_{t-1} \\ & + \omega_5 \text{INFinstab}_{t-1} + \varepsilon_t \end{aligned} \quad (4b)$$

Adding the partial sum into the model, Eqs. (4a) and (4b) are commonly denoted as nonlinear or asymmetric ARDL, whereas Eqs. (2a) and (2b) are linear ARDL. The nonlinear ARDL approach is used the same testing procedure as well as similar estimates via OLS method. Shin et al. (2014) also test the few assumptions with regards to the asymmetric dynamic impacts of economic freedom on economic growth and CO2 emissions. In the short-run, if positive shocks take a different lag order than negative shocks and if the estimates are different at any given lag order  $k$ , it means that asymmetries exist and short-run effects of economic freedom will be asymmetric. Using the Wald test, we can also confirm the short- and long-run asymmetric effects of economic freedom on economic growth and CO2 emissions. Similarly, the directions of linear and nonlinear causality are examined by using Toda and Yamamoto (1995) and Hatemi-j (2012) techniques.

## Results and discussion

Although the unit root testing is not a compulsory condition for ARDL methodology, to our satisfaction, we have confirmed through Phillips-Perron (PP) and augmented Dickey-Fuller (ADF) tests, noted that none of our variables is  $I(2)$ . Table 1 offered the ARDL and NARDL both in the short-run and long-run for both models i.e., economic growth and carbon emissions. The ARDL in both short-run and long-run results depicts that economic freedom and other selected variables have a statistically insignificant effect on output growth.

**Table 1** ARDL and NARDL results

Variable	ARDL-EG		ARDL-CO <sub>2</sub>		NRDL-EG		NARDL-CO <sub>2</sub>	
	Coefficient	t-Stat	Coefficient	t-Stat	Coefficient	t-Stat	Coefficient	t-Stat
Panel A: short-run estimates								
$\Delta EF_t$	0.05	0.26	-4.85	0.78				
$\Delta EF_{t-1}$			1.87**	2.72				
$\Delta EF_t^+$					-0.86**	4.29	12.31*	1.64
$\Delta EF_{t-1}^+$					-0.61**	3.79		
$\Delta EF_t^-$					0.41**	2.43	4.17	-0.51
$\Delta PR_t$	0.08	0.73	4.39	1.13	0.25**	3.05	1.69	0.05
$\Delta INFinstab_t$	-0.11	1.12	4.96*	1.76	-0.17**	3.18	6.25**	2.28
Panel B: long-run estimates								
EF	-0.58	1.04	-4.64*	1.85				
EF <sup>+</sup>					0.69*	1.87	9.91**	2.01
EF <sup>-</sup>					-4.78	0.71	-5.95*	1.75
PR	0.02	0.15	-1.28	0.34	0.01	0.03	-7.68	1.59
INFinstab	-0.14	0.96	4.35	0.85	-0.29	0.53	9.91*	1.67
C	36.62	1.18	27.81	1.96	16.98	0.87	88.41**	2.34
Panel C: diagnostic statistics								
ECM-t-1	-0.64**	3.82	-0.07**	5.19	-0.13**	5.68	-0.55**	4.72
ADJ-R2	0.42		0.98		0.61		0.98	
F-test	3.13		4.42**		4.08**		4.26**	
LM	0.31		0.16		0.05		0.73	
RESET	1.63		0.79		0.07		0.66	
CUSUM	S		S		S		S	
CUSUMSQ	S		US		S		S	
Wald-SR					1.45		2.86*	
Wald-LR					0.44		17.87**	

\*\* $p < 0.05$  and \* $p < 0.1$ , respectively

Besides, in the case of the carbon emissions model, the results show that inflation instability has a significant and positive impact on pollution emissions while other variables such as economic freedom and the political regime have insignificant linkage with carbon emissions in the short run. Further, the empirical results revealed that economic freedom has been negatively associated with carbon emissions in the long-run. The results show that a 1% increase in economic freedom improves environmental quality by approximately -4.64% at a 10% significance level. For the stability and reliability of the model, we employed a few diagnostic tests. The statistical results indicate that model is stable and free from all the statistical issues. Moreover, the ECM value has a negative and statistically significant value.

NARDL results for the growth model are represented in Table 1. The results demonstrate that a partial sum of positive change in economic freedom is negatively linked with output growth in the short-run while a partial sum of negative change in economic freedom shows a negative impact on output

growth. Further, the political regime contributes to output growth; on the other hand, inflation instability indicates a statistically significant and negative effect on economic growth in the short-run. Besides, the long-run results are denoted in panel B in Table 1. The results revealed that a partial sum of positive change in economic freedom has a statistically significant impact on economic growth such as a 1% increase in economic freedom enhances the output growth approximately by 0.69% at the significance level of 5% while the partial sum of negative change in economic freedom has an insignificant and negative effect on output growth. Besides, the empirical long-run results suggest that economic freedom is positively linked with economic growth. It highlights that economic freedom is the important driver for enhancing economic growth by government investment expenditure and fiscal freedom. Further, the expenditure on public security, health, environment, and education is to promote economic growth. Also, fiscal freedom is an important part of economic freedom. Meanwhile, economic freedom has provided a choice

for economic integration. Trade freedom, business freedom, preservation of property rights, financial freedom, and monetary freedom are parts of economic freedom. It enhances opportunities for investment by the protection of property theft or loss, domestic and international trade, financial investment, and independence in monetary exchange. In addition, economic freedom promotes economic opportunities, which enhance income per capita and eradicate poverty and improve environmental quality. These results are consistent with past studies such as Hussain and Haque (2016), Rode and Coll (2012), Matallah and Ghazi (2015), Compton et al. (2011a, b), and Hafer (2013) exhibit that economic freedom promotes the financial system and output growth. Numerous past studies indicate that economies with a higher level of economic freedom, in turn, promote economic growth and achieve a higher level of wealth along with a happier and healthier population (Yilmaz and Tag 2016; Rode et al. 2013; Grubel 2015, Evrensel 2015; Lipford 2007; Lee and Yeung 2012; Zaman et al. 2011a, b; Campbell et al. 2012; Cebula and Mixon 2012). Thus, other selected variables show an insignificant and positive effect on output growth in the long-run.

In Table 1, panel C offered various statistical tests. The ECM values imply that the value is negative and statistically significant implying that the speed of adjustment is approximately 0.15% per year in Pakistan. Based on the value of *F*-statistics, we support the existence of cointegration in the long-run. We employed various diagnostic tests to confirm the validity and reliability of the model such as LM test, heteroscedasticity, and RESET test statistics for the stability of the model CUSUM and CUSUM square; all these tests show that our model has been free from all type of statistical issues.

NARDL carbon emissions model results are demonstrated in Table 1. The NARDL empirical outcome depicts that a partial sum of positive change in economic freedom is positively associated with pollution emissions in the short-run while a partial sum of negative change has an insignificant impact on pollution emissions in Pakistan. Additionally, the results showed that a 1% increase in economic freedom contributes to pollution emissions by approximately 9.12% at a 10% significance level in the short-run. The control variable political regime has an insignificant impact on carbon emissions while inflation instability has a statistically significant and positive effect on pollution emissions in the short-run. Further, the long-run results are reported in panel b in Table 1. The results show that a partial sum of positive change in economic freedom shows a substantial positive impact on pollution emissions in the long-run while a partial sum of negative change in economic freedom has a negative association with carbon emissions. For instance, the long results show that a 1% increase in the partial sum of positive change in economic freedom enhances pollution emissions by about 9.91% at the 5% significance level; on the other hand, 1% change in the partial sum of negative change in economic

freedom mitigate the carbon emissions is about -5.95% at 10% level of significance in the long-run in Pakistan. The turnout from NARDL techniques for Pakistan suggests that economic freedom has significantly promoted pollutions emissions and has deteriorated environmental quality. Besides, the increase in the level of economic freedom particularly which in turn expands the economic activities and, as a result, increases the intensity of carbon emission in the environment (Dinda 2004). Thus, the increase in economic freedom, certainly contracts has enforced, property rights have respected, and the institutional and governmental regulation over the economy shrinks which in turn the environmental performance improved. So, economic freedom may not be absolute. Hence, government regulation may temper and guide further economic development to prevent environmental pollution, and then such rules and regulations end up restricting some economic freedom. Moreover, the results show that the political regime has an insignificant and negative impact on carbon emissions while inflation instability is positively associated with carbon emissions in the long-run.

Panel C demonstrated the diagnostic tests. The results show that the *F*-statistic value is greater than the upper bound value and confirms the cointegration among the variables. Further, the ECM value is negative and statistically significant suggesting that the speed of adjustment towards the equilibrium path is about 0.55% per year in Pakistan. LM tests accept the null hypothesis that shows that this did not suffer from serial correlation. For the good fitness of the model, the RESET test is utilities. This test indicates that our model is correctly

**Table 2** Symmetric and asymmetric causality results

Symmetric causality	Prob.	Asymmetric causality	Prob.
EF→CO <sub>2</sub>	0.07	EF <sup>-</sup> →CO <sub>2</sub>	0.18
CO <sub>2</sub> →EF	0.42	CO <sub>2</sub> →EF <sup>-</sup>	0.16
INFinstab→CO <sub>2</sub>	0.35	EF <sup>+</sup> →CO <sub>2</sub>	0.19
CO <sub>2</sub> →INFinstab	0.01	CO <sub>2</sub> →EF <sup>+</sup>	0.02
PR→CO <sub>2</sub>	0.25	INFinstab→CO <sub>2</sub>	0.35
CO <sub>2</sub> →PR	0.34	CO <sub>2</sub> →INFinstab	0.01
INFinstab→EF	0.16	PR→CO <sub>2</sub>	0.25
EF→INFinstab	0.16	CO <sub>2</sub> →PR	0.34
PR→INFinstab	0.09	INFinstab→EF <sup>-</sup>	0.97
INFinstab→PR	0.65	EF <sup>-</sup> →INS	0.72
		PR→EF <sup>-</sup>	0.67
		EF <sup>-</sup> →PR	0.04
		INFinstab→EF_POS	0.62
		EF <sup>+</sup> →INFinstab	0.94
		PR→EF <sup>+</sup>	0.05
		EF <sup>+</sup> →PR	0.08
		PR→INFinstab	0.09
		INFinstab→PR	0.65

specified. Additionally, CUSUM and CUSUM square demonstrate the stability of the model; the results are reported in panel c. Thus, the null hypothesis of the Wald test shows both the short-run and long-run nonlinear impacts of economic freedom on carbon emissions.

Table 2 explored the symmetric and asymmetric causal linkage. The results show that unidirectional causal linkage exists from economic freedom to carbon emissions, from carbon emission to inflation instability, and from political regime to inflation instability. Moreover, the asymmetric causal linkage shows that unidirectional causality exists from pollution emissions to a partial sum of positive change in economic freedom, and from carbon emissions to inflation instability. Besides, results confirm the presence of causal linkage from the partial sum of negative in economic freedom to the political regime while the bidirectional causal linkage exists between political regime and the partial sum of positive change in economic freedom.

## Conclusion and policy implication

The aim of this study is to explore symmetric and asymmetric effects of economic freedom on economic growth and air quality for Pakistan from 1990 to 2019. The empirical analysis is based on both linear and nonlinear ARDL methods. The linear ARDL result suggests that economic freedom and other variables did not show any visible impact on growth and pollution. However, in the long-run, economic freedom significantly mitigates air pollution suggesting that a 1% increase in economic freedom lowers emissions by  $-4.64\%$ . Besides, inflation instability increases emissions. NARDL results show that a positive change in economic freedom is negatively linked with output growth in the short-run while a partial sum of negative change in economic freedom shows a positive impact on output growth. However, these results do not hold in long-run.

The NARDL results show that the partial sum of positive change in economic freedom has a positive impact on economic growth in the long-run whereas the partial sum of negative change has a negative but insignificant impact confirming the asymmetric link between economic freedom and economic growth. This finding confirms economic freedom as an important driver of long-run economic growth. Economic freedom boosts growth by supporting market activities, providing choices for economic integration, and promoting economic opportunities. Besides, trade freedom, business freedom, preservation of property rights, financial freedom, and monetary freedom are important components of economic freedom that support economic growth. Further, inflation instability indicates a positive effect on economic growth in both and short- and long-run.

The NARDL results for the pollution model show that a partial sum of positive change in economic freedom has a positive impact on emissions in both the short- and long-runs. A 1% increase in the positive component of economic freedom escalates pollution about 9.12% and 9.91% in the short- and long-runs, respectively. Contrary to this, a partial sum of negative change has no significant effect in the short-run and has a negative impact in the long-run. A 1% increase in the negative component of economic freedom mitigates pollution by about 5.98%. Thus, economic freedom supports economic activities that, in turn, escalate emissions in the atmosphere. It can be concluded that economic freedom needs to be complemented with government intervention to manage environmental quality. Thus, government regulation may control and guide more economic development to prevent environmental pollution.

This research has a certain limitation: first, this study mainly focused on linear and nonlinear dynamic effects of economic freedom on economic growth and pollution ignoring the effects of different forms of economic freedom. Second, this study did not control other relevant growth determinants such as capital formation, population growth, trade, and human capital. Third, this study did not control other pollution determinants such as energy consumption, urbanization, and affluence. Future research can spread this work in the neoclassical growth model framework. Besides, future studies can extend this work in the extended environmental Kuznets curve framework.

**Author contribution** This idea was given by Sana Ullah, Zhiyuan Yu, Sana Ullah, Mesfin Genie, Adnan Maqbool, and Muhammad Tariq Majeed analyzed the data and wrote the complete paper, while Waheed Ahmad and Adnan Maqbool read and approved the final version.

**Data availability** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethical approval** Not applicable

**Consent to participate** I am free to contact any of the people involved in the research to seek further clarification and information.

**Consent for publication** Not applicable

**Conflict of interest** The authors declare no competing interests.

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