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Nexus between CO2 Emissions and Natural Resources Rents: Evidence from Pakistan by using Quantile ARDL Approach

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Keywords:
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ABSTRACT

Purpose:
The climate change threat to humanity occupies the top position on the global agenda. The sustainable growth notion has captured great attention worldwide to formulate policies for human survival.

Design:
This research paper analyses the association of CO2 emissions with total natural resources rents while also incorporating other control variables for Pakistan for the time period of 1971 – 2020. The quantile autoregressive distributed lag (QARDL) model is used to evaluate the cointegration linkage of the variables

Findings:
The findings of this study confirm the existence of asymmetries and nonlinearities in the long run relationship for energy consumption and total natural resources rents. Energy consumption has stronger deteriorating effect on the environment; therefore, it is recommended to impose more tax on non-renewable energy sources

Originality and Value:
Natural resources could help to achieve sustainable development targets by vertical integration of manufacturing and energy sectors.

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1. Introduction

The local governments, academics and global community recognize climate change as a crucial problem due to its detrimental effect on the environment and have been trying to take measures to mitigate its causes. According to the report of BP statistical review (2021), the primary energy consumption and CO2 emissions fell by 4.5% and 6.3% respectively in the year 2020 due to dramatic impact of COVID-19 pandemic. The discharge of greenhouse gasses (GHG), carbon dioxide (CO2) in particular, is a major factor attributable to environmental deterioration. Extant research identifies many factors that could be helpful in reducing CO2 emissions, such as green energy, technological advancements, industrialization etc.

Environmental degradation obstacles the sustainable growth and has become a critical issue for countries for half a century. Two explanations could be provided for the role of economic growth in creating polluted environment. First, as Sarkodie and Strezov (2019) argue that economic development escalates extraction of natural resources, resulting in wastage dumping. Though, technological advancements regulate stern environmental policies and provide economic change framework to pollution-intensive firms to move to services sector thereby reducing polluted environment. Panayotou (1993) asserts that promoting economic development, initially requires the use of raw material in the production process which contributes to polluted environment. Furthermore, extreme levels of consuming resources for mining, deforestation and industrialization produce a detrimental effect on environment quality. Assimilating, justifiable management practices with production process, lowers the intensity of depleting natural resources, permitting the resources to redevelop thereafter. Secondly, the economic growth requires higher demand and usage of energy thereby producing CO2 emissions in the atmosphere. Energy consumption, especially through utilizing fossil fuels could be considered as the major source of GHG emissions and according to Bhat (2018), a critical catalyst for socio-economic activities in the world by its potential to affect the quality of life.

Pakistan is a land, having location in South Asia, enriched with valuable natural resources. The immense reserves of natural resources include salt, coal, copper, gold, iron core, oil and many others. Pakistan's coal reserves amount to 175 billion, equivalent to 618 billion barrels of crude oil. Pakistan has 885.3 billion cubic meters of natural gas reserves in Balochistan, gold/copper reserves in Saindak and salt rocks in Pothohar Plateau (Nawaz et al., 2019). Balsalobre-lorente et al. (2018) suggests that due to the low dependency of resources enriched economies on energy imports, they could help in controlling environmental deterioration by utilizing their resources to generate renewable energy. The economies with low levels of natural resources are mostly dependent upon energy imports in the form of fossil fuels, contributing to the environmental deterioration. Despite its combative nature, the research on environment issues have ignored the role of natural resources so far. There are few studies found in the extant literature that investigate the linkage of natural resources with the environment. Thus, this research investigates the nexus of environmental pollution with economic growth, energy consumption, financial development and natural resources rent for the emerging economy of Pakistan. The major research question that motivates the study is, if natural resource rents influence the CO2 emissions?

Including natural resources rents in the model would be beneficial to apprehend the present energy scenario in Pakistan, as the potential consequences of natural resources on the environment have become a current hot debate, globally.

This research has chosen Pakistan because of its raising CO_2 emissions, substantial reliance on natural resources, fossil fuel-based energy generation and higher exposure to climate change. Due to its status as a developing country, Pakistan is experiencing progress in industrial and technological sector, which makes it a suitable case for examining multifarious impacts of extraction of natural resources on environmental deterioration employing the Quantile ARDL technique. The results are anticipated to provide significant policy suggestions for managing sustainable resources and protecting environment in emerging countries.

Despite, most studies use linear framework to draw inferences that could be misleading, this study employs the finest non-linear econometric technique to examine relationships between variables of interest. The QARDL model generates results for both short-run and long-run parameters simultaneously incorporating any possible non-linear and asymmetric relationships between the employed variables (He et al., 2021). To the best of author's knowledge, this research is the first to employ QARDL model within Pakistan to offer regional underpinnings about the contingent characteristic of natural resources curse. Thus, this research contributes not only in methodology but also in regional-based findings to generate distinctive policy suggestions.

The other sections of the research paper are organized in the following manner. The extant literature is discussed in section 2, while data and methodology are covered in section 3, results and analysis are discussed in section 4 and conclusions of this paper are presented in section 5.

2. Literature Review

Utilization and production sustainability are enlisted in 17 sustainable development goals presented in United Nations (UN, 2019) charter. Because of the excess usage of natural resources by economies, implementation of consuming resources efficiently becomes a slow process. Bayramov (2018) defines natural resources in the context of The World Trade Organization, as scarce resources, present naturally in the earth and could be utilized in crude or processed manner. The natural resources of a country are a key driving force in promoting economic development. The linkage of natural resources with economic development has been the focus of many studies recently. Haseeb et al. (2020) states that all living beings are dependent upon natural resources as they provide material foundation for modern production.

According to Ahmad et al. (2020), resource enriched countries' focus is based on the utmost usage of their natural resources to achieve the economic objectives. Likewise, Van der Ploeg (2011) argues that though natural resources play a key role in elevating the economic development but the high level of natural resources consumption to achieve economic boost and social development, may result in positive or negative impacts on the economy. A resource blessing occurs, if consuming natural resources results in positive economic development. On the contrary, it becomes resource curse, if it shows inverse

relationship with economic growth. In addition, Atil et al. (2020) assert that as utilizing more resources to attain economic growth, could result in more GHG emissions in the environment, economy could establish its material reproduction framework for providing material and financial support to the production industries to improve the environment and growth sustainability. Thus, there is a general consensus among scholars regarding the importance of natural resources in developing economy and social environment of a country.

The recent controversy regarding the linkages of natural resources rents/revenues with economic growth has become a much-debated issue as some researchers find this relationship positive (e.g., Tiba & Frikha, 2019) while others find it negative (e.g., Erdogan et al., 2020). Yasmeen et al. (2021) confirm the existence of resource curse hypothesis in Pakistan by finding inverse association between natural resources and economic growth by using recent data. The study of Haseeb et al. (2020) find mixed results by employing the quantile-on-quantile regression method by pooling data of Asian economies for the time period of 1970 till 2018. They confirm resource curse hypothesis for India by finding an inverse association of natural resources with economic development. Whereas, resource blessing is confirmed for other Asian countries in the panel, where the authors observe a positive link between the two variables. Using data of 29 African countries, Zalle (2019) shows that resource curse exists in this region for time span of 2000 - 2015. The study recommends the formation of human capital and improvement of institutional quality for converting the curse into blessing (Wang et al., 2024).

One line of research justifies the resource curse in natural resource enriched countries by reporting inefficient financial system. Asif et al. (2020) reports inverse linkages of natural resources with financial development in the long term for Pakistan for the time period spanning 1975 till 2017, using ARDL bounds testing approach. Hadj and Ghodbane (2021) argue that to examine the curse or blessing hypothesis by only relying on the impact of resources on economic development is not adequate and studies should also incorporate the varying role of other factors as well, such as human capital and institutional quality on financial development. They find detrimental impact of natural resources rents on financial development in those economies which have advanced financial system, however an enhancing effect was observed in economies which earn high revenues from natural resources. Countries with high value of natural resources face the issue of increasing corruption due to lack of institutional development as firms seek plausible rents. According to Mehlum et al. (2006), rent-seeking behaviour drives countries to a fail of manufacturing sector, favouring non-transformative activities. Arvanitis and Weigert (2017) assert that the availability of natural resources pushes countries to earn from exporting them instead of benefiting by utilizing through manufacturing sector. But, Sarraf and Jiwanji (2001) provide another phenomenon that results due to the appreciation of exchange rate, which causes the exports, expensive for countries having abundance of natural resources, putting negative effects on their economic development, termed as Dutch disease. According to Gerelmaa and Kotani (2016), a resource curse and the so-called “Dutch disease” exist during 1970 – 1990 but not in 1990 – 2010 simply due to the sufficient growth of manufacturing sector. Vertically integrating manufacturing and energy sectors could convert the curse into blessing.

Though, there are studies on exploring the relationship among financial development, economic development and natural resources but a few examined the nexus between natural resources and CO2 emissions. Hassan et al. (2019) argue that the economic growth curse results in blistering industrial and urban growth worldwide, escalating the demand for natural resources, which leads to severe environmental consequences. Balsalobre-lorente et al. (2018) estimates a negative link between natural resources and environmental degradation. On the other hand, Bekun et al. (2019) find the contribution of natural resource rents in increasing pollution for European Union (EU) countries. Similarly, Ulucak et al. (2020) report supportive evidence for the role of natural resources extraction in escalating CO2 emissions for the Organization for Economic Cooperation and Development (OECD) countries, covering time period from 1980 to 2016. Danish et al. (2019) discover mixed results for Brazil, Russia, India, China, and South Africa (BRICS) countries. However, Khan et al. (2020) find that natural resources adversely affect CO2 emissions in BRICS countries while incorporating the role of technological advancements. Taking the data of 93 countries for 1995 till 2017, Nwani and Adams (2021) examine impact of natural resources on consumption based and production based CO2 emissions and show that natural resources rents increase both type of CO2 emissions significantly for the low quality of government (QoG) countries. While the estimates show a reducing impact on production based CO2 emissions in upper high QoG countries. Using ecological footprint to proxy for environmental deterioration in Pakistan, Hassan et al. (2019) find that natural resources escalate ecological footprint. Ahmed et al. (2020) find similar results for China. On the contrary, Danish et al. (2020) find that both renewable energy and natural resources decrease ecological footprint. Though, fossil sources are limited and unsustainable, causing polluted environment, renewable energy sources are plenteous and sustainable, helping in enhancing the environmental quality (Owusu & Asumadu-Sarkodie, 2016).

Balsalobre-lorente et al. (2018) states that most industrial economies rely on fossil sources for their production processes and the energy needs are met by utilizing fossil fuels and therefore it is necessary to seek the association among energy consumption, natural resources and CO2 emissions. This research contributes to existing literature by examining the role of natural resources rents in reducing environmental degradation or otherwise, for Pakistan.

3. Methodology

3.1 Data

The annual data of the response and explanatory variables of the study, for the period spanning 1971 till 2020 have been used for Pakistan. There were some missing values in the data which are interpolated by utilizing 'makima' interpolation method. Moreover, for improving the frequency, annual data is converted to quarterly observations by employing quadratic match sum method (Hadj & Ghodbane, 2021). CO2 emissions (metric tons per capita) are used to proxy for evaluating the quality of the environment. To measure economic development of the country, GDP per capita (current US$) is obtained. Energy consumption is presented by energy use (kg of oil equivalent per capita). Domestic credit to the private sector as a percentage of GDP proxies for financial development. Total natural

resources rents are utilized as a percentage of GDP. The data for CO2 emissions, GDP, energy consumption, financial development and total natural resources rents are extracted from the website of World Bank as World Development Indicators for Pakistan. Natural resources are of several types, however, the data is available only for coal, forest, mineral, natural gas and oil and their sum equals total natural resources as used in this study. Table 1 describes and explains the variables under study.

3.1 Variables' names, symbols, descriptions and sources

Table 1

Variable	Symbol	Description	Source
Carbon emission	CO2	CO2 emissions (metric tons per capita)	CAIT, world resources institute
Gross Domestic Product	GDP	GDP per capita (current US$)	World Bank
Energy consumption	ENR	Energy use (kg of oil equivalent per capita)	World Bank
Financial development	FD	Domestic credit to the private sector	World Bank
Total natural resources rents	TNR_rents	Total natural resources rents (% of GDP)	World Bank

3.2 Research Model

The model employed in this study is the quantile autoregressive distributed lag (QARDL) proposed by Cho et al. (2015) for investigating the cointegrated relationships among Co2 emissions, GDP, energy consumption, financial development and natural resources in Pakistan. The QARDL model extends ARDL technique by allowing examination of long term equilibrium effects of explanatory variables on response variable across quantiles spectrum. Moreover, Wald test could be employed for checking the consistency in the estimated parameters because of the temporal quality of measured integrations. The empirical estimation of the model can be designed as follows:

$$CO2_t = \mu + \sum_{i=1}^{p} \upsilon_{CO2_i} CO2_{t-i} + \sum_{i=0}^{q} \upsilon_{GDP_i} GDP_{t-i}$$

$$+ \sum_{i=0}^{r} \upsilon_{GDP_i^2} GDP_{t-i}^2 + \sum_{i=0}^{s} \upsilon_{ENR_i} ENR_{t-i} + \sum_{i=0}^{u} \upsilon_{FD_i} FD_{t-i} \quad (1)$$

$$+ \sum_{i=0}^{v} \upsilon_{TNR\_rents_i} TNR\_rents_{t-i} + \varepsilon_t$$

Where ε_t presents $CO2_t - E[\frac{CO2_t}{\lambda_{t-1}}]$, and λ_{t-1}stands for the smallest plausible ϑ-field produced by $\{CO2_t$, $GDP_t, GDP_t^2, ENR_t, FD_t, TNR\_rents_t, CO2_{t-1}, GDP_{t-i}, GDP_{t-i}^2, ENR_{t-i}, FD_{t-i}, TNR\_rents_{t-i}\}$. The lag orders p, q, r, s, u and v are determined by using Bayesian (Schwarz) information criterion (BIC). CO2, GDP, GDP^2, ENR, FD and TNR_rents stand for CO2 emissions, gross domestic product and its square, energy consumption, financial development and total natural resources rents respectively. According to the quantile scenario of Cho et al. (2015), the extension of equation (1) could be written as follows:

$$Q_{CO2_t} = \mu(\tau) + \sum_{i=1}^{p} \upsilon_{CO2_i}(\tau) CO2_{t-i} + \sum_{i=0}^{q} \upsilon_{GDP_i}(\tau) GDP_{t-i} + \sum_{i=0}^{r} \upsilon_{GDP_i^2}(\tau) GDP_{t-i}^2 + \sum_{i=0}^{s} \upsilon_{ENR_i}(\tau) ENR_{t-i} + \sum_{i=0}^{u} \upsilon_{FD_i} FD_{t-i} + \sum_{i=0}^{v} \upsilon_{\text{TNR\_rents}_i}(\tau) \text{TNR\_rents}_{t-i} + \varepsilon_t(\tau) \quad (2)$$

Where $\varepsilon_t(\tau) = CO2_t - Q_{CO2_t}(\frac{\tau}{\delta_{t-1}})$ and quantiles range between 0>τ <1. For the plausible existence of serial correlation in $\varepsilon_t(\tau)$, equation (2) could be rewritten as follows:

$$Q_{\Delta CO2_t} = \mu + \rho CO2_{t-1} + \kappa_{GDP} GDP_{t-1} + \kappa_{GDP^2} GDP_{t-1}^2 + \kappa_{ENR} ENR_{t-1} + \kappa_{FD} FD_{t-1} + \kappa_{TNR\_rents} TNR\_rents_{t-1} \sum_{i=1}^{p} + \upsilon_{CO2_i}(\tau) CO2_{t-i} + \sum_{i=0}^{q} \upsilon_{GDP_i} \Delta GDP_{t-i} + \sum_{i=0}^{r} \upsilon_{GDP_i^2} \Delta GDP_{t-i}^2 + \sum_{i=0}^{s} \upsilon_{ENR_i} \Delta ENR_{t-i} + \sum_{i=0}^{u} \upsilon_{FD_i} FD_{t-i} + \sum_{i=0}^{v} \upsilon_{TNR\_rents_i} \Delta TNR\_rents_{t-i} + \varepsilon_t(\tau) \quad (3)$$

In the preceding equation (3), the coefficients attached with differenced (Δ) terms indicate short run findings. The ECM reparametrization model of QARDL provided by Cho et al. (2015), can be

represented as follows:

$$Q_{\Delta CO2_t} = \mu(\tau) + \rho(\tau)(CO2_{t-1} - \beta_{GDP}(\tau)GDP_{t-1} - \beta_{GDP^2}(\tau)GDP^2_{t-1} - \beta_{ENR}(\tau)ENR_{t-1} - \beta_{FD}(\tau)FD_{t-1} - \beta_{TNR\_rents}(\tau)TNR\_rents_{t-1}) + \sum_{i=1}^{p} \upsilon_{CO2_i}(\tau)\Delta CO2_{t-i} + \sum_{i=0}^{q} \upsilon_{GDP_i}(\tau)\Delta GDP_{t-i} + \sum_{i=0}^{r} \upsilon_{GDP_i^2}(\tau)\Delta GDP^2_{t-i} + \sum_{i=0}^{s} \upsilon_{ENR_i}(\tau)\Delta ENR_{t-i} + \sum_{i=0}^{u} \upsilon_{FD_i}(\tau)\Delta FD_{t-i} + \sum_{i=0}^{v} \upsilon_{TNR\_rents_i}(\tau)\Delta TNR\_rents_{t-i} + \varepsilon_t(\tau) \quad (4)$$

The additive impact of the prior CO2 on the current levels is estimated by using delta method. υCO2 shows the cumulative term for the short-term period. Similar procedure is utilized to measure the additive short term influence of prior and current levels of GDP, GDP^2, ENR, FD and TNR_rents on present CO2 and are presented by υGDP=$\sum_{i=0}^{q} \upsilon_{GDP_i}$, υGDP^2=$\sum_{i=0}^{r} \upsilon_{GDP_i^2}$, υENR=$\sum_{i=0}^{s} \upsilon_{ENR_i}$, υFD=$\sum_{i=0}^{u} \upsilon_{FD_i}$, υTNR_rents=$\sum_{i=0}^{v} \upsilon_{TNR\_rents_i}$. The measured estimates of ρ should be significantly negative. The long run cointegrating parameters of GDP, GDP^2, ENR, FD and TNR_rents are presented by βs and are calculated in the following manner:
βGDP= - βGDP/ρ, $\beta GDP^2 = -\beta GDP^2/\rho$, βENR= - βENR/ρ, βFD= - βFD/ρ, βTNR_rents= - βTNR_rents/ρ.

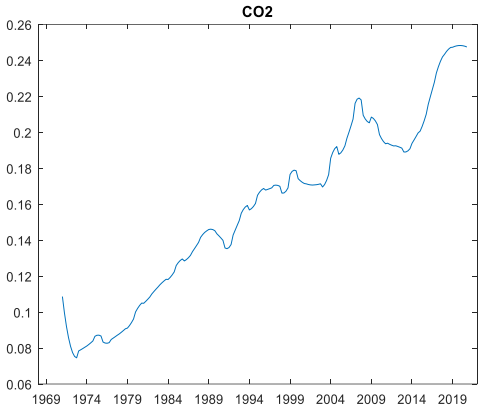
To test the short-term and long-term asymmetries, the paper employs Wald test. For example, the null hypothesis to test the parameter of the speed of adjustment ρ is, H_0: ρ (0.05) = ρ (0.15) = ρ (0.95).

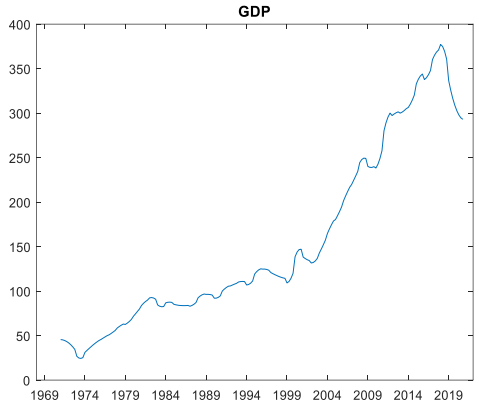
The long term estimators βGDP, βGDP^2, βENR, βFD, βTNR_rents and the short term estimators υGDP, υGDP^2, υENR, υFD, υTNR_rents are also tested by using the same hypothesis.

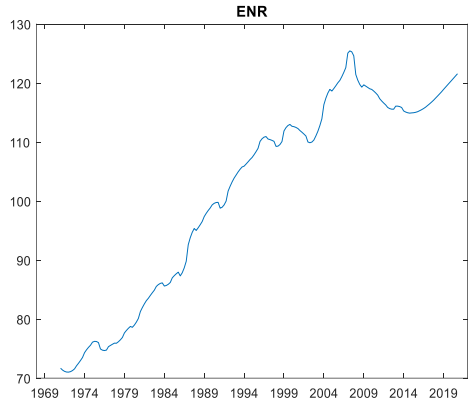
4. Data Analysis and Findings

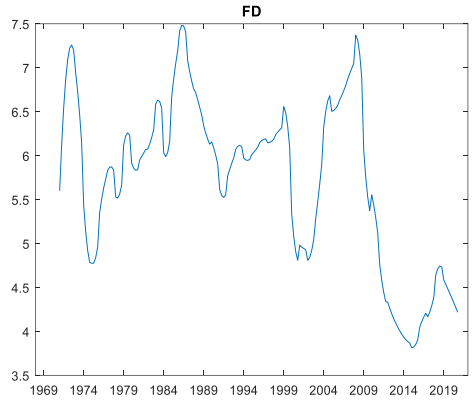
The trending patterns of both response and explanatory variables employed in the research are depicted in Fig. 1. The summary statistics for the variables as reported in Table 2, clearly show the skewed distributions of the variables under study. The frequency distributions of CO2 emissions, energy consumption and financial development have negative skewness, however, GDP and total natural resources rents have positively skewed distributions. Jarque-Bera statistics is used to further confirm that the data is non normal. Thus, the non-normality of data, an integral requirement to use quantile regression models, provides motivation to use QARDL model (Mishra et al., 2019).

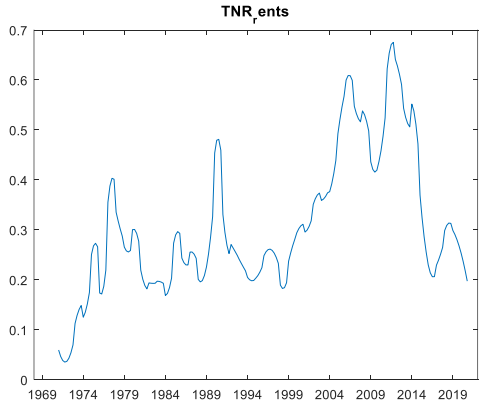
Figure 1: Trending pattern of the variables











4.1 Results of descriptive statistics

Table 2

Variables	CO2	GDP	ENR	FD	TNR_rents
Mean	0.158	154.689	101.497	5.728	0.309
Minimum	0.075	24.348	71.018	3.813	0.035
Maximum	0.248	377.173	125.45	7.481	0.675
Std. Dev.	0.049	100.682	17.043	0.957	0.142
Skewness	-0.011	0.78	-0.49	-0.361	0.701
Kurtosis	2.05	2.275	1.732	2.185	2.91
Jarque-Bera	7.525	24.667	21.392	9.87	16.44
Probability	0.028	0.001	0.002	0.016	0.004

Source: Author estimation

To check if the variables are stationary, Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests are employed. Table 3 reports the results for unit root tests. None of the variables are stationary at levels as evidenced by the insignificant results for both type of tests. The first differenced forms of all the variables are stationary at 1% level of significance as reported under first difference panel heading of Table 3. Such as the order of integration of the variables under study is I(1). The ARDL models could only be used if the order of integration of the variables is either a mix of I(0) and I(1) or I(1). The level of I(1) order at maximum, is a required attribute to proceed towards using ARDL models.

4.2 Results of Unit root tests

Table 3

Variables	Level		First difference	
	ADF	PP	ADF	PP
CO2	4.352	0.388	-6.657***	-6.519***
GDP	3.42	-0.254	-6.097***	-6.218***
ENR	5.538	-1.449	-6.245***	-6.923***
FD	-0.678	-1.937	-7.102***	-6.650***
TNR_rents	-0.481	-1.895	-7.96***	-6.968***

Note: ***, ** and * present significance at 1%, 5% and 10% level respectively.

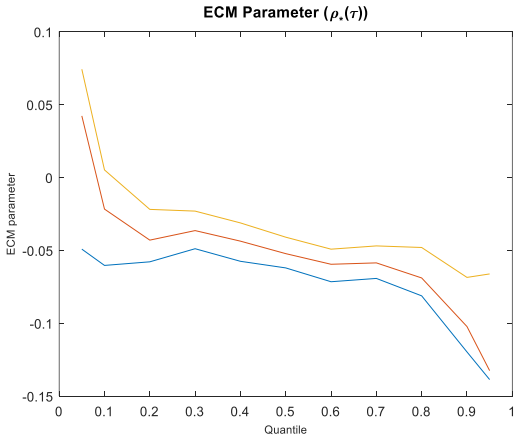
Table 4 reports the estimated findings of QARDL model. The estimated parameters for ρ are negative for all quantiles and significant at 1% level with the exception of the first two quantiles. These results for error correction term ρ indicate a long term equilibrium reverting association between CO2 and GDP, GDP^2, ENR, FD and TNR_rents. Furthermore, the β coefficients show the long-run

association among the response (CO2) and explanatory variables (GDP, GDP^2, ENR, FD and TNR_rents).

The β values for GDP are mostly positive as reported by extant literature (e.g., Godil et al., 2020; Usman et al., 2020) but significant only for 0.6^{th} and 0.7^{th} quantiles. The β coefficients for GDP^2 are all insignificant with one exception. The βENR coefficients are positive and significant at 1% level of significance except for the first two quantiles, inferring that CO2 emissions expand with increasing energy consumption. Ulucak et al. (2020) find evidence for the detrimental impact of non-renewable energy on the environment by using three indicators of environmental deterioration for 26 OECD countries. The βFD coefficients show mingled results as they have negative and insignificant values at lower quantiles but become positive and significant gradually with increasing quantiles i.e., from 0.6 till 0.95. These results are in line with Tsaurai (2019). Negative relationship with CO2 emissions is found for the major variable of this study, total natural resources rents, as the long-term cointegrating parameter βTNR_rents have negative and significant values except at some lower quantiles, suggesting that extraction and utilization of natural resources helps in improving the environmental quality in Pakistan. Nwani & Adams (2021) find similar results for upper-high QoG countries in their varied sample of 93 countries. These measures highlight the quality of institutions and good governance in supporting sustainable usage of natural resources in Pakistan. Balsalobre-Lorente et al. (2018) assert that natural resource endowments could assist in decreasing CO2 emissions by reducing consumption and import of fossil fuels.

Turning towards short run estimates, the results provide adequate evidence for highly significant positive influence of previous levels of CO2 emissions on their current levels across all quantiles. The present and past changes in GDP and its square factor does not show any significant impact on environmental degradation in the short-term period. However, the current and prior changes in energy consumption retains the same highly significant positive linkage with CO2 emissions, revealing the adverse effect of energy consumption on environmental degradation in the short run as well. The current and past changes in financial development losses its influence on present level of CO2 emissions. Furthermore, the current and prior changes in total natural resources rents losses its significance in the short-term period. Fig. 2, Fig. 3, Fig. 4 and Fig. 5 support the results of cointegrated QARDL model, reported in Table 4.

Figure 2: Error correction term ρ through quantiles



4.3 Results of quantile autoregressive distributed lag (QARDL) model for CO2 emissions

Table 4

Quantiles (τ)	μ∗(τ)	ρ∗(τ)	βGDP(τ)	βGDP2(τ)	βENR(τ)	βFD(τ)	βTNR_rents(τ)	υCO2	υGDP	υGDP2	υENR	υFD	υTNR_rents
0.05	0.0138***	0.0422	-0.0066	0.4101	0.0045	0.0201	0.0333	0.7985***	-0.0014	0.0884	0.0001	0.001	0.0008
	(3.481)	(1.131)	(-0.025)	(0.038)	(0.041)	(0.035)	(0.009)	(7.41)	(-0.954)	(1.142)	(0.214)	(0.538)	(0.098)
0.10	0.0075**	-0.0217	0.0166	-0.6276	-0.0019	-0.0314	-0.1489	0.6439***	-0.0009	0.0339	0.0005	-0.001	0.0002
	(2.393)	(-1.175)	(0.235)	(-0.213)	(-0.072)	(-0.139)	(-0.628)	(11.595)	(-1.4)	(1.193)	(1.541)	(-1.276)	(0.054)
0.20	-0.0008	-0.043***	0.0031	-0.0428	0.0018***	-0.0079*	-0.057*	0.5257***	0.0006	-0.0264	0.0014***	0.0004	-0.0008
	(-0.5)	(-3.858)	(1.057)	(-0.286)	(4.005)	(-1.798)	(-1.946)	(9.346)	(0.951)	(-0.925)	(4.609)	(0.717)	(-0.337)
0.30	-0.0018	-0.0365***	-0.0004	0.1583	0.0022***	-0.0047	-0.0412	0.5162***	0.0004	-0.0057	0.0014***	0.0004	-0.0024
	(-1.427)	(-4.436)	(-0.143)	(1.231)	(5.854)	(-1.335)	(-1.499)	(7.453)	(0.547)	(-0.199)	(4.85)	(0.589)	(-1.091)
0.40	-0.0025**	-0.0437***	0.0002	0.1207*	0.0021***	-0.0026	-0.0309	0.5128***	-0.0003	0.0211	0.0015***	0.0006	-0.0006
	(-2.343)	(-5.381)	(0.188)	(1.914)	(9.673)	(-1.016)	(-1.582)	(6.608)	(-0.55)	(0.915)	(4.989)	(0.904)	(-0.251)
0.50	-0.0035***	-0.0523***	0.0022	0.0327	0.0019***	0.0015	-0.0394**	0.485***	-0.0003	0.0171	0.0014***	0.0009	0.0021
	(-3.723)	(-8.03)	(1.496)	(0.446)	(8.471)	(0.708)	(-2.181)	(6.621)	(-0.387)	(0.59)	(5.082)	(1.432)	(0.681)
0.60	-0.0037***	-0.0596***	0.0035***	-0.0267	0.0017***	0.0031**	-0.0506***	0.4526***	0.0001	0.0035	0.0015***	0.0013**	0.0027
	(-4.653)	(-9.67)	(3.731)	(-0.529)	(12.977)	(2.207)	(-5.439)	(7.847)	(0.143)	(0.134)	(7.101)	(2.231)	(0.987)
0.70	-0.0034***	-0.0586***	0.0042***	-0.0715	0.0016***	0.0028*	-0.0459***	0.4734***	0.0002	0.0021	0.0014***	0.0009	0.0057*
	(-4.441)	(-8.796)	(4.009)	(-1.272)	(11.469)	(1.868)	(-4.07)	(7.558)	(0.21)	(0.069)	(6.317)	(1.521)	(1.775)
0.80	-0.0055***	-0.069***	0.0018	0.0508	0.002***	0.004***	-0.0444***	0.482***	-0.0001	0.0163	0.0017***	0.0003	0.0029
	(-4.239)	(-6.651)	(1.038)	(0.562)	(7.398)	(2.869)	(-4.222)	(7.891)	(-0.189)	(0.597)	(9.398)	(0.575)	(1.169)
0.90	-0.0127***	-0.1023***	0.0005	0.1039	0.0025***	0.0071***	-0.0576***	0.7195***	0.001	-0.0533	0.0011***	0.0004	0.0071*
	(-5.94)	(-6.247)	(0.188)	(0.749)	(5.818)	(3.51)	(-4.596)	(9.09)	(1.11)	(-1.239)	(4.509)	(0.397)	(1.848)
0.95	-0.0121***	-0.1326***	0.0036	-0.0804	0.0021***	0.0048*	-0.062***	0.7256***	0.001	-0.0585	0.0013***	-0.0001	0.0071*
	(-4.916)	(-6.058)	(1.021)	(-0.433)	(3.989)	(1.875)	(-3.943)	(6.973)	(1.008)	(-1.557)	(3.128)	(-0.046)	(1.675)

The table reports the QARDL estimation results. The t-statistics are between brackets. ***, **, and * present significance at the 1%, 5%, and 10% levels, respectively. Source: Author estimations

Figure 3: Long-run parameters βs of explanatory variables, GDP, ENR, FD and TNR_rents.

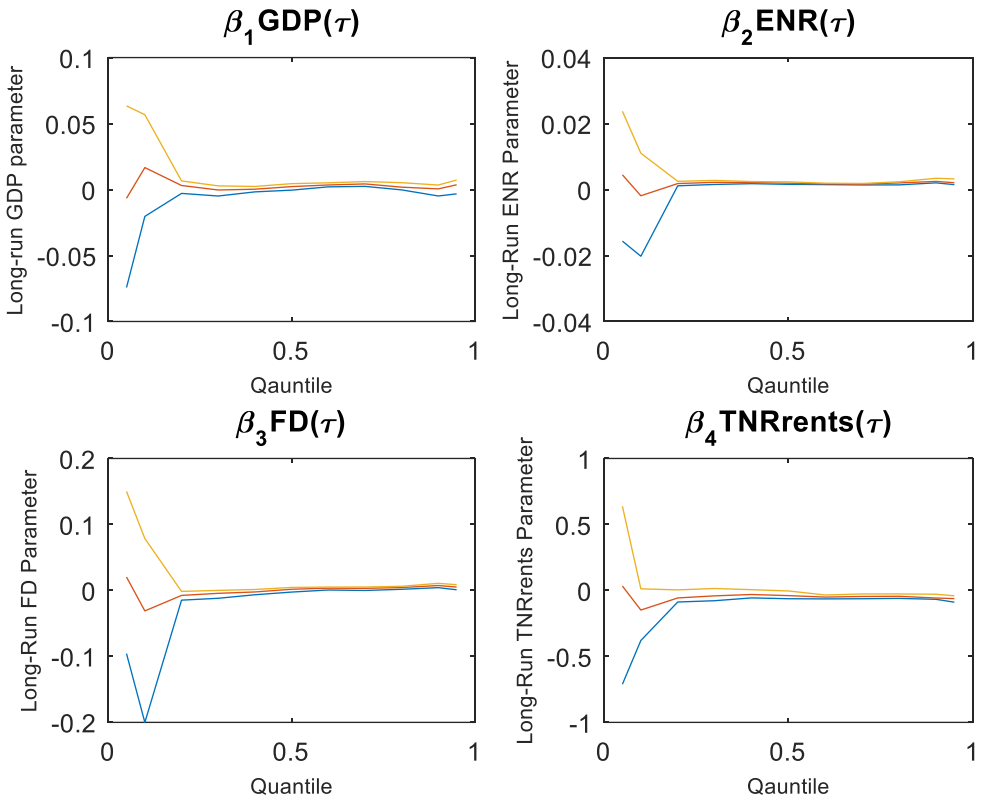


Figure 4: Impact of past and current changes in CO2 on current levels

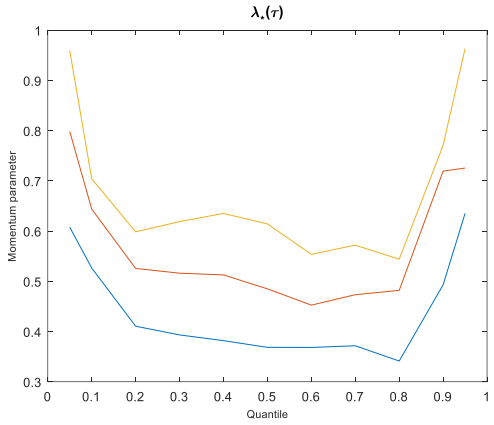
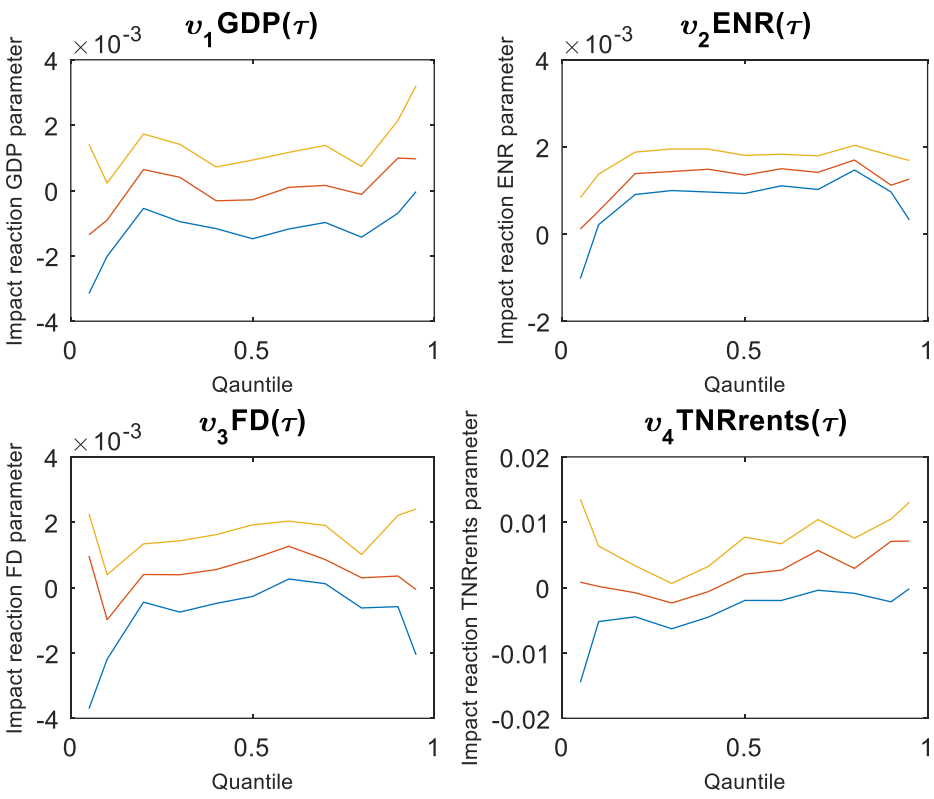


Figure 5: Short run parameters through quantiles



4.4 Findings of Wald test for parameters' consistency

Table 5

Variables	F-statistics (P-value)
ρ∗(τ)	44.139***(0.000)
βGDP(τ)	1.559(0.459)
βGDP2(τ)	0.274(0.872)
βENR(τ)	23.673***(0.000)
βFD(τ)	3.257(0.196)
βTNR_rents(τ)	15.602***(0.000)
υCO2	50.946***(0.000)
υGDP	1.672(0.434)
υGDP2	3.247(0.197)
υENR	11.697***(0.003)
υFD	0.005(0.998)
υTNR_rents	2.732(0.255)

The p-values are between brackets. *, ** and *** indicate significance at the 10%, 5%, and 1% levels respectively. Source: Author's estimation

The Wald test is used in this study to test the coefficients' consistency across quantiles. The Wald test is useful to identify any non-linear relationships in long and short term parameters to estimate locational asymmetries (Cho et al., 2015). The acceptance of null hypothesis demonstrate that no significant evidence is detected for asymmetries and nonlinearities in the association between response and explanatory variables. The Wald test findings further confirm the asymmetric and dynamic influence of energy consumption and total natural resources rents on CO2 emissions in the long and short term period for Pakistan as depicted in Table 5. The Wald test statistics provide adequate proof to reject the null hypothesis for finding no trace of asymmetric and non-linear linkages across considered quantiles for the speed of adjustment parameter ρ. Similar evidence is reported for energy consumption and total natural resources rents across quantiles in the long run relationship. Which shows that the cointegrating estimates between CO2 emissions and concerned variables i.e., ENR and TNR_rents are asymmetric. Regarding the effect of past and present changes of CO2 emissions on its present levels, the Wald test also rejects the null hypothesis of parameter stability. The study fails to reject the null hypothesis based on Wald test for short run parameters of GDP, GDP^2, FD and TNR_rents. Thus, hinting that linear and symmetric linkage is detected for these variables in the short run dynamics. The null hypothesis of the Wald test for ENR is rejected showing that the linkage between CO2 emissions and ENR is asymmetric and nonlinear.

5. Conclusions and Policy Implications

The Environmental Kuznets Curve (EKC) states that economies rich with natural resources undergo increasing CO2 emissions during earlier development but decline at later stages because of rise in income level enabling cleaner technology adoption. If natural resource rents boost governmental revenues, enhance monetary position and empower investing in cleaner projects, then natural resources utilization can decrease CO2 emissions (Sibanda et al., 2023).

Natural resources rents gain a prominent position in economics related to climate change (Canh et al., 2020). There are a few studies within the context of emerging market of Pakistan that check the impact of natural resources on CO2 emissions along with considering other control variables which are held responsible for environmental degradation. Including total natural resources rents of GDP in the model could help in incorporating the role of earnings from natural resources of Pakistan in driving pollution and formulating policies. The key focus of climate change affected countries is to persistently work for mitigating the factors responsible for environmental pollution.

Though there are studies where the impact of natural resources on economic growth or financial development has been examined, the role of natural resources rents and their effect on CO2 emissions is not discussed much. Primarily, these resources rents are a result of natural resources extracted from the earth and therefore require high level of energy usage, thus leading to muddled dumping of chemical wastage into land, air and water. Generally trending practice of illegal mining, cutting trees and fishing while using obsolete equipment is observed in numerous under developed countries which brings about environmental damages. Moreover, the ways of sourcing and generating energy while extracting natural resources have serious consequences on the environment (e.g., Adedoyin et al., 2020; Kwakwa et al., 2020).

The results of QARDL model exhibit that the parameters for ρ are negative (with one exception)

and significant (except for the first two quantiles) at all quantiles. The long run relationship is evidenced between CO2 emissions and explanatory variables of the study especially at extreme quantiles. It is evident that increasing energy consumption escalates CO2 emissions due to energy conservation policy. The government should use the rents generated from natural resources in green energy projects and put more tax on non-renewable energy sources to help in improving energy efficiency and reducing CO2 emissions. Interestingly total natural resources rents show a decreasing pattern with negative and mostly significant coefficients. This shows the positive role of natural resources in reducing environmental deterioration and combine with sustainable management policies in consumption and production processes slows the natural resources depletion and environmental stress, thereby allowing the resources to regenerate. This result is parallel to Balsalobre-lorente et al. (2018). Negative but insignificant parameters are observed for financial development at lower quantiles and significantly positive at upper quantiles. The credit policies that facilitate loans to sustainable projects, should be implemented by the policy makers.

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