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Role of Natural Resources and Eco-Innovations in Determination of the Environmental Quality of Pakistan: Evidence through Vector Autoregressive (VAR) Estimation

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ABSTRACT

The present study estimates the impact of natural resources, eco-innovations and economic growth on CO_2 emissions in Pakistan over 1990-2019 period. For empirical estimation, Vector Autoregressive Model (VAR) and Granger Causality Analysis, Variance Decomposition Analysis and Impulse Response Function are applied after checking the stationarity properties and long run cointegration among the variables. According to the empirical findings, natural resources have significant positive impact, whereas eco-innovations have negative impact on CO_2 emission in Pakistan. Bi-directional causal association is present between CO_2 and eco-innovations, and CO_2 and economic growth, but no causal association is present between natural resources and CO_2 emission. In addition, Variance Decomposition Analysis and Impulse Response Function show the forecasted effects of natural resources, eco-innovations and economic growth on future CO_2 emissions. The findings are robust to various policy recommendations. The study recommends the policymakers and the government to implement strict regulations to curb the over utilization of natural resources. Government should also start new businesses and research and development programs in collaboration with private sector to promote eco-friendly technologies that will help in mitigation of environmental pollution in Pakistan.

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1. Introduction

Human beings have been confronted with the fundamental problem of global warming since the beginning of this century. Many environmental studies have emphasized the need to limit greenhouse gas emissions (GHGs), particularly CO_2 emissions, as CO_2 emissions account for a major proportion of GHGs (Mohsin, Kamran, Nawaz, Hussain, & Dahri, 2021; Nawaz, Hussain, et al., 2021). Previous studies identified different factors responsible for increasing the share of CO_2 emission such as energy consumption, globalization, financial development, economic growth etc. (R. Ali, Bakhsh, & Yasin, 2019; Lei, Xie, Hafeez, & Ullah, 2022; M. Liu, Ren, Cheng, & Wang, 2020; Namahoro, Wu, Zhou, & Xue, 2021; Xu, Schwarz, & Yang, 2020). In the same vein, natural resources are also occupying the centre of attention in recent studies for their ambiguous impact on environmental quality. Natural resources are considered as the essential component of the global economy, especially in poor economies where their extraction accounts for a significant portion of the gross domestic product (Z. A. Baloch et al., 2021; Hassan, Xia, Khan, & Shah, 2019; Nawaz, Seshadri, et al., 2021). Natural resources and ecological concerns, however, are a cause of petty arguments. Several economic activities, rapid rise in urbanization, income inequality and industrialization processes cause more natural resource exploitation and uses that result in environmental damages. Furthermore, there are allegations that human activities such as mining, and deforestation are major causes of habitat loss, soil, water and air pollution. Existing studies on environmental sustainability and natural resources do not agree in this way (Shair, Shaorong, Kamran, Hussain, & Nawaz, 2021; H. Sun et al., 2020). Danish (2020) for example, found that natural resources are blame worthy for rising environmental contamination, while certain empirical research contradict these allegations (Balsalobre-Lorente, Shahbaz, Roubaud, & Farhani, 2018; Chien, Hsu, Zhang, Vu, & Nawaz, 2021; Zafar et al., 2019; Zaidi et al., 2019). Furthermore, the studies on the nexus between natural resources and ecological problems mentioned above are inadequate, and further research is needed to arrive at a sensible conclusion.

With growing environmental concerns, it is vital for all countries to choose effective CO2 emission mitigation methods (Chien, Kamran, et al., 2021; Xiang et al., 2021; Xiaoman, Majeed, Vasbieva, Yameogo, & Hussain, 2021). In this regard, the concept of eco-innovation has indeed been represented as a tool for anticipating environmental harms related to GHG emissions, and intends to reduce material resource consumption, air and waste pollution. The concept of eco-innovation emerges when strategies and policies are aligned with ecological concepts (Chien, Pantamee, et al., 2021; Li et al., 2021). It is defined as the total patents in the economy with a focus on the environment. Ecological innovation contributes to natural sustainability goals through acknowledging groundbreaking ideas, methods, technologies, and cycles (Rennings, 2000). Eco-innovation provide a better business plan that helps to reduce environmental risks, pollution, and the harmful impacts of resource use, as compared to traditional plans that ignore the worsening influence of economic growth on the environment (Afshan & Yaqoob, 2021; Chien, Sadiq, Kamran, et al., 2021).

Following this brief discussion, the main objective of the current study is to analyze the impact of natural resources and eco-innovations on environmental quality of Pakistan over 1990 to 2019 period. Pakistan is the most vulnerable to harmful consequences of climate change like other developing countries. Pakistan is rich in natural resources such as natural gas, land, oil, coal, iron, copper, minerals, gold, salt, other minerals. Pakistan, in reality, possesses the second-largest salt mine and coal mine, fifth largest gold mine, seventh largest copper mine, 12th-largest rice production, and 11th-largest wheat production (Hassan, Xia, Huang, Khan, & Iqbal, 2019). Pakistan is utilizing its natural resources like fossil fuels, petroleum, natural gas and coal as the main sources for energy production that not only leads to over exploitation of these resources, but also has serious environmental concerns (Iqbal, Wang, Shaikh, Maqbool, & Hayat, 2022). Pakistan government has started a number of programs involving the consumption of natural resources to prevent environmental hazards arising due to over utilization of natural resources.

To our knowledge, the present study is the first one that investigates the impact of eco-innovations on CO2 emissions in the context of Pakistan that makes it distinguishable from earlier studies. The impact of natural resources and income on CO2 emissions are also estimated. Furthermore, Vector autoregressive (VAR) is used to provide more accurate findings and compelling policy recommendations which is also a novelty of this study. The study offers valuable insight to policymakers and government in Pakistan about how to balance the process of natural resource utilization while maintaining stable environmental quality.

The remaining sections are organized in the way that review of existing literature is provided in Section 2. Section 3 describes data and applied methodology. Results and their discussion are given in Section 4. Section 5 concludes the study with worthy recommendations.

2. Literature Review

In the existing literature, a few studies are available that explored the natural resources and environment quality nexus as compared to the wide range of studies investigating natural resources and economic growth nexus (Haseeb, Kot, Hussain, & Kamarudin, 2021; Hayat & Tahir, 2021; Khan, 2021; Z. Liu, Lan, Chien, Sadiq, & Nawaz, 2022; Shabbir, Kousar, & Kousar, 2020; Yasmeen, Tan, Zameer, Vo, & Shahbaz, 2021). For instance, Balsalobre-Lorente et al. (2018) estimated the effects of natural resources, energy innovation renewable electricity and trade openness on CO2 emission in EU countries. Natural resources, energy use and renewable electricity were found to be important factors that contributed to mitigate CO2 emission. M. A. Baloch, Mahmood, and Zhang (2019) explored the impact of natural resources on CO2 emission in BRICS. By applying AMG estimation, the researchers concluded that natural resources had positive association with CO2 emission in South Africa but negative association with CO2 emission in China. Similarly Mehmood, Agyekum, Uhunamure, Shale, and Mariam (2022) studied the effects of population ageing, globalization and natural resources on CO2 emission in G-11 economies. According to the findings of CS-ARDL model, natural resources enhanced CO2 emission in the selected countries. Iqbal et al. (2022) explored the nexus between economic growth, renewable energy and natural resources in Pakistan by applying non-linear ARDL model. In contrast to previous studies, the authors concluded that changes in natural resources were negatively related to CO2 emission in Pakistan. Hassan, Xia, Khan, et al. (2019) also considered Pakistan as the case study to examine the association between natural resources, economic growth and ecological footprints. From the findings of ARDL approach, the authors concluded that natural resources contributed to ecological footprints in Pakistan. In another study by the same authors Tauseef Hassan, Xia, and Lee (2021) in the context of Pakistan, they concluded that natural enhanced CO2 emission in Pakistan.

In addition, previous researches also focused on the role of innovation in environmental pollution. For instance, Chien, Sadiq, Nawaz, et al. (2021) studied the nexus among eco-innovations, environmental taxes and green energy, co2 emission and PM2.5 in top Asian countries. Their findings from CS-ARDL, CCEMG and AMG estimations indicated that eco innovations and environmental taxes were helpful in mitigating the environmental pollution. Jun et al. (2022) estimated the role of ecological innovations and renewable and non-renewable electricity production on CO2 emission in top ten highly emitting countries of the world and observed that innovations and renewable electricity were negatively related to CO2 emission. Amin, Zhou, and Safi (2022) estimated the role of eco innovations on carbon-based emissions. According to the authors' findings from CS-ARDL, the authors concluded the positive contribution of eco-innovations on emissions.

Applying Quantile ARDL (QARDL) approach, J. Liu et al. (2021) also estimated the role of innovations and renewable energy in the context of China on environmental pollution measured by CO2 emission. They observed that renewable energy and innovations reduced CO2 emission in China. Taking G-7 countries Zhao, Liu, and Huang (2022) estimated how solar energy and innovations affected CO2 emission by applying CS-ARDL and AMG estimations. Both solar energy and innovations reduced CO2 emission in G-7 countries according to their findings. Taking the USA as the focus area for study Chien, Ananzeh, et al. (2021) analyzed the relationship between innovations, environmental taxes, clean energy and CO2 emission by applying QARDL approach and concluded that innovations had significantly negative relationship with CO2 emission at all quantiles. In another study for the USA Y. Sun, Yesilada, Andlib, and Ajaz (2021) also found that innovations together with environmental taxes were responsible for mitigating the environmental pollution in QARDL findings. Wei and Lihua (2022), Wang, Chang, Rizvi, and Sari (2020), Ahmad et al. (2021) and S. Ali, Dogan, Chen, and Khan (2021) also concluded the similar results.

Thus, it is worth noting that previous studies have established the association between natural resources and economic growth but did not pay more attention to natural resources and environmental quality nexus. Recent studies, Balsalobre-Lorente et al. (2018), Iqbal et al. (2022), Tauseef Hassan et al. (2021) attempted to understand this nexus, but their findings, which are based on opposing viewpoints, indicate that more attention needs be paid to the empirical examination of the topic. Moreover, researchers did not pay attention towards estimation of the eco-innovations and environmental quality nexus in Pakistan although a significant number of studies are present that investigated this relationship for different countries or different group of countries. Therefore, this study makes an attempt to study the nexus between natural resources, eco-innovations and environmental quality in the context of Pakistan to fill in this research gap.

3. Data and Methodology

The present study aims at estimating the role of natural resources and eco-innovations on CO2 emissions in Pakistan. For this purpose, time series data over the period 1990 to 2019 has been taken from secondary sources. CO2 emission is taken as the dependent variable, measured by CO2 emission (killo tons). Natural resources and eco-innovations are the two main explanatory variables. Natural resources is proxied as total natural resource rents (% of GDP), whereas environmental related technologies (% of all technologies) is taken as a measure for eco-innovation. Economic growth is the control variable which is measured as GDP constant dollar (2015). The data for GDP and natural resources is taken from WDI (World Bank, 2020) and the data for eco-innovations is sourced from OECD.

The model of the study is specified as:

$$CO_{2t} = \alpha_0 + \beta_1 NR_t + \beta_2 EI_t + \beta_3 GDP_t + \varepsilon_t \quad (1)$$

Where, α= constant, β =coefficient, t= time period, NR= natural resources, EI = eco-innovations, GDP = economic growth and CO2= CO2 emission.

3.1 Methodology

Differenced approaches are commonly used to manage non-stationary series. Differenced methods, however, constantly overlook essential information contained in the original levels. Therefore, long-term relationship cannot be revealed through regression. Sims (1980) first presented the vector autoregressive model (VAR) and assessed the homogeneity of variables in some of the simultaneous equations system. In this method, variables are treated on an equal basis and no differentiation between independent and dependent variables is made ahead of time. The VAR model was created primarily for this purpose.

In time series equation $y_t = (y_{1t}, \ldots, y_{Kt})'$, at the beginning of the data processing variables, it is required to distinguish between stochastic and deterministic elements.

$$y_t = \mu_t + \chi_t \quad (2)$$

μ_t denotes error term having a linear trend. Nevertheless, χ_t denotes stochastic term that can be integrated of order 1 and is far more important as it includes a stochastic trend with a mean co-integration via VAR estimation.

Assume that procedure stochastic term is Vector autoregressive average of order p.

$$\chi_t = A_i\chi_{t-1} + \cdots . + A_p\chi_{t-p} + u_t \quad (3)$$

Coefficient matrices (K × K) are represented by A_i (i 1 to p) and $u_t = (u_{1p}, \ldots UK)'$ represents a covariance matrix with K-dimensions $E(u_t u'_t) = \sum u$ and $u_t \approx (0, \sum u)$. $A(L) = I_k - A1L - \ldots - A_pL^P$. We can rewrite the equation 3 as

$$A(L)\chi_t = u_t \quad (4)$$

We get a stable VAR procedure if;

$$\det A(y) = \det(I_k - A_{Iy} - \cdots - A_pY^p) \neq 0 for\ y \epsilon \mathbb{C}|y| \leq 1 \quad (5)$$

det A (y) is equal to zero for y equal to 1 and indicates the presence of unit root problem and the polynomial indicator's related roots are all outside the unit circle, such that approximately all variations are interconnected, therefore not stationary. Multiplication of A (L) with equation (2), $A(L)y_t = A(L)u_t + u_t$, is generated that presents y_t into the VAR lags in χ_t form. Alternatively, if $\mu_t = \mu_0 + \mu_{1t}$, $A(L)y_t = v_0 + v_{1t} + u_t$.

$$y_t = w_0 + w_1t + A_1y_{t-1} + \cdots . + A_py_{t-p} + u_tt = 1, \ldots, T \quad (6)$$

4. Results and Discussion

First, ADF unit root test is used to investigate the stationarity properties of time series variables. We fail to reject the null hypothesis of unit root at level for all of the series and found that variables are stationary at the first difference as shown in Table 1.

Table 1
ADF Unit Root Test

(level)	Intercept	Intercept and Trend
CO2	-3.302	-2.374
NR	-2.622	-4.674
EI	-3.108	-4.411
GDP	-1.490	-4.196
(first difference)		
CO2	-3.354***	-4.330*
NR	-5.891***	-2.169**
EI	-2.561***	- 4.518**
GDP	-6.055***	-3.974***

Where, *=p<0.05, ** =p=0.05 and ***= p>0.05

Since all of the series are integrated of order one, it necessary to check the long run cointegration among them. For this purpose, the Johansen Juselius cointegration test is performed to estimate the number of cointegrating equations. Table 2 shows the corresponding results. The results reveal that both maximum eigen-value values and trace statistics are insignificant at each rank. Since no cointegrating equation is found, we proceed to unrestricted vector autoregressive model

Table 2
Johansen Juselius Cointegration Test

CO2 =f (NR, EI, GDP)			
Null hypothesis	**Trace statistic**	**Critical value 5%**	**P-value**
r=0	65.347	39.818	0.310
r≤1	32.789	15.494	0.756
r≤2	28.194	29.79	0.913

H0= no cointegration

Table 3
VAR Estimations

Variables	**CO2**	**NR**	**EI**	**GDP**
CO2(-1)	-0.345***	-1.887	-2.230***	-0.195*
	(0.000)	(0.524)	(0.009)	(0.087)
CO2(-2)	-0.371***	-1.656	-1.994***	0.245***
	(0.004)	(0.379)	(0.087)	(0.008)
NR(-1)	0.590***	0.765***	-2.758	0.039**
	(0.039)	(0.033)	(0.431)	(0.057)
NR(-2)	0.231***	0.304	-4.171*	0.001***
	(0.001)	(0.987)	(0.076)	(0.048)
EI(-1)	-0.105***	0.023	-2.790***	0.005
	(0.005)	(0.567)	(0.000)	(0.024)
EI(-2)	-0.107***	0.446*	-2.571***	0.039
	(0.009)	(0.087)	(0.001)	(1.581)
GDP(-1)	0.634***	3.761***	1.965**	0.098***
	(0.098)	(0.045)	(0.056)	(0.064)
GDP(-2)	2.431	3.212***	0.753	0.199*
	(0.199)	(0.036)	(0.061)**	(0.093)

R^2 = 0.885
Adj. R^2 = 0.869
AIC Criterion = 4.867
Schwarz Criterion = 4.098
Mean dependent = 0.7606
Sum square resid = 0.0342
S.E equation = 0.0189
F-stat = 41.714
S.D dependent = 0.093
Log likelihood = 79.27

Note: *=p>0.05, **=p=0.05, ***<0.05 and parentheses contain P-value

We estimated the VAR model to understand the impact of NR, GDP, EI on CO2 emission. Two lags are used for each variable. The estimation results are provided in Table 3. High value of adjusted R^2 shows that model is good fit. It shows that 88% of the variation in dependent variable is jointly determined by explanatory variables. The value of F-statistic is also very high which shows that our model is a good fitted model. In terms of coefficients, the lags of CO2 emission are significant at 5% level indicating that current value of CO2 emission is determined by its own past value. Natural resources are indicated to be positively associated with CO2 emission. Both 1st and 2nd lag of NR are statistically significant. The empirical studies of Tauseef Hassan et al. (2021), Iqbal et al. (2022) and Hassan, Xia, Khan, et al. (2019) strongly agree with our findings.

These findings show that Pakistan is not properly employing the natural resources and is employing ineffective energy methods which are unable to reduce the country's reliance on traditional energy resources. The effect of natural resource availability on CO2 emissions in Pakistan can be attributed notably to its illegal mining and deforestation activities. Pakistan thus needs to set environmental laws in order to achieve environmental goals without jeopardizing the country's economic development. Similarly both 1st and 2nd lags of EI are statistically significant but in contrast to other variables, EI is negatively related with CO2 emission in Pakistan in line with (Y. Sun et al., 2021)(Chien, Sadiq, Nawaz, et al., 2021; Wang et al., 2020), (Amin et al., 2022) . Thus, all environmental protection (hazardous material disposal reduction), waste management (scrap elimination), pollution prevention (improved manufacturing techniques), and remedial technology procedures have a favourable impact on the environment according to our findings. We observe that GDP is positively related with CO2 emissions as the first lag of GDP is statistically significant. Our results are consistent with (Mikayilov, Galeotti, & Hasanov, 2018), (Cai, Sam, & Chang, 2018; Farhani & Rejeb, 2012) and (Wu, Zhu, & Zhu, 2018). This clearly shows that rising aggregate income has negative environmental consequences by raising carbon dioxide emissions.

4.1 Granger Causality Analysis

We applied Granger causality test to check the causal association among the variables. The causal relationships between CO2, EI, NI, and GDP are shown in Table 4 which is separated into four components.

Table 4
Granger Causality Results

	Excluded	χ^2	df	P-value
Dependent variable: CO2				
	EI	2.799235	2	0.0467
	GDP	7.179956	2	0.0276
	NR	1.335824	2	0.5128
Dependent variable: EI				
	CO2	7.364517	2	0.0252
	GDP	14.70562	2	0.0006
	NR	2.277508	2	0.3202
Dependent variable: NR				
	CO2	3.300537	2	0.1920
	EI	0.511277	2	0.7744
	GDP	2.491616	2	0.2877
Dependent variable: GDP				
	CO2	4.812484	2	0.0420
	EI	0.588666	2	0.7450
	NR	2.276841	2	0.3203

Where χ^2= chi-square distribution and df= degree of freedom

According to granger causality results, there is significant bi-directional causal association between CO2 and GDP and CO2 and EI at 5% level of significance. However, no causal association is found to exist between CO2 and NR. Unidirectional causality (from GDP to EI) is present between EI and GDP and no causal association is present between EI and NR. NR has no causal relationship with GDP, CO2 and EI.

4.2 Impulse Response Function

The response of any dynamic system in reaction to some external or internal change is referred to as the impulse response function. This is used to generate the time path of the response variable in VAR to all explanatory variables shocks. As we have four variables in our VAR model, the response can be predicted among the four variables as shown in Figure 1. Graph 1 shows the impulse response of CO2 to CO2 is positive till 6th period and declines to be negative from 6th to 10th period. Graph 2 shows that from 1st to 6th period, CO2 does not respond to any shock in EI, and its response becomes negative from 3rd to 10th period. Similarly, Graph 3 shows that CO2 responses positively to shock in GDP till 7thh period and declines from 7th to 10th period.

Graph 4 shows that impulse response of CO_2 to NR slightly increases till 4^{th} period, shows a stationary trend till 7^{th} period and then declines from 7^{th} to 10^{th} period.

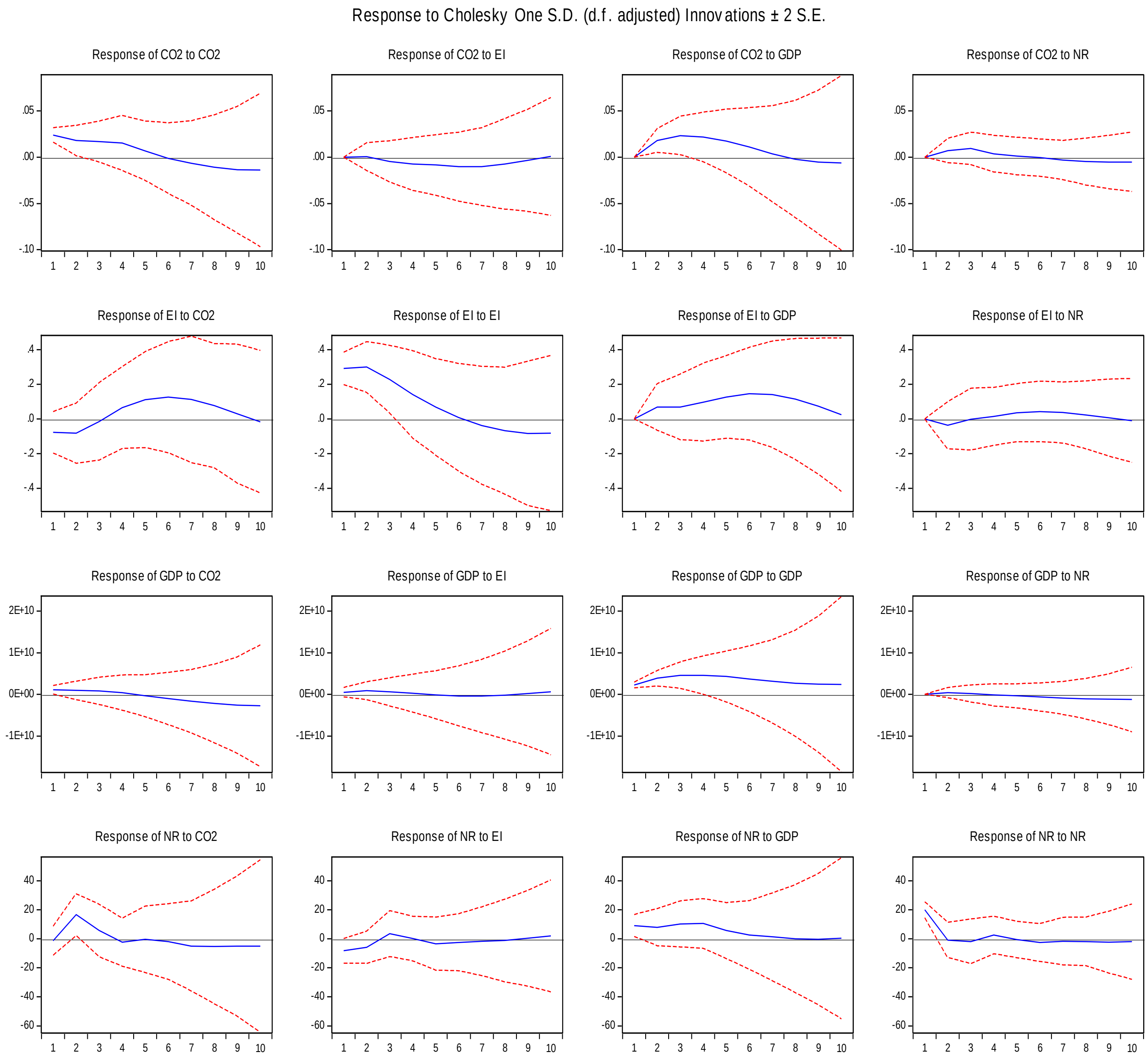

Figure 1: Impulse Response Function

4.3 Variance Decomposition Analysis

Since impulse response function only indicates the direction of the influence and not the size of the changes, we employ variance decomposition to calculate the percentage of changes due to shocks in variables in our equation system. We can now comprehend the magnitude of impact that was previously calculated in the impulse response functions. How long will the effects of GDP, EI and NR have an impact on CO_2 emission? Table 5 to 8 shows the estimated outcomes of Variance Decomposition Analysis.

Table 5
Variance Decomposition of CO2

Period	SE	CO2	EI	NR	GDP
1	0.0239	100.00	0.0000	0.0000	0.0000
2	0.0357	70.304	12.930	16.760	0.0019
3	0.0470	53.238	23.396	22.463	0.8992
4	0.0547	47.252	24.013	25.864	3.4123
5	0.0584	42.743	24.389	26.268	6.1647
6	0.0603	41.112	24.400	26.965	9.3167
7	0.0617	40.578	23.478	25.662	12.020
8	0.0633	40.479	22.439	24.589	13.057
9	0.0653	40.443	21.724	23.590	12.716
10	0.067274	39.461	21.657	22.335	11.990

Table 6
Variance Decomposition of NR

Period	SE	CO2	EI	NR	GDP
1	23.465	0.3725	99.627	0.0000	0.0000
2	30.366	29.942	61.553	3.1222	5.3813
3	32.789	28.584	52.898	13.890	4.6198
4	34.605	26.158	50.687	18.956	4.2007
5	35.231	25.248	49.598	19.584	5.5690
6	35.565	25.081	48.678	19.597	6.6428
7	36.029	26.399	47.442	19.173	6.9854
8	36.496	27.893	46.330	18.685	7.0898
9	36.929	29.149	45.627	18.263	6.9593
10	37.371	30.248	44.926	17.994	6.8301

Table 7
Variance Decomposition of EI

Period	SE	CO2	EI	NR	GDP
1	2.509	17.647	7.3564	74.995	0.000
2	4.809	8.8470	12.215	78.814	0.122
3	6.709	6.052	12.957	80.749	0.240
4	8.209	4.368	12.538	82.118	0.973
5	9.269	3.534	12.060	82.209	2.1953
6	1.010	4.009	11.339	80.982	3.6687
7	1.070	5.908	10.341	78.868	4.8812
8	1.130	9.103	9.302	76.142	5.4513
9	1.190	12.914	8.391	73.277	5.4165
10	1.250	16.454	7.644	70.871	5.0304

Table 8
Variance Decomposition of GDP

Period	SE	CO2	EI	NR	GDP
1	0.3017	6.6222	11.597	11.024	70.755
2	0.4398	6.5562	11.664	21.030	60.749
3	0.5007	5.1400	10.201	24.207	60.450
4	0.5332	6.0568	8.992	27.439	57.511
5	0.5647	9.3108	8.9595	29.631	52.098
6	0.5982	12.695	10.271	30.614	46.417
7	0.6271	14.758	11.870	30.634	42.736
8	0.6462	15.297	13.046	30.169	41.486
9	0.6563	15.030	13.581	29.535	41.852
10	0.6622	14.823	13.554	29.008	42.613

In Table 5, the shock in CO_2 emissions has a progressive effect over time. 1^{st} period has the greatest and maximum effect of 100 percent. After that, it gradually decreases and reaches a minimum value of 39 percent in the 10^{th} period. In the beginning, shocks in eco innovations have no impact on CO_2 emissions. Their influence begins in the second period with a value of 12 percent, that steadily grows till 6^{th} period and then progressively decreases to 21 percent in the 10^{th} period. Similarly, there is no influence of any NR shock in 1st period. Its impact begins in the 2nd period with a value of 16 percent, rises to 26 percent in the fifth period, and then drops to 22 percent in the tenth period. Moving on to GDP, it has a minimal 0.16 percent influence on CO_2 in period 2, but the intensity of the impact is steadily increasing. The greatest value of 13 percent is obtained in the 8^{th} period, followed by a decline of 11 percent in the 10^{th} period.

5. Conclusion and policy Recommendations

Different factors of environmental pollution are highlighted in the literature, but the relationship of natural resources with environmental sustainability has not been explored extensively. Therefore, the present study is an attempt to estimate the relationship of natural resources, eco innovations and GDP with CO_2 emissions in Pakistan over 1990 to 2019 period. To our best knowledge, the current study is the first one that estimated the effect of eco-innovations on the environmental quality in the context of Pakistan. After checking the order of integration and long run cointegration by applying ADF test and Johansen Juselius Cointegration test respectively, VAR model and Impulse Response Function, Granger Causality and variance Decomposition analysis are used to understand the relationship between the variables. Natural resources and GDP are positively related while eco-innovations are negatively related with CO_2 emission in Pakistan in VAR estimation. Granger Causality Analysis provides the evidence for bidirectional association between CO_2 emission and GDP and between CO_2 and EI. According to the Variance Decomposition Analysis, nearly 21% of future fluctuations in CO_2 emissions are related to shocks in the EI, 22% are related to shocks in NR and 11% are related to shocks in GDP. The forecasted effects of EI, NR and GDP on future CO_2 emissions are given by Impulse Response Function.

The study has a number of policy recommendations on the basis of the estimation findings. The government of Pakistan should urge people to adjust their consumption behavior to regulate natural resource exploitation, deforestation, land devastation, fishing, and preservation of pasture land. When it comes to natural resources illegal mining and deforestation activities are frequent in the country. Therefore, increased awareness and rigorous restrictions are needed to keep these illegal operations in check. Government must also rethink the process of registration (that small scale miners go through) and make it easy for them to obtain the necessary permits. Decision-makers must maintain a balance between demand and supply for natural resources and CO_2 by public awareness of environmental issues, education, safety, science and technology, workshops, seminars and vocational training. Regarding the positive contribution of eco-innovation in decreasing CO_2 emissions, more awareness and training campaigns in the country should be started to highlight the importance of eco innovations combined with methods to encourage reduced resource use. Policymakers should make plans to promote ecological benign technologies. The government must establish new businesses and encourage research and development in ecological technologies that are proved as an important factor for curbing CO_2 emission. Government officials should collaborate with the private sector to establish creative programs in this area. Efficient policies are necessary to implement in order to encourage businesses to adopt environmentally friendly practices, while investors must be encouraged to support companies that are taking significant steps to reduce their negative externalities by implementing ecological innovations.

This study focuses on Pakistan only. Future researches can replicate these estimations for different resource abundant countries like China, India, Brazil etc. Different groups of countries e.g. BRICS, G-7, N-11, ASEAN can also be considered as focus area in future researches. On methodological aspects, different time series estimations including ARDL, QARDL, FMOLS, DOLS etc, can be used for analysis purpose. Moreover, researchers are suggested to enrich the study model by adding more relevant variables such as financial development, financial innovations, energy consumption etc, which will eliminate omitted variable bias to provide more comprehensive insight.

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