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Natural resources and CO_2 emissions nexus: Sustainable development path for South Asian countries

Usman Mehmood

Dept. of Political Science, University of Management and Technology, Lahore, Pakistan.

Corresponding author: usmanmehmood.umt@gmail.com

Abstract

The rapid deterioration of the environment has attracted the world's attention to find the determinants of carbon dioxide (CO_2) emissions. In this line, many studies have probed the factors affecting CO_2 emissions, but the role of natural resources has been overlooked significantly. Therefore, this study attempts to fill this gap by investigating the role of natural resources in CO_2 emissions in four South Asian countries over the annual period of 1990-2019. Other variables of trade openness, renewable energy, energy use, and gross domestic product (GDP) were also included in the model. The autoregressive distributed lag (ARDL) method reveals that natural resources reduce CO_2 emissions in Pakistan and India. On the other hand, the abundance of natural resources increases CO_2 emissions in Bangladesh. This association was not found significant in Sri Lanka. Moreover, this research confirmed Environmental Kuznets curve (EKC) in Pakistan, India, Bangladesh, and Sri Lanka. Renewable energy is reducing CO_2 emissions in these countries. Therefore, natural resources are essential to reducing CO_2 emissions in Pakistan and India. Bangladesh needs to utilize its natural resources efficiently to improve air quality.

Keywords: ARDL; CO_2 emissions; Natural Resources; renewable energy; South Asian countries

1. Introduction

The global situation is crystal clear, and crying at the top of its voice that if the measures are not taken, the whole situation will be jeopardized (Tariq *et al*. 2017, 2021; Mehmood 2020a, b, 2021b, a, c, d; Mehmood and Tariq 2020). Environmental issues are playing havoc in making the roots quite a hallow, and the dream of sustainable development will remain a failure (Shah *et al*,. 2020). Abnormal emission of carbon dioxide (CO_2), population explosion, prevailing economic activities, and excessive use of fossil fuels are a great menace even to the existence of human beings on this planet due to unbearable temperature (Shahbaz and Muhammad 2019).

Much has been said and done to reduce CO_2 emissions, but its threatening increase is alarming. To achieve sustainable development, it is essential to reduce CO_2 emissions significantly (Tariq 2017). Therefore, it has become compulsory to determine the factors affecting CO_2emissions. In this framework, most past studies have focused on the nexus of CO_2 emissions-GDP-energy use (Balsalobre-Lorente *et al*., 2018). Similarly, the subsequent studies continued to present new models to show the political, economic, and social determinants of CO_2 emissions (Katircioglu *et al*,. 2020). The available literature investigating the determinants of CO_2 emissions mainly considered the variables of urbanization, financial development, tourism, agriculture, globalization, institutional quality, population, education, and income inequality. Despite the contribution of these research studies in making environmental policies, there are still some deficiencies to be observed (Uzar and Eyuboglu 2020). Therefore, the role of natural resources is almost neglected in the function of CO_2 emissions in South Asian countries.

The inverse relationship between GDP and CO_2 emissions was introduced by (Grossman *et al*. 1991); according to scholars, at the early stage of economic growth, CO2 emissions will start to increase, and after some threshold level, the air pollution begins to decline. Therefore, the EKC model began to investigate the linkages between economic growth and air pollution. For example, Apergis *et al*,.(2009) validated the existence of EKC in six Central American countries. But Arouri *et al*. (2012) cannot find the validity of EKC in the middle east and north American countries. They concluded that energy use was increasing CO_2 emissions significantly. At the same time, other studies included other variables to study their linkages with CO_2 emissions. In this regard, Shahbaz *et al*. (2013) investigated the role of trade in CO_2 emissions in South Africa over the period of 1965-2008. The scholars found that trade was reducing CO_2 emissions in South Africa.

Apergis & Ozturk (2015)included the population into the CO_2 model in fourteen Asian countries from 1990-2011. GMM indicated that population enhances CO_2 emissions. Ali *et al*. (2019) also probed the effect of urbanization on CO_2 in Pakistan over the annual data of 1972-2014. This research also argued that urbanization increase CO_2 emissions. In Northern Cyprus, the scholars (Katircioglu *et al*. 2020) found that education activity enhances CO_2 emissions. (Rehman *et al*. 2020)use agricultural products as the main determinants of CO_2 emissions. In a research covering from 1988-2017, it was conducted that the maize crop left a positive impact on CO_2 emissions in Pakistan. Yang *et al*. (2020) investigated the linkages between financial instability and CO_2 emissions and found that economic instability reduces CO_2 emissions in 54 countries. Wang & Zhang (2020) made the same effort from transportation in China and concluded that private ownership and industrial structure increase CO_2 emissions. Keeping in view all extensive research referenced in the literature that examined the determinants of CO_2 emissions, there are still limitations. Few studies investigating the effects of natural wealth on CO_2 emissions presented positive and negative effects. Similarly, (Balsalobre-Lorente *et al*. 2018)incorporated natural resources in their research and concluded that profusion of natural resources helps to reduce CO_2 emissions in five European countries. Danish *et al*. (2019)found the abundance of natural resources decreases CO_2 emissions in Russia and increases CO_2 emissions in South Africa**.** Hassan *et al*. (2019)explored linkages between natural resources and ecological footprint in Pakistan during the data of 1970-2014 and found the abundance of natural resources positively affects ecological footprint and increases environmental erosion.

Today's economies are striving to gain sustainable GDP growth. Still, when we peep into the unique conditions of South Asia, it can be seen that no study has been conducted to probe the association between natural resources and CO_2 emissions in South Asia. South Asian countries are rich in natural resources, especially solar and wind energy. Therefore, finding the linkages between natural resources and CO_2 emissions in South Asian countries is essential.

Hence, it can be said that an abundance of natural resources can reduce CO_2emissions, but the bungling use of natural resources can harm the environment badly. Therefore, the impact of natural resources on the environment is not clear. Few types of research (Balsalobre-Lorente *et al*. 2018; Danish *et al*. 2019) have focused on the association between natural resources and CO_2 emissions and found complexities about the effect of natural resources on CO_2 emissions. To provide a clear picture of the linkages between natural resources and CO_2 emissions, this research investigates the links between natural resources and CO_2 emissions for 4 South Asian countries over the annual data of 1990-2019. To gain the status of high-income land, South Asian countries have to create a balance between economic developments and increased CO_2 because monitoring GDP and increase in energy use is responsible for air pollution in Asian countries. This research will surely be essential for policymakers in South Asian countries because it presents a country-specific analysis to find the impacts of natural resources on CO_2 emissions. The policy-makers are in a predicament in achieving sustainable development in South Asia, and this research will be helpful in developing environmental and economic policies.

The prime objective of this paper is to find out the impacts of natural resources on CO_2 emissions in four South Asian countries over the annual period of 1990-2019. Other variables of trade openness, renewable energy, energy use, and gross domestic product (GDP) were also included in the model. In terms of methodology, this research is also different from past studies. Danish *et al*. (2019) utilized panel data methodology, which may not provide country-specific policy instruments. This research is also a virgin effort to determine the impact of natural resources on CO_2 emissions in South Asian countries.

2. Methodology

The fundamental purpose of this study is to find the linkages between natural resources and CO_2 emissions in Pakistan, India, Bangladesh, and Sri Lanka. Considering the past literature, this study included other variables in the model, which may affect CO_2 emissions. Sound literature is available that investigated the existence of EKC. Therefore, this study included GDP and its square terms to check the presence of EKC. In addition, other widely used variables of per capita energy consumption, renewable energy consumption, and trade openness are included in the model. Hence, a comprehensive study is performed to probe the factors of CO_2emissions in South Asian countries. This study conducts an analysis of annual data of four South Asian countries for the period of 1990-2019. Therefore, the estimated equation is as follows:

$$CO2_t = \beta_0 + \beta_1 NAT_t + \beta_2 EN_t + \beta_3 RE_t + \beta_4 G^2{}_t + \beta_5 G_t + \beta_6 TR_t + \epsilon_t \quad (1)$$

In equation 1, CO_2, NAT, EN, RE, G^2, G, and TR represent per capita carbon emissions (CO_2), total natural resource rents % of GDP (NAT), energy consumption (EN), renewable energy consumption % of total energy consumption (RE), GDP per capita (G), its square term, and trade openness (TR). All data is obtained from world data indicators(WDI, 2019).

3. Autoregressive distributed lag (ARDL)

This research applied the ARDL method (Pesaran and Pesaran 1997) to show the short-run and long-run association. This method is accompanied by the error correction term and is helpful for knowing short and long-run dynamics (Liu *et al*. 2019). Because environmental pollution is of international concern, it is important to set short and long-run targets to achieve sustainable development goals. So, applying the ARDL method is quite suitable for long-term policymaking. This methodology presents some advantages over other econometric methods. Firstly, this method has no restrictions for the variables to be stationary at the level or the first difference. Additionally, no variable should be stationary at the second difference. Secondly, the ARDL method includes the lag length of both dependent and independent variables, eliminates endogeneity problems, and provides consistent results (Uzar, 2020).To find the long-run values following equation is used:

$$\begin{aligned}\mathrm{lnCO2}_t = \beta_0 &+ \sum_{n=1}^{p} \partial_n\, lnCO2_{t-n} + \sum_{o=1}^{q1} \delta_o\, lnNAT_{t-o} + \sum_{p=1}^{q2} \varphi_p\, lnEN_{t-p} + \sum_{r=1}^{q3} \mu_r\, lnRE_{t-r} \\ &+ \sum_{s=1}^{q4} \emptyset_s\, lnG^2{}_{t-s} + \sum_{u=1}^{q5} £_u\, lnG_{t-u} + \sum_{v=1}^{q6} \mu_v\, lnTR_{t-v} \\ &+ \varepsilon_t \qquad (2)\end{aligned}$$

To find the short-run association, the vector error correction-based equation is used as below:

$$\begin{aligned}\Delta(lnCO2)_t = \beta_0 &+ \sum_{n=1}^{p} \partial_n \Delta(lnCO_{t-n}) + \sum_{o=1}^{q1} \delta_o\, \Delta(lnNAT_{t-o}) + \sum_{p=1}^{q2} \varphi_p\, \Delta(lnEN_{t-p}) \\ &+ \sum_{r=1}^{q3} \mu_r\, \Delta(lnRE_{t-r}) + \sum_{s=1}^{q4} \emptyset_s\, \Delta(lnG^2{}_{t-s}) + \sum_{u=1}^{q5} £_u\, \Delta(lnG_{t-s}) \\ &+ \sum_{v=1}^{q6} \varphi_v\, \Delta(lnTR_{t-v} + \vartheta z_{t-1} \\ &+ \varepsilon_t \qquad (3)\end{aligned}$$

Δ represents the change operator, while the error correction term (ECT) is ϑz_{t-1}, which calculates the extent of disequilibrium. The prime objective of this research is to probe the effect of natural resources on CO_2 emissions in four South Asian countries. We performed unit root tests with structural breaks for the robustness of the results and then applied the co-integration test.

Therefore, this study conducts the unit root test with structural breaks before the co-integration test.

4. Results and discussion

ARDL model requires that all variables should be of either I(0)or I(1), and no variable should be stationary at the second difference I(2). Therefore, to check the unit root of the variables, the Augmented Dickey-Fuller (ADF) unit root test with structural breaks was applied. According to table 1, the data of all variables for Pakistan and Bangladesh is stationary at the first difference, but data of India and Sri Lanka has mix order of integration. Few variables are integrated at I(0), and some are integrated at I(1).

Table 1. Unit root Test for natural resources, CO_2 emissions, trade openness, renewable energy, energy use, and gross domestic product

Economy	Variable	Unit root at I(0)		Unit root I(1)	
		T stat	Break year	T stat	Break year
Pakistan	$lnCO_{2t}$	-2.95	2014	-4.37*	2014
	$lnNAT_t$	-201	2016	-4.44**	2014
	lnG_t	-2.08	2002	-5.52***	2004
	$lnG^2{}_t$	-2.02	2002	-5.47***	2004
	$lnTR_t$	-3.00	2004	-5.59***	2016
	$lnEN_t$	-3.92	2002	-5.57***	2007
	$lnRE_t$	-2.98	2002	-7.59***	2007
India	$lnCO_{2t}$	-3.21	2004	-5.59***	2005
	$lnNAT_t$	-2.22	2003	-6.01***	2011
	lnG_t	-7.04***	2012	-1.86	2008
	$lnG^2{}_t$	-7.70***	2015	-5.41***	2008
	$lnTR_t$	-3.21	2001	-5.74***	2011
	$lnEN_t$	-1.01	2006	-5.52***	2003
	$lnRE_t$	-2.35	2006	-5.91***	2007
Bangladesh	$lnCO_{2t}$	-2.42	2010	-5.38***	2001
	$lnNAT_t$	-2.59	2004	-4.72**	2011
	lnG_t	-2.27	2010	-10.80***	2006
	$lnG^2{}_t$	-0.62	2016	-11.08***	2010
	$lnTR_t$	-3.58	2004	-5.85***	2013
	$lnEN_t$	-1.41	2005	-6.87***	2010
	$lnRE_t$	-0.45	2009	-4.71**	2007
Sri Lanka	$lnCO_{2t}$	-2.40	2014	-5.66***	2000
	$lnNAT_t$	-4.90**	2013	-6.29***	2001
	lnG_t	-2.74	2004	-4.89**	2012
	$lnG^2{}_t$	-2.56	2004	-4.72**	2012
	$lnTR_t$	-5.86***	2008	-6.14***	2009
	$lnEN_t$	-1.91	1998	-6.43***	2012
	$lnRE_t$	-3.27	2014	-6.34***	2014

Note: ***, **, and* show the significance at 1%, 5%, and 10% respectively

To check the association between variables, we applied the bounds test. According to Table 2, it is evident that all variables in Pakistan, India, Bangladesh, and Sri Lanka have a strong relationship at the 1% level. This means that CO_2, NAT, G, G^2, EN, REN, and TR move together in all estimated countries. Moreover, it can also be observed that our model passed all diagnostic tests successfully in all countries.

Table 2. Co-integration test results for natural resources, CO_2 emissions, trade openness, renewable energy, energy use, and gross domestic product

Economies	Pakistan	India	Bangladesh	Sri Lanka
Lag length	2	1	2	2
Break year	2014	2004	2010	2014
F-stats	4.40***	5.41***	85.65***	6.40***
R^2	0.96	0.46	0.99	0.93
Adj- R^2	0.83	0.17	0.99	0.76
D.W test	2.75	2.43	3.53	2.46
Diagnostic Tests				
X^2NORMAL	0.40	0.88	0.04	1.62
X^2 SERIAL	4.27	1.13	13.23	1.60
X^2 ARCH	1.44	0.86	6.32	0.07
X^2 WHITE	5.01	0.37	76.32	0.45
X^2RAMSAY	3.41	0.07	1.74	0.03
CUSUM	Stable	Stable	Stable	Stable
CUSUMsq	Stable	Stable	Stable	Stable

After the conduction of the unit root test and bounds test, this study conducted long run and short-run tests for Equations 2 and 3. According to table 3, GDP and its square term are positively and negatively associated with CO2 emissions in Pakistan, India, and Sri Lanka, respectively. In other words, a 1% increase in GDP will increase 1.54%, 10.85%, and 4.18% CO_2 emissions in India, Pakistan, and Sri Lanka, respectively. Similarly, 1% increase in G^2 will reduce 0.70%, 0.06%, 0.27% CO_2 emissions in Pakistan, India and Sri Lanka. These findings suggested the inverted U shape association in these countries. This means the existence of EKC in Pakistan, India, and Sri Lanka. These results are similar as (Bölük and Mert 2015; Uzar and Eyuboglu 2019).

Table 3. Long Run test results for natural resources, CO_2 emissions, trade openness, renewable energy, energy use, and gross domestic product

Economy	Variable	Coefficient	T stat	Prob value
Pakistan	$lnNAT_t$	-0.16**	-3.21	0.07
	lnG_t	10.85**	2.81	0.04
	$lnG^2{}_t$	-0.70**	-2.31	0.08
	$lnTR_t$	-0.48***	-6.03	0.00
	$lnEN_t$	-2.71**	-2.34	0.07
	$lnRE_t$	-4.65**	-3.51	0.02
India	$lnNAT_t$	-0.04**	-1.91	0.07
	lnG_t	1.54**	2.35	0.03
	$lnG^2{}_t$	-0.06	-1.47	0.15
	$lnTR_t$	0.14	1.70	0.10
	$lnEN_t$	0.18	0.83	0.41
	$lnRE_t$	-0.53**	-2.01	0.06
Bangladesh	$lnNAT_t$	0.09**	5.69	0.02
	lnG_t	-18.47***	-15.49	0.00
	$lnG^2{}_t$	1.33***	15.25	0.00
	$lnTR_t$	0.21**	4.31	0.04
	$lnEN_t$	-2.09**	-8.12	0.01
	$lnRE_t$	-2.88***	-13.30	0.00
Sri Lanka	$lnNAT_t$	0.03	0.25	0.80
	lnG_t	4.18**	2.40	0.05
	$lnG^2{}_t$	-0.27**	-2.28	0.06
	$lnTR_t$	-0.50	-1.75	0.12
	$lnEN_t$	0.52	1.03	0.34
	$lnRE_t$	-3.50***	-4.52	0.00
Note: ***, **, * shows the significance at 1%, 5%, and 10% respectively				

According to table 4, the results are in line with long-run consequences. Natural resources and renewable energy reduce CO_2 emissions in Pakistan, India, and Bangladesh. Moreover, the error correction term (ECM) value is negative and significant at a 1% level for Pakistan, India, Bangladesh, and Sri Lanka.

Table 4. Short Run test results for natural resources, CO_2 emissions, trade openness, renewable energy, energy use, and gross domestic product

Economy	Variable	Coefficient	T stat	Prob value
Pakistan	$lnNAT_t$	-0.10**	-2.27	0.08
	lnG_t	-71.88**	-2.34	0.07
	$lnG^2{}_t$	5.35**	2.33	0.08
	$lnTR_t$	0.27**	2.72	0.05
	$lnEN_t$	0.85	0.96	0.38
	$lnRE_t$	-2.27**	-3.59	0.02
	ECM^{-1}	-1.07**	-3.54	0.02
India	$lnNAT_t$	-0.03	-1.73	0.10
	lnG_t	1.38**	1.84	0.08
	$lnG^2{}_t$	-0.09**	-1.86	0.08
	$lnTR_t$	0.05	0.87	0.39
	$lnEN_t$	0.16	0.87	0.39
	$lnRE_t$	-0.47	-1.67	0.11
	ECM^{-1}	-0.89***	-4.17	0.00
Bangladesh	$lnNAT_t$	-0.13**	-6.99	0.01
	lnG_t	49.85**	7.22	0.01
	$lnG^2{}_t$	-5.01**	-7.77	0.01
	$lnTR_t$	0.45**	8.43	0.01
	$lnEN_t$	1.94**	9.57	0.01
	$lnRE_t$	-4.07 ***	-13.27	0.00
	ECM^{-1}	-1.63***	-14.72	0.00
Sri Lanka	$lnNAT_t$	0.25	1.90	0.10
	lnG_t	6.86**	2.40	0.05
	$lnG^2{}_t$	-0.36**	-1.99	0.09
	$lnTR_t$	-0.44	-1.91	0.10
	$lnEN_t$	0.66	1.47	0.19
	$lnRE_t$	-0.73	-1.41	0.20
	ECM^{-1}	-1.64***	-4.78	0.00
Note: ***, **, * shows the significance at 1%, 5%, and 10% respectively				

In the early stages of economic growth, CO_2 emissions will also increase, but after some time, more economic growth will start to reduce CO_2 emissions in these countries. After getting a certain level of economic growth, these countries may acquire technical advancements. Moreover, technical progress will increase the service sector, which has lower environmental effects. At the same time, with economic prosperity, people start to demand a cleaner environment because of environmental awareness (Danish *et al*., 2019). Additionally, it can be noted that G and G^2 are negatively and positively associated with CO_2 emissions in Bangladesh. This means EKC does not hold for Bangladesh. More economic growth will produce more CO_2 emissions in Bangladesh. These findings are consistent with (Miah *et al*. 2011). Therefore, Bangladesh needs to invest in green technology to achieve sustainable development.

The coefficients of RE show that renewable energy consumption significantly reduces CO_2 emissions in India, Pakistan, Bangladesh, and Sri Lanka. A 1 % increase in renewable energy will reduce CO_2 emissions by 4.65%, 0.53%, 2.88%, and 3.50% in Pakistan, India, Bangladesh, and Sri Lanka. Therefore, to minimize CO_2 emissions in these countries, it is important to enhance renewable energy. According to the World Bank data, these countries have started investing in renewable sources like wind and thermal energy to increase renewable energy production (WDI, 2019).

Trade can affect CO_2 emissions in terms of their composition, scale, and technical effects. It can be observed that trade increases CO_2 emissions in Bangladesh, which means that the scale effects are affecting dominantly. At the same time, in Pakistan, trade reduces CO_2 emissions by 0.48%. This means that composition and technical efforts are valid in Pakistan to reduce CO_2 emissions by trade. The effects of trade on CO_2 emissions in India and Sri Lanka are insignificant. These findings are not consistent with (Uzar & Eyuboglu, 2020).

The main independent variable of this study is NAT, and the Long-run coefficient of NAT is negative in Pakistan and India. This implies that the abundance of natural resources in Pakistan and India are reducing CO_2 emissions by 0.16% and 0.04%, respectively. These findings align with the findings of (Uzar & Eyuboglu 2020). The findings indicate that natural resources can be an important factor in reducing air pollution in Pakistan and India. This can be done by reducing the imports of fossil fuels in these two countries. These countries should rely on local resources for energy production to improve air quality. Pakistan and India have good potential in terms of solar energy production, and this source should be enhanced to improve air quality. Therefore, these countries need to depend on domestic sources for energy production rather than to import fossil energy sources.

The coefficient values of energy use are negative for Pakistan, and Bangladesh, which means that energy production reduces CO_2 emissions in these countries. The effects of energy production on CO_2 emissions in Sri Lanka and India are insignificant.

Table 4 shows the coefficients of the short-run analysis. The negative value of ECT is significant for all countries, which indicates that short-run values are consistent with the long-run values.

According to Narayan & Smyth (2006), the value of ECT between -1 and -2 shows that the error correction procedure can vary just about the long-term value in an oppressive way. According to table 4, short-run values are in line with long-run values in India. Natural resources, renewable energy, and economic growth reduce CO_2 emissions in the short-run in Pakistan. Moreover, the square of G, TR, and EN increase CO_2 emissions in the short-run in Pakistan. In Bangladesh, NAT, G^2, and RE are lowering CO_2 emissions. NAT, TR, and RE also reduce CO_2 emissions in Sri Lanka in the short run.

5. Conclusion

For the last few decades, the research community has been striving to determine the determinants of CO_2 emissions in the world. Although many variables have been employed to find their association with CO_2 emissions but the role of natural resources is almost neglected. As discussed earlier, the effects of natural resources on carbon emissions are evident. Therefore, it is essential to discuss this association in detail. Thus, the impact of natural resources on carbon emissions over the annual data of 1990-2019 has been conducted for 4 South Asian countries. Moreover, trade, energy use, renewable energy use, and GDP are also included in the model. The ARDL estimation shows that EKC is valid in Bangladesh, India, and Sri Lanka. This means that at a high-income level and due to innovative technologies, CO_2 emissions will start to reduce in these countries. In Pakistan, the situation is the inverse. More economic growth will increase CO_2 emissions in Pakistan. Our findings confirmed that natural resources, which is the primary variable of our study, will reduce CO_2 emissions in Pakistan and Bangladesh. Natural resources will increase and decrease CO_2 emissions in Sri Lanka and India, respectively. But this link is not significant in India and Sri Lanka. Our findings indicate that natural resources can be essential in reducing CO_2 emissions in Pakistan, Sri Lanka, and Bangladesh. This study also finds that renewable energy is reducing CO_2 emissions significantly in all countries. On the other hand, energy use is contributing to more air pollution. Trade is contributing to more CO_2 emissions in Pakistan, India, and Bangladesh. On the other hand, trade is decreasing CO_2 emissions in Sri Lanka.

These results present some essential policy instruments for South Asian countries. Pakistan, Bangladesh, and India can use natural resources to reduce air pollution. These countries have to discover more renewable natural resources to improve air quality. There will be a need for technological innovation and finance in discovering more renewable natural resources. Therefore, governments should encourage the private sector and invest in research and development efforts. These efforts will surely help to discover and utilize renewable natural resources.

Despite the contribution to the existing literature, this study has some limitations. Firstly, it employed CO_2 emissions as an indicator of environmental pollution. Future studies can include other indicators of air pollution like ecological footprints. Secondly, this study utilized the technique of ARDL, and future studies can use the dynamic technique of ARDL to present a comprehensive study.

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