Renewable and nonrenewable energy consumption, real GDP and CO2 emissions nexus: a structural VAR approach in Pakistan

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Renewable and Nonrenewable Energy Consumption, Real GDP and CO_2 Emissions Nexus: A Structural VAR Approach in Pakistan

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Abstract:
Any rise in real GDP crafts higher energy demand in Pakistan. This short-term rising energy requirement is fulfilled with the help of nonrenewable and renewable energy consumption, but nonrenewable energy consumption adds more in it. The rise in nonrenewable energy consumption lifts real GDP up in short-run. Forecast error variance decomposition illustrates nonrenewable energy consumption alone passes 87% variation in the CO_2 emissions. This verifies fossil fuels are accountable for environmental degradation in Pakistan. The CO_2 emissions worsen economic activity, real GDP falls but renewable energy consumption augments. This elevation in renewable energy consumption is the proof of stabilization efforts that are being initiated by official authorities as CO_2 emissions reach to alarming level. The rise in renewable energy consumption boosts economic activity, and real GDP breeds. Most of times, an increase in renewable energy consumption is an effort to substitute it with nonrenewable energy consumption, resulting in lower level of CO_2 emissions.

Keywords: Energy Consumption, Real GDP, CO_2 Emissions

Introduction

The objective of this pioneering effort is to investigate the dynamic relationships between renewable (R) energy consumption, nonrenewable (NR) energy consumption, real GDP (Y) growth and CO_2 (C) emissions in case of Pakistan. The importance of clean and sustainable environment was recognized by both developing and developed worlds in the arbitration of the Kyoto Protocol in 1997. The main aim of this Protocol was to reduce Greenhouse gas emissions (GHGs) by 5.2 % from the level of the 1990 over the period of 2008-2012. The special focus to control CO_2 emissions considered as main source of global warming. Latter on, Halicioglu (2009) pointed out that the worldwide contribution of carbon dioxide emissions to GHGs is 58.8%. However, it was unable to resolve the environmental issues in an appropriate manner and came up with a judgmental and adequate roadmap (Sathaye et al. 2006). Nevertheless, the protocol accepted renewable energy sources (RES) as one of the key solutions to climate change and to the increasing energy demand. This threat of global warming attracted researchers to pay their attention in alleviating its effects and suggesting other sources of energy to meet the rising demand to sustained economic growth rate. Global warming depends on worldwide GHGs emissions but the nastiest effects are faced by developing and populous countries[1], of course they are not main culprit. There is no grantee that use of renewable energy will lead economic growth with rapid speed (Tiwari, 2011a).

However, Domac et al. (2005) and Chien and Hu (2007) suggested that renewable energy consumption might boost economic growth by increasing macroeconomic efficiency in an economy[2]. Apart from that, Masui et al. (2006) argued that the climate change issue could be solved by adopting environment friendly technologies, improving energy efficiency, forest conservation, reforestation, water conservation, or energy saving etc. This implies that exploration of renewable energy sources is another accepted way to mitigate CO_2 pollutants. But, Krewitt et al. (2007) pointed out that renewable energy sources could provide as much as half of the world's energy needs by 2050 in a target-oriented scenario to prevent any dangerous anthropogenic interference with the climate system. Moreover, Abulfotuh (2007) suggested that one possible solution to the environmental risks brought by the accelerating demand for energy is to consider immediate change in the composition of an energy resource portfolio. It is expected that renewable energy sources had great potential to solve a major part of global energy sustainability.

We use structural break unit test developed by Clemente et al. (1998) and long run relationship between the variables is investigated by autoregressive distributive lag model (ARDL) or bounds testing approach to cointegration. A structural vector autoregressive (SVAR) developed by Blanchard and Quah (1989) is used to test the dynamic relationship between renewable energy consumption, nonrenewable energy consumption, economic growth and CO_2 emissions.

The rest of paper is organized as follows: section-II discusses energy consumption scenario in Pakistan, section-III deals with review of literature, section-IV describes methodological framework, section-V interprets empirical results and conclusion and policy implications are drawn in section-IV.

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[1] Stern et al. (2006) emphasized that the radical change in temperatures would affect all economies disregarding the nature of the economy.

[2] This either might be due to the expansion of business and new employment opportunities brought by renewable energy industries or through the import substitution of energy, which has direct and indirect effects on the increase of an economy's GDP and/or trade balance.

II. Pakistan Context:

Energy demand is gratified with the help of renewable and nonrenewable energy consumption in Pakistan. Data revealed inconsistency in the energy consumption and economic growth in 70s and mid 80s. This situation compelled the concerned authorities for taking some initiatives to overcome the energy deficit. For some time, there was sustained growth in the economic activity and energy consumption, but the late 2000s again exhibited the inconsistent relationship between economic growth and energy consumption. One of the possible reasons for this misfortune might be the circular debt in energy sector of Pakistan. PEPCO, Shell, oil marketing companies and many independent power producers owed Rs. 485 billion to oil suppliers in December, 2009 (Ali and Badar, 2010). Since oil has most of the share in the fossil fuels, it resulted in inconsistent flow of the energy in the production activities and worsened economic growth, see Figure-a.

Government of Pakistan took initiative for the promotion of renewable energy consumption in 1974. The prime objective was the substitution of the fossil fuels with renewable energy. Data discloses renewable energy consumption had strong correlation with economic growth in 70s, 80s and up to mid 90s. Subsequent period perceived no serious concern by the officials for the utilization of this huge energy potential. The situation became devastating in late 2000s, for both the sources of energy, renewable as well as nonrenewable energy, were meandering downward. Lack of funds might be one possible reason for this unfortunate situation. The severe financial problems made renewable energy plants difficult to operate in 1990s, especially all the biogas projects were closed (Khalil and Mirza, 2005), see Figure-b.

Nonrenewable energy consumption and CO_2 emissions were correlated significantly throughout the period of analysis. That fact is consistent with the literature that fossil fuels play the major role in polluting the environment, see Figure-c. Rise in renewable energy consumption upshots the mounting CO_2 emissions, most of the times, and vice versa. Finally, renewable energy consumption and CO_2 emissions were uncorrelated, see Figure-d. There might be a number of possibilities behind it, but one it evident. Pakistan fulfills, more than 99% of, its energy requirement with fossil fuels (Sheikh, 2010), while renewable energy contribute just less than 1% of our energy requirements. As the share of renewable energy consumption is very small in total energy consumption that is why it cannot deal significantly with CO_2 emissions.

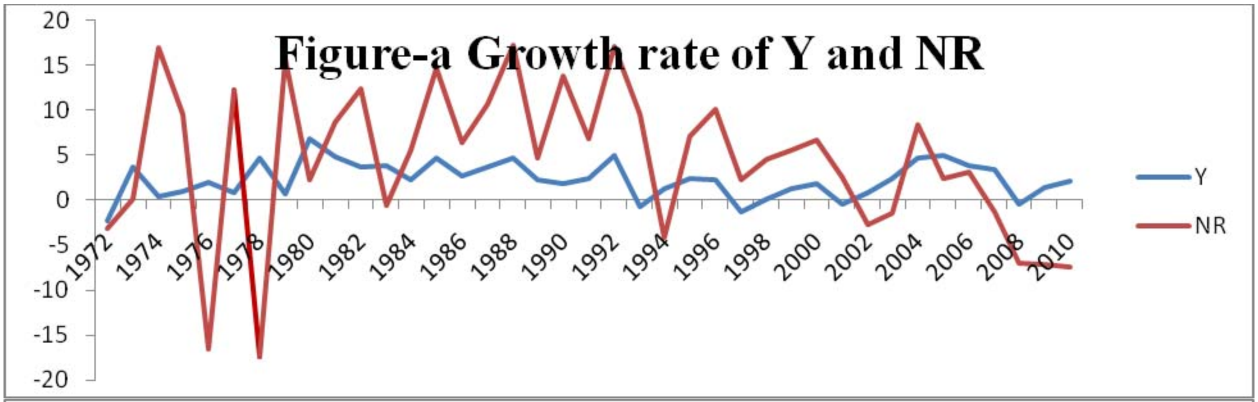
Figure-a Growth rate of Y and NR
Y
NR

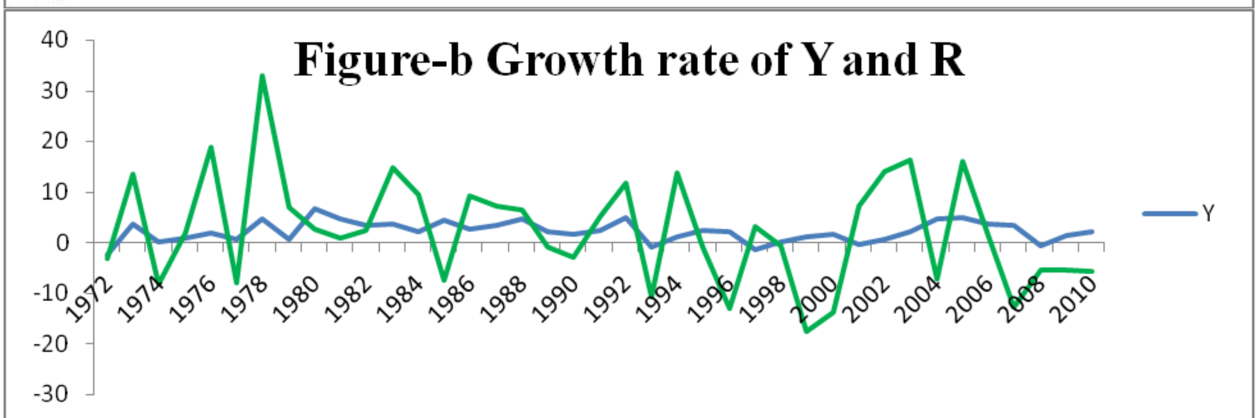
Figure-b Growth rate of Y and R
Y

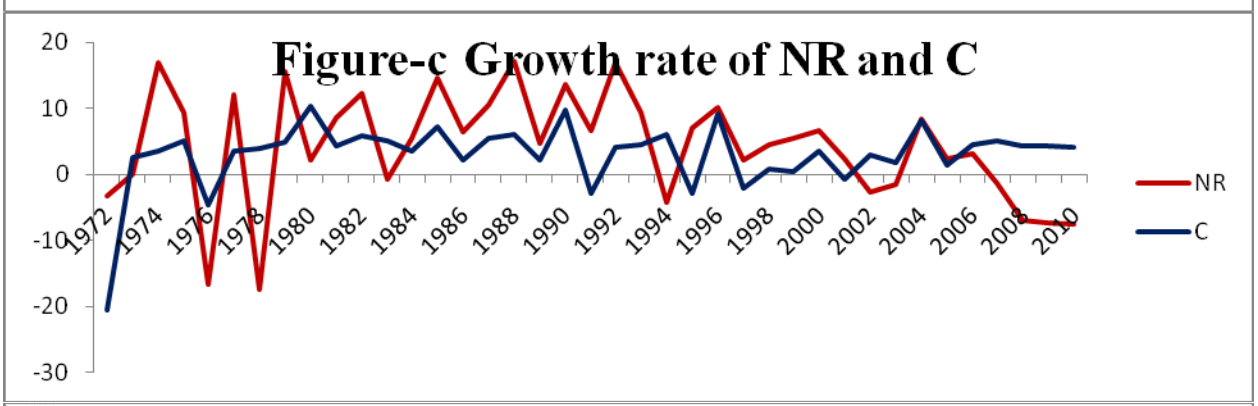
Figure-c Growth rate of NR and C
NR
C

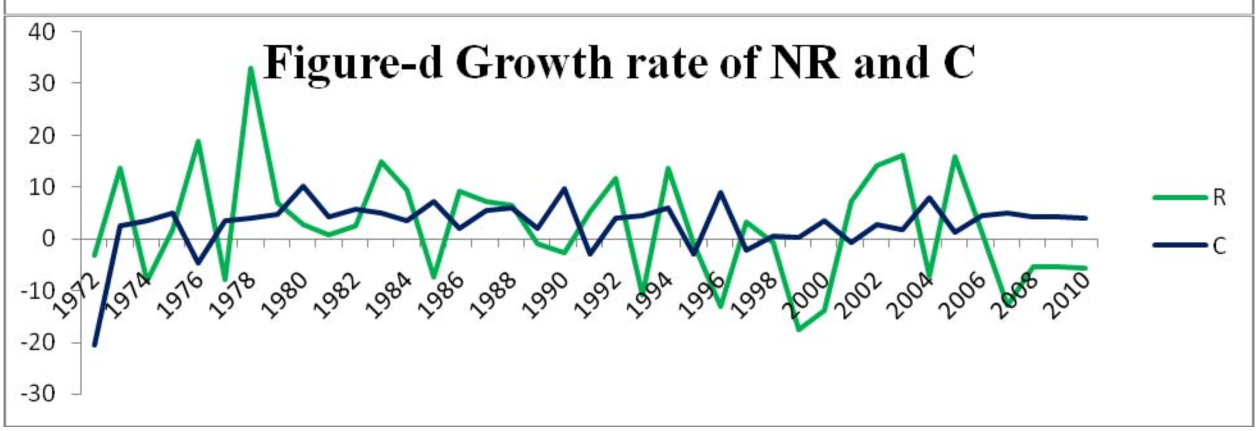
Figure-d Growth rate of NR and C
R
C

III. Lietraure Review

Energy literature provides various studies investigating the dynamics of relationship between energy consumption and economic growth using either bivariate or multivariate framework. But studies analyzing the relationship between renewable and non-renewable energy consumption and economic growth are comparatively few. Our focus is to present literature review describing the relationship between renewable energy consumption, non-renewable energy consumption, and economic growth. The finings seem to suggest us to divide studies into four categories or groups.

First group deals with energy-led-growth hypothesis, for example, Yang (2000) concluded that natural gas Granger causes economic growth in case of Taiwan. In case of Shanghai, Wolde-Rufael (2004) investigated causal relationship using disaggregated energy consumption and economic growth. The empirical results reported that economic growth was Granger caused by coal, coke, electricity, and total energy consumption[3]. Awerbuch and Sauter (2006) reported that renewable energy consumption affected positively the economic growth but Ewing et al. (2007) concluded that impact of nonrenewable energy consumption like coal, gas and oil was larger on economic growth as compared to renewable energy consumption. Using data of 116 countries, Chien and Hu (2008) concluded that renewable energy consumption stimulated economic growth by promoting capital formation. In case of Iran, Lotfalipour et al. (2010) used data on economic growth, carbon emission, and fossil fuels consumption to investigate direction of causal relationship between the variables applying Toda-Yamamoto causal approach. Their results indicated unidirectional casual relationship running from gas consumption to economic growth[4]. Recently, Tiwari (2011e) investigated link between renewable energy consumption, CO_2 emissions and economic growth using structural vector autoregressive (SVAR) approach for Indian economy and found energy-led-growth hypothesis. Furthermore, Tiwari (2011a) considered relationship between renewable energy consumption, nonrenewable energy consumption and economic growth using data of European and Eurasian countries. The results showed renewable energy consumption led economic growth but nonrenewable energy consumption had negative effect on economic growth and increase CO_2 emissions.

On contrary, empirical evidence regarding unidirectional causality running from economic growth to energy consumption also exists. For instance, Yang (2000) reported that economic growth Granger caused oil consumption in case of Taiwan. In case of USA, Sari et al. (2008) concluded that industrial production and employment were the key determinants of fossil fuel, hydro, solar, waste and wind energy consumption. Sadorsky (2009a) investigated effect of renewable energy consumption i.e. geothermal, wind and solar power, waste and wood on economic growth and CO_2 emissions and oil price in case of G7 countries and concluded that economic growth led renewable energy consumption[5]. Moreover, Sadorsky, (2009b) concluded that economic growth had significant effect to increase the demand of renewable energy consumption in case of 18 emerging countries.

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[3] Sari and Soytas (2004) found unidirectional causality running from lignite, waste, oil, and hydropower to economic growth.

[4] Shahbaz et al. (2010) investigated relationship between CO_2 emissions, energy consumption and economic growth in case of Pakistan and concluded that economic growth and energy consumption had positive impact on CO_2 emissions.

[5] Oil prices had a smaller and negative effect on renewable energy consumption. In the short term, movements drove variations in renewable energy consumption back to the long-term equilibrium rather than short term shocks.

The feedback hypothesis reveals that energy consumption Granger causes economic growth by stimulating economic activity and in resulting, economic growth raises the demand of energy. So, empirical studies such as Yang (2000) concluded that feedback hypothesis was validated between energy consumption and economic growth in case of Taiwan. Apergis and Payne (2010) investigated causality between renewable energy consumption and economic growth using multivariate framework by capital and labor. Their results showed long run relationship between the variables and bidirectional causal relationship existed between renewable energy consumption and economic growth.

The fourth group deals with neutral hypothesis between economic growth and energy consumption (aggregate or disaggregate level). For example, Wolde-Rufael (2004) reported no causality between oil consumption and economic growth. As well as, Payne (2009) found that there was no causal relation between renewable and nonrenewable energy consumption, and economic growth in case of USA. Apart from that, Menegaki (2011) used multivariate panel framework to investigate causal link between renewable energy consumption and economic growth and found no causality between the variables in 27 European countries.

IV. Methodological Framework

Lucas (1976) critique came with devastating effects on the disciples of econometrics; it seemed as if there was no future for this profession. However, time is subject to continuous change. Soon after this critique, Sims (1980) came into the sight with the Vector Autoregression (VAR) framework. Introduction of VAR at this crucial time ended in much support to the dwindling profession of econometrics, it imparted an initiation to the modern prophecy. Recursive VAR requires $\frac{(n^2-n)}{2}$ restrictions to design a possible identification scheme, formally known as Cholesky decomposition. This method of decomposition was commented an adhoc proposal by critics, for these restrictions bear no economic justification. This rebirth was not sufficient enough to overcome all the problems, there were critiques on this methodology as well (Sargent 1979, 1984; Learner 1985).

With the passage of time, further grafting fitted it into the possible estimation of the structural VAR (Sims, 1986; Bernanke, 1986; Blanchard and Watson, 1986). This suggested imposing restrictions originating from the theory rather than from some adhoc proposal. Later one, Blanchard and Quah (1989) earned much fame for introducing the long-run restrictions to estimate a structural VAR model; their work was also based on theoretical basis rather than some adhoc proposition. It presumed orthogonal structural shocks, normalized to unit variance, and the presence of at least such a structural shock that could have no long-run effect. For this purpose, it decomposed the series into their temporary and permanent components. It can be elaborated as; let there are two matrices of variables in the system ‘x’ and ‘y’ such that the former one is a matrix of nonstationary variables, whereas the later one is a matrix of stationary variables. In addition, the ‘x’ is I (1). As this practice is mainly concerned with the ‘y’ matrix, so it divides the integrated series into its short-run and long-run components. Avoiding the intercept terms for notational convenience, the moving average representation in the compact form becomes:

$$\begin{bmatrix} \Delta x_t \\ y_t \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \qquad (1)$$

Where ε_{it} stands for the white noised disturbances and each disturbance has a constant variance, $C_{ij}(L)$ are the polynomials in the lag operator L. Time subscripts of variance and covariance have been omitted for notational expediency, and shock are normalized such that each shock have a unit variance. The variance covariance matrix of pure these innovations are as:

$$\sum_{\varepsilon} = \begin{bmatrix} \text{var}(e_1) & \text{cov}(e_1, e_2) \\ \text{cov}(e_1, e_2) & \text{var}(e_2) \end{bmatrix} \quad (2)$$

$$\sum_{\varepsilon} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad (3)$$

In their original work, Blanchard and Quah (1989) split the integrated variables in their temporary and the permanent component and assume a shock transports no impact on the real GNP in long-run. This procedure inherits a well defined theoretical background for the structural identification of the VAR system. In the present perspective, if a shock is introduced in the system, it would have no long-run impact on the impulse responses of the all the variables in 'x' matrix. It turns into:

$$\sum_{k=0}^{\infty} c_{11}(k)\varepsilon_{1t-k} = 0 \quad (4)$$

$$\sum_{k=0}^{\infty} c_{11}(k) = 0 \quad (5)$$

Blanchard and Quah (1989) bivariate SVAR is criticized for its provincial application (Faust and Leeper, 1997). In Pakistan, Haider et al. (2008) extended it for three variables, while the present study endeavors to go ahead for four variables: real GDP, renewable energy consumption, nonrenewable energy consumption and the CO_2 emissions. Keeping in view the issue of global warming and the subsequent efforts for the substitution of the renewable energy consumption with the nonrenewable energy consumption, it supposes renewable energy consumption is going to be utilized to satisfy the energy requirements, and neither it will result in higher consumption of nonrenewable energy consumption nor it fetch higher level of CO_2 emissions in the environment in the long-run. Current rise in the renewable energy consumption will not turn out in higher future consumption of fossil fuels. Finally; as CO_2 emissions will not ensure the economic prosperity but economic catastrophe, so the mounting level of CO_2 emissions daunts the mounting nonrenewable energy consumption in the long-run. The above mentioned restrictions identify our SVAR.

V. Results and their Discussions

The traditional unit root tests such ADF, P-P, DF-GLS, KPSS, Ng-Perron provide inappropriate and inconsistent results either variables are integrated at I(0) or I(1). Moreover, these tests do not have information about break occurring in the series. To avoid such spuriousness, we used Clemente et al. (1998) structural break unit root test. The results are reported in Table-1 revealing that the variables have unit root problem at their level form and results show that all the variables are found stationary at their 1st differenced form. This leads us to apply ARDL bounds testing approach in investigating long run relationship between the variables[6].

[6] The ARDL bounds testing approach to cointegration is preferred over traditional cointegration analysis techniques because it can be applied regardless of whether the variables are integrated of order I(0) or integrated of order I(1)

Table-1: Clemente-Montanes-Reyes Detrended Structural Break Unit Root Test

Variable	Innovative Outliers				Additive Outlier			
	t-statistic	TB1	TB2	Decision	t-statistic	TB1	TB2	Decision
$\ln Y_t$	-4.067(2)	1978	2002	I(0)	-5.939(3)*	1991	2000	I(1)
$\ln R_t$	-3.102 (3)	1976	2000	I(0)	-6.777 (2)*	1994	2001	I(1)
$\ln NR_t$	-1.701 (3)	1986	2003	I(0)	-6.714(2)*	1983	2006	I(1)
$\ln C_t$	-2.047 (2)	1978	2002	I(0)	-11.047(3)	1978	2002	I(1)
Note: * and ** indicates significant at 1 and 5 per cent level of significance. Lag order is shown in parenthesis								

Table-2: Bounds Testing Analysis

Estimated equation	$F_{C_t} = (C_t / N_t, NR_t, Y_t)$	
F-statistics	16.735[a]	
Optimum lag order	(1, 1, 1, 0, 1)	
Significant level	Critical values (T = 40)[b]	
	Lower bounds, $I(0)$	Upper bounds, $I(1)$
1 per cent	7.763	8.922
5 per cent	5.264	6.198
10 per cent	4.214	5.039
Diagnostic tests	Statistics	
R^2	0.8309	
Adjusted-R^2	0.6885	
J-B Normality	1.3840 (0.5000)	
Breusch-Godfrey LM	0.5433 (0.5905)	
ARCH LM	0.2881 (0.6080)	
Ramsey RESET	0.3640 (0.5537)	
Note: [a] Significant at 1 per cent level. [b] Critical values bounds are computed by surface response procedure by Turner (2006).		

The two step procedure of ARDL bound test requires lag length of variables. Based on the minimum value of Akaike Information Criteria (AIC), the optimum lag order is (2, 2, 2, 1). The results are reported in Table-2. The F-statistic is greater than UCB infers that there is cointegration among the variables over the study period 1971-2010. The diagnostic tests show the validity of the estimation in the model.

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and it has better results for small data sample. In addition, unrestricted error correction is derived from ARDL model using simple linear specification which integrates both long run as well as short run dynamics. The UECM model does not seem to lose information about long run relation.

Analysis of the Forecast Error Variance Decomposition:

Forecast error variance decomposition test spells out shocks to renewable and the nonrenewable energy are responsible for the most of the variation in the real output. These shocks bring about a combined 85 percent variation in it. Any shock to the CO_2 emissions or the real GDP itself has a very small contribution in the total variation. After a period of four years; renewable energy consumption, nonrenewable energy consumption, real GDP itself and the CO_2 emissions are stable and the system is convergent, finally they bring 44%, 20%, 20% and 5% variation in the real GDP respectively.

Table-4: Variance Decomposition Approach (VDA)

Horizon	**Variance Decomposition of** $\ln Y_t$				**Variance Decomposition of** $\ln R_t$				**Variance Decomposition of** $\ln NR_t$				**Variance Decomposition of** $\ln C_t$			
	$\ln Y_t$	$\ln R_t$	$\ln NR_t$	$\ln C_t$	$\ln Y_t$	$\ln R_t$	$\ln NR_t$	$\ln C_t$	$\ln Y_t$	$\ln R_t$	$\ln NR_t$	$\ln C_t$	$\ln Y_t$	$\ln R_t$	$\ln NR_t$	$\ln C_t$
1	8.91	50.17	35.24	5.66	5.30	44.97	6.87	42.84	51.88	41.05	2.04	5.02	8.25	1.55	87.01	3.17
2	17.35	45.51	31.47	5.65	6.57	44.98	6.53	41.91	45.51	47.60	3.34	3.54	7.50	4.13	80.83	7.53
3	19.73	44.51	30.11	5.61	6.85	45.20	6.86	41.07	45.88	45.16	3.59	5.35	7.40	4.56	80.17	7.85
4	20.46	44.04	29.71	5.72	6.92	45.07	6.90	41.09	45.97	45.03	3.75	5.24	7.38	4.66	80.03	7.91
5	20.70	43.92	29.59	5.79	6.95	45.07	6.91	41.04	46.04	44.83	3.75	5.36	7.37	4.68	80.00	7.93
6	20.77	43.88	29.55	5.79	6.96	45.06	6.91	41.04	46.07	44.82	3.75	5.35	7.37	4.69	80.00	7.93
7	20.79	43.87	29.54	5.79	6.97	45.06	6.91	41.04	46.08	44.79	3.75	5.36	7.37	4.69	80.00	7.93
8	20.80	43.86	29.53	5.79	6.97	45.06	6.91	41.04	46.08	44.79	3.75	5.36	7.37	4.69	80.00	7.93
9	20.80	43.86	29.53	5.79	6.97	45.06	6.91	41.04	46.08	44.79	3.75	5.36	7.37	4.69	80.00	7.93
10	20.80	43.86	29.53	5.79	6.97	45.06	6.91	41.04	46.08	44.79	3.75	5.36	7.37	4.69	80.00	7.93

Renewable energy consumption and the CO_2 emissions are responsible for most of the variation in renewable energy consumption; they pass a combine variation of 87% in it. This analysis brings to light the response of the officials to the rising level of CO_2 emissions in the environment; change in CO_2 emissions is followed by the variation in the renewable energy consumption that is a good indicator towards our environmental responsibilities for clean environmental efforts. Furthermore, real GDP and the nonrenewable energy consumption brings in about 5% and 6 % variation in it and this composition doesn't change much throughout the period of analysis. The shocks in the real GDP and the renewable energy consumption are responsible for most of the variation in the nonrenewable energy consumption; they constitute 51% and 41 percent of the total variation respectively. The remaining variation in the nonrenewable energy consumption is caused by the nonrenewable energy consumption and the CO_2 emissions that is 2% and 5% respectively. This composition varies after the period of one year and then it converges for the entire period of analysis. The final composition of the variation is 45%, 47%, 3% and 3.5% for real GDP, renewable energy consumption, nonrenewable energy consumption and the CO_2 emissions respectively.

The shocks in the real GDP and the renewable energy consumption are responsible for most of the variation in the nonrenewable energy consumption; they constitute 51% and 41 percent of the total variation respectively. The remaining variation in the nonrenewable energy consumption is caused by the nonrenewable energy consumption and the CO_2 emissions that is 2% and 5% respectively. This composition varies after the period of one year and then it converges for the entire period of analysis. The final composition of the variation is 45%, 47%, 3% and 3.5% for real GDP, renewable energy consumption, nonrenewable energy consumption and the CO_2 emissions respectively. Nonrenewable energy consumption passes the most of the variation to the CO_2 emissions; it alone carries 87% variation in the CO_2 emissions. All other shocks; the real GDP, renewable energy consumption and the CO_2 emissions transport 8%, 1.5 % and 3% variation in it. The composition of this variation is readjusted after one year time span and then converges at 7.5%, 4%, 80.8% and 5.5% for the shock of real GDP, renewable energy consumption, nonrenewable energy consumption and CO_2 emissions, for further details please see the Table-4.

Results of the Blanchard and Quah SVAR:

A surprising rise in real income creates higher energy demand. This short-term rising energy requirement is fulfilled with the help of nonrenewable energy consumption as well as renewable energy consumption. It is evident, however, that most of the energy requirements are contented with the help of nonrenewable energy consumption in Pakistan, see Figure-1. Forecast error variance decomposition has already assured, renewable and the nonrenewable energy consumption donate 50% and 35% in the total variation in the real GDP. Moreover, it also marks renewable energy consumption puts more in the total variation (see Figure-1 in Appendix).

An unforeseen ascending in the nonrenewable energy consumption lifts the real GDP up in the short-run, whereas the renewable energy consumption plummets initially. This initial drop in the renewable energy consumption implies the substitution of the nonrenewable energy consumption with the renewable energy consumption; this relation becomes stable after some time. The central point in this scenario is the mounting level CO_2 emissions (see Figure- 2 in Appendix). This verifies fossil fuels are accountable for the environmental degradation in Pakistan. In addition, the forecast error variance decomposition of CO_2 emissions reports nonrenewable energy consumption is liable for the 87% variation in CO_2 emissions. Thus, short-run rise in nonrenewable energy consumption resulting from the economic progress brings the huge implicit social loss to the economy.

Any startling improvement in the renewable energy consumption boosts the economic activity, and the real GDP breeds. Most of the times, an increase in the renewable energy consumption is an effort to substitute this source of energy with the nonrenewable energy consumption which results in the lower consumption of the nonrenewable energy; resultantly, there is fall in the CO_2 emissions as well (see Figure-3 in Appendix). This fact is also supported with the findings of the forecast error variance decomposition; a one standard deviation shock to the renewable energy consumption brings 41% variation in the nonrenewable energy consumption and just 1.5% variation in the CO_2 emissions.

The escalating pollution in the environment is responsible not only for the environmental degradation but also for the lower level of economic growth. An unexpected shock to the CO_2 emissions worsens the economic activity, real GDP falls but the renewable energy consumption augments. This elevation in the renewable energy consumption is the proof of stabilization efforts that are being initiated by the official authorities as the CO_2 emissions reach to alarming level (see Figure-4 in Appendix). This fact is reinforced by the forecast error variance decomposition for a shock in the CO_2 emissions conveying 42.8% of the variation in the renewable energy consumption.

VI. Conclusions and Policy Implications

Forecast error variance decomposition analysis reveals shocks to renewable and the nonrenewable energy are responsible for the most of the variation in the real GDP. These shocks bring about a combined 85% variation in it. The shocks in the real GDP and the renewable energy consumption are responsible for 51% and 41% variation in nonrenewable energy consumption respectively. Nonrenewable energy consumption passes the most of the variation to the CO_2 emissions; it alone carries 87% variation in the CO_2 emissions and a shock to CO_2 emissions is responsible for 42.8 % variation in renewable energy consumption. All these findings convey there is strong correlation among the series under analysis. To find the nature of this correlation, it exercises Blanchard and Quad Structural Vector Auroregressive framework for having meaningful structural inferences. Basically, this study is an effort to extend the bivariate Blanchard and Quah (1989) SVAR to a 4 variable structure.

Impulse responses portray any unexpected rise in real GDP crafts into higher energy demand. This short-term rising energy requirement is fulfilled with the help of nonrenewable energy consumption as well as renewable energy consumption in Pakistan; nonetheless, most of the share comes from nonrenewable energy consumption. Although the rise in nonrenewable energy consumption lifts the real GDP up in the short-run, but dependence on this source of energy is also a social gaffe, for it is responsible for 87% variation in the CO2 emissions. One point is crystal clear, it is the nonrenewable energy consumption that pollutes environment the most and fossil fuels are accountable for the environmental degradation in Pakistan.

The CO_2 emissions worsen the economic activity; real GDP falls, but the renewable energy consumption augments. The rise in the renewable energy consumption is the evidence of stabilization efforts initiated by the officials to encounter the escalating level CO_2 emissions. It also lowers the level of CO_2 emissions in environment. Although at this time, the rise in renewable energy consumption cannot boost the economic activity as much as the nonrenewable energy can, but there is always a trade-off. This substitution would secure us against the future shocking threats of global warming and rising temperature.

Pakistan is in the middle of energy crisis, situation is getting worse for our energy demand is also rising and the supplies are stagnant. There is a dire need of new and sustainable avenues of energy sources for the development for the economic and the social uplift. Along with the domestic consumption of the fossil fuel, Pakistan is heavily dependent on the imported oil which is responsible for the huge deficits in the current account deficits and raising our debt burden day by day. Although it is blessed with plenty of natural resources but they are unutilized, yet conventional energy is meets most of the energy requirements. Renewable energy is not much utilized yet; Pakistan fulfills less than 1% of its energy requirements from renewable energy consumption, it is recommended to make this source of energy useful and operational. This energy not only can fulfill our energy needs but also lessen the environmental degradation. Research finds that:

Pakistan is situated on the high wadding belt, having the comparative advantage in solar energy production, but its use is provincial. The coastal belt of Singh and Baluchistan and the some deserted area in Punjab and Singh contain huge potential for the wind power. 60 km wide and 180 km long corridor of the coastal belt can generate 50,000 MW of the energy. Waterfalls in Northern areas have the potential of 300 MW of hydel energy. Punjab has a vast canal networks, having 300 such sites which can produce 350 MW of this energy. Assuming a 50 percent collectability of the animal dung in Pakistan, biogas plants can generate 17.25 million cubic meters of biogas daily which is sufficient for cooking arrangement of 50 million people. Unfortunately, all these energy resources are needed to unearth and operational.

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Appendix-A

Figure-1 Shock to D(Ln Y, Shock 1)

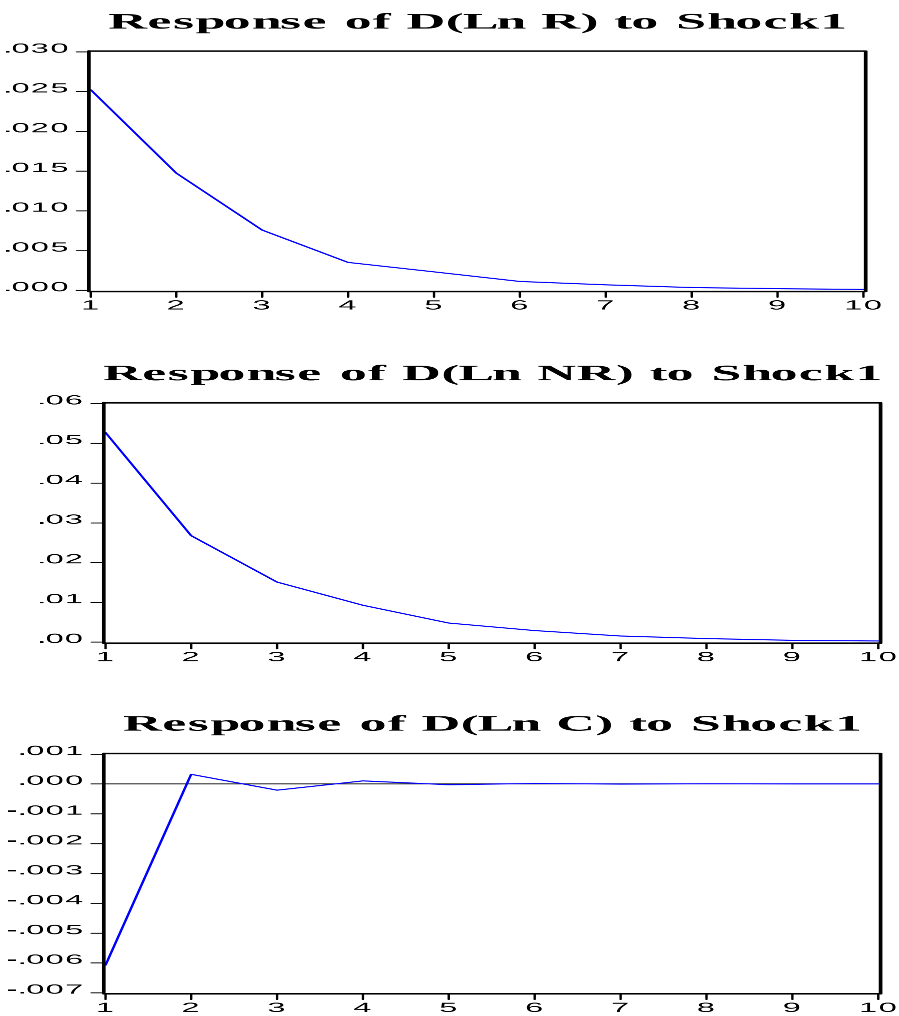


Figure-2 Shock to D(Ln NR, Shock 3)

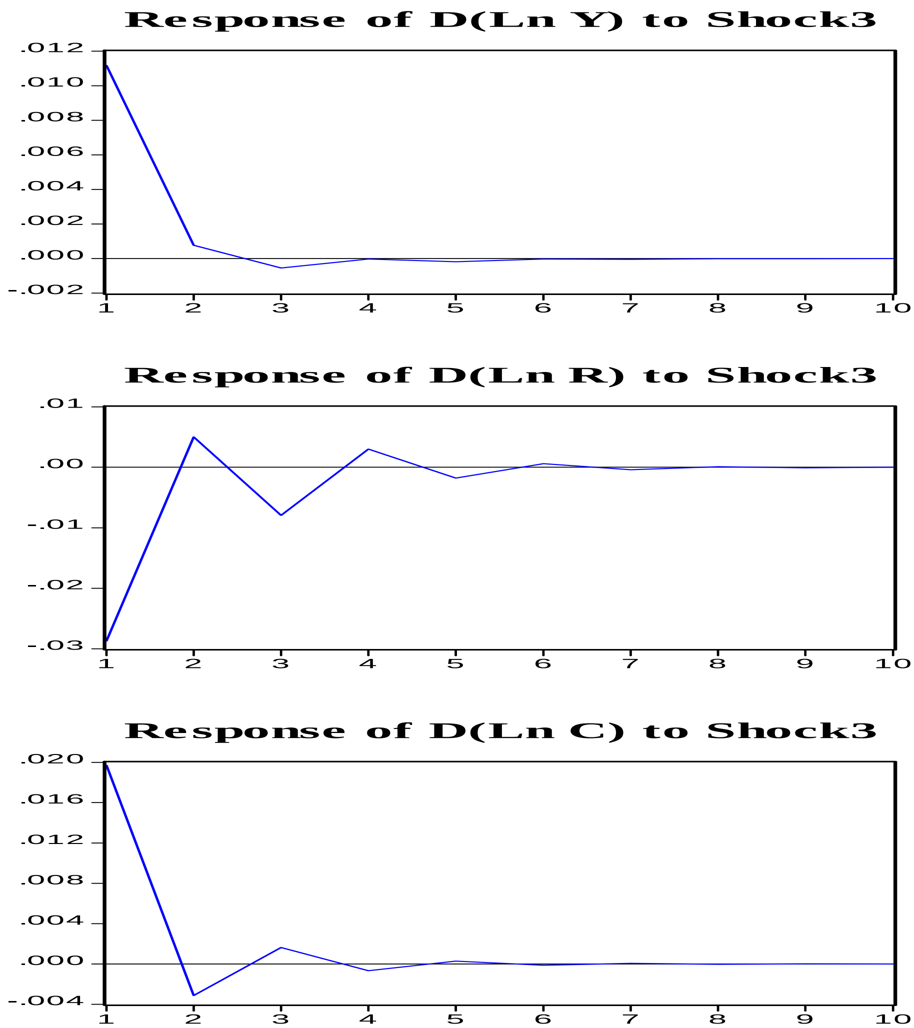
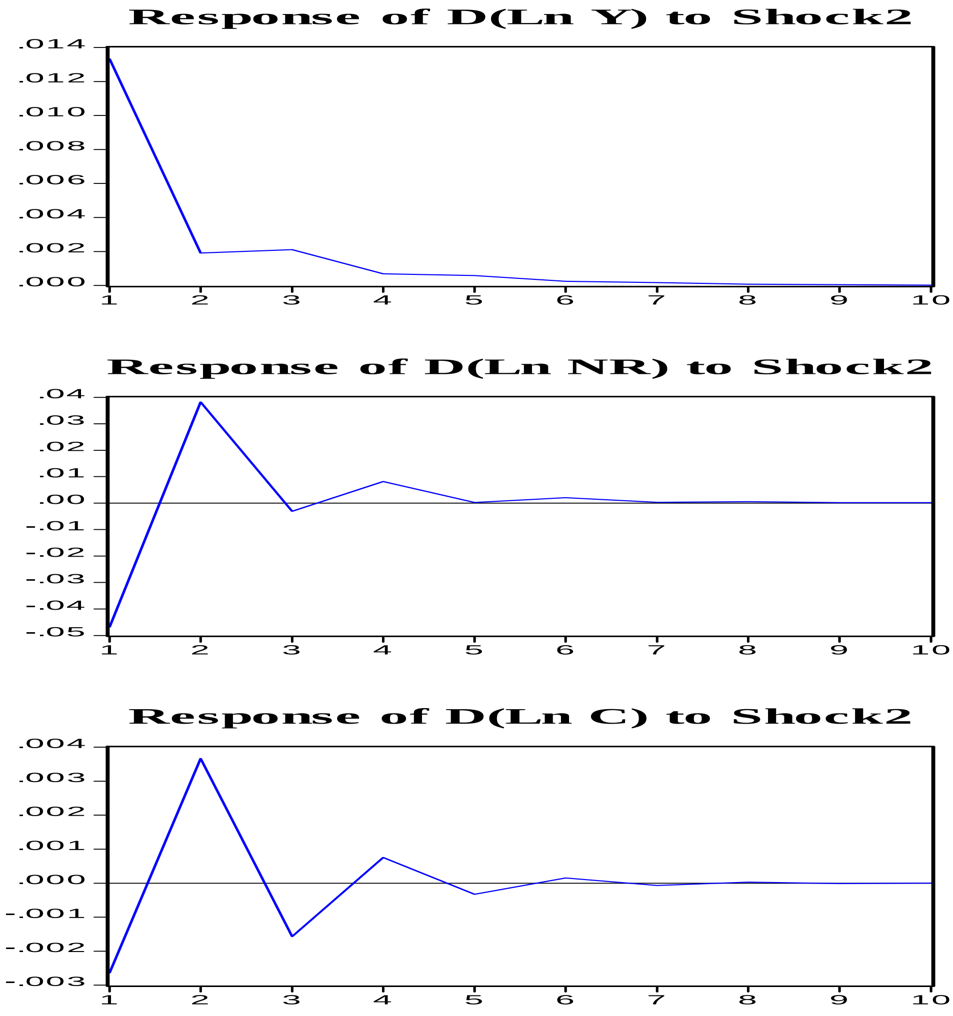


Figure-3 Shock to D(Ln R, Shock 2)



Shock to D(Ln C, Shock 4)