European Online Journal of Natural and Social Sciences 2018;
Vol.7, No 2 pp. 348-357
ISSN 1805-3602
www.european-science.com

Reinvestigating the Role of Coal Consumption in Indian Economy: An ARDL and Causality Analysis

Umer Shahzad[1], Mumtaz Hussain[2], Fengming Qin[1], Mehnoor Amir[3]
[1]School of Economics, Shandong University. Jinan. PR China; [2]Center for Economic Research, Shandong University, Jinan P.R China; [3]Management Sciences, COMSATS Institute of Information Technology. Lahore. Pakistan
***E-mail:** shehzad-umer@hotmail.com

Received for publication: 06 February 2018.
Accepted for publication: 17 April 2018.

Abstract

The present study investigates the role of coal consumption on the economic growth in India from 1980-2016. We use panel data estimation techniques for long run and VECM Granger causality for short run analysis to find the direction of causality between coal consumption and economic growth. The model specification also incorporates the urbanization, labor, fiscal deficit and service sector value added. In long-run analysis, the results confirm the unidirectional relationship from economic growth to coal consumption. On contrary, in short-run, bidirectional causal relationship between coal consumption and Indian economic growth confirms that higher coal consumption supports the Indian economy through energy. Furthermore, bidirectional causality is confirmed between economic growth and population; besides, the results show the unidirectional causality from service sector to economic growth.

Keyword: Coal consumption, population, fiscal deficit, GDP, India.

Introduction

The significance and importance of energy cannot be denied, but long-run economic growth is only possible if productive measurements are taken to improve the efficient and optimal use of energy resources. This will not only be beneficial to the industries but also for the factors of production and households which boost the industrial productions and living standards. In 80s and 90s the Indian government had never formulated any significant energy policy to cover the electricity deficit. In addition, government has never maintained the current power sources and pays no attention for up gradation of the energy infrastructure. With the passage of time, the increasing population and industries push the electricity demand, but the Indian government has not installed new energy generation capacity to meet the demand. On the contrary, in late 90s the government started to explore efficient alternates of energy and decreased the energy demand and supply gap, but still there is a whole gamut of challenging areas in the energy sector that government needs to pay attention on priority basis in order to encounter upcoming energy deficit.

India is fourth largest energy consuming country in the world after USA, China and Russian. In 2013, the energy mix of India consists 52% on coal and 29% on oil. According to World Bank, (2017) the annual gross domestic product growth (GDP) of India is 7.1%. The sudden oil price fluctuations destabilize the economic and electricity supply, Indian government working to mitigate this problem by shifting its electricity production infrastructure from oil to coal. Though there has been an effort to launch a few projects to generate energy but most of them are very expensive and the time consuming. Over the period of time, the increasing economic activities have been lifted the energy consumption. The demand of energy has increased due to some other important factors such

as; urbanization, industrialization and agriculture sectors. The motive behind this study is to reveal the attention of policy makers responsible for the control of energy resources in India; oil is not the sole option for the source of energy production. As, the production cost of energy through oil is much higher than coal, so coal is better alternative of oil to produce energy and to fulfill the energy requirements. Previously, coal was used as a principal source of energy, even till 1960, coal was regarded as the fundamental source of energy and has contributed in the industrial revolution. In the modern era, the exploration of coal has contributed in energy generation and is one of the cheap sources of energy which decrease the cost of production and fiscal deficit.

India has large reserves of coal that can be used easily. According to estimation, the world's coal reserves will end up in about 146 years. On contrary, It will take 63 years for the gas to last oil resources and 41 years for oil. These calculations clearly show that the demand for coal will increase in the future. In 2006, the coal consumption of the world was 127.5 quadrillion Btu which will rise to 190.2 quadrillion Btu up to 2030; 62% of coal consumed to generate the electricity; 34% used be the industries and the rest 4% utilized by the household and commercial sectors. According to energy information administration (EIA, 2009), the consumption of coal will grow up to 28% in 2030.

The contribution of the current study is to re-examine the case of India. As India is blessed with coal resources and having the world fourth largest coal reserve, in Chhattisgarh, Odisha and Jharkhand etc. and the coal reserves are about 297.421 billion tones in Gondwana, 99.5% of the whole coal reserves in India that can produce electricity for many years. Coal India Limited (CIL) is the national coal producer, but outsourcing the production operations to foreign and private companies to enhance the mining expertise and mechanism. CIL has planned to produce more than 1 billion metric tons of coal by 2020. India can surely decrease the cost of production by using coal and replacing it with oil in the industrial sector. As a result, after the above discussion, we have developed a hypothesis that coal consumption is the cheap source of energy that fulfill the electricity needs and play a significant role to improve the economy. But on the other hand, the environmental degradation resists the developing economies to reduce the non-renewable sources of energy. Such policies will have adverse impact on developing economics as it has to move towards renewable sources of energy that are costly and are time consuming which may affect the pace of economic growth. However, we attempt to reinvestigate the relationship between coal consumption and economic growth in case of India.

The first objective of the study is to find the role of coal consumption in economic growth of India. Secondly, the study investigates the causality relationship from economic growth toward coal and vice versa. Finally, the study provides policy implications for long term growth of economy of India and for proper management of major energy source (coal). This paper also covers the model specification by incorporating population, urbanization, fiscal deficit, service sector value added and coal consumption domestically.

Background Literature

Previously, the researchers mainly focused on the oil consumption in development of the economies, but very little literature is available, as far as author's knowledge, that investigates the role of coal consumption in the economies. Satti et al. (2014) studied the causal relationship between economic growth and coal consumption by incorporating additional determinants such as unemployment, fiscal deficit, urbanization and service sector value added in Pakistan. Their finding confirmed bidirectional relationship between economic growth and coal consumption. Kumar and Shahbaz (2012) analyzed the relationship between Pakistani economic growth and coal consumption

over the period of 1971-2009. The endogenous two-break unit root test and the ARDL bounds approach utilized to observe the causal relationship. Dynamic and fully modified ordinary least square (FMOLS) is used to check the robustness of empirical estimations. The bidirectional causality confirmed between coal consumption and economic growth. Another study by Shahbaz and Dube (2012) confirmed the feedback hypothesis; there is a bidirectional relationship between renewable energy consumption and economic growth. The results of non-renewable energy consumption also validated the similar finding. Bloch et al. (2012) analyzed the causal relationship between coal consumption and economic growth of China by dividing the supply side and demand side functions from 1997-2008 and 1965-2008 respectively. By using the VECM and innovation accounting method, the results reveal the bidirectional causal relationship between coal consumption and aggregate output. In case of supply side, the finding confirmed the unidirectional causality from coal consumption to aggregate output. Li and Leung (2012) suggested that there is an interconnection between the real GDP and the coal consumption in case of China from 1985 to 2008. They employed the panel unit root test and co integration test to examine the stationary and the existence of long run relationship between variables. These factual findings exposed there is a significant relationship between economic growth and coal consumption and there is a feedback effect among both variables. Nasiru (2012) examined the Nigeria economy to investigate the role of coal consumption in Nigerian economy over the period of 1980 to 2010. By adopting the granger causality approach, unidirectional causality confirmed between coal consumption and economic growth. The result confirmed that coal consumption trigger economic growth.

Behname (2011) investigated the role of coal consumption in the economic growth of Greater Middle East for the period 1965-2008. By applying the Pedroni co-integration test, the results confirmed the neutral hypothesis; there is no causal relationship between coal consumption and economic growth. Yuan et al. (2008) analyzed the relationship between coal consumption and economic growth in China. Johansen Juselius (1990) Cointegration, Generalized Impulse Response Analysis found the bidirectional relationship between economic growth and coal consumption. Hu and Lin (2008) reported the bidirectional causality between economic growth and coal consumption in Taiwan. Zhang and Li (2007) utilized the error correction method to investigate the empirical relationship between economic growth of China and coal consumption from 1980-2004, their finding confirmed the bidirectional relationship between coal consumption and economic growth. Yilmaz and Uslu (2007) attempted to analyze the role of coal consumption on economic development of Turkey from 1994-2004, the results reported the significant role of coal consumption in economic growth. Yoo (2006) examined the causal relationship between coal consumption and economic for the period 1968 to 2002 by utilizing Granger causality based on ECM. The results of causality reported a bidirectional relationship between coal consumption and economic growth in Korea. Alam and Butt (2002) on the other hand found out the relationship between them by focusing on the production of Pakistan. Both of them believed that both the variables are interlinked and shared a long relationship. They are interdependent upon each other. Aqeel and Butt (2001) reported that the total energy consumption is caused by economic growth Granger.

Wolde- Rufael (2010) studies the relationship among coal consumption and economic growth of 6 coal consuming countries from 1965-2005. By using the Toda and Yamamoto within VAR approach, unidirectional causality validated from coal consumption to economic growth in Japan and India; causality from growth to coal consumption proved in South Korea and China. United States and South Africa reported bidirectional relation. Jinke and Li (2011) studied the Indian and Chinese economy to analyze the role of coal consumption in the economic growth. Granger causality results found the unidirectional causality from coal consumption to economic

growth in India. Whereas, in case of China, the result revealed that economic growth granger causes the coal consumption. Chandra and Tang (2013) studied about the emission of CO2 incorporated with the consumption of coal. The relationship between the consumption of coal and the economic growth in India also critically studied. The results showed that coal consumption is a factor responsible for the economic growth and co integration exists between these two variables. Jin and Kim (2015) reported a long-run relationship between coal consumption and economic growth for OECD and non-OECD countries. Odhiambo (2016) empirically analyzed the relationship between coal consumption and economic growth in South Africa. Their finding reported the unidirectional flow from economic growth to coal consumption.

Methodology

Data

The data of real GDP per capita is used as a proxy of economic growth, population, urban population per capita and real service sector value added per capita, fiscal deficit from the world development indicators, (2016)[1], whereas, coal consumption is obtained from Statistical review of World Energy[2]. The data of studied variables cover the period of time from 1980 to 2016.

Methodological framework

To investigate the impact of coal consumption, population, urbanization, fiscal deficit, and service sector value added on economic growth, the study follows the log–linear approach: The equation for the economic growth in case of India is modeled below:

$$\ln GDP_{it} = \alpha_i + \gamma_c \ln Coal_t + \gamma_p \ln P_{it} + \gamma_u \ln U_t + \gamma_{fd} \ln FD_t + \gamma_{ss} \ln SS_t + \varepsilon_i \quad (1)$$

Following the Shahbaz, et al., (2017) the natural logirgithem of all variables obtained, where lnGDP is the natural log of real GDP per capita, lnCoal is the natural log of coal consumption, lnP is the natural log of population per capita, lnU is for the natural log of urbanization per capita, lnFD is the natural log of real fiscal deficit per capita, lnSS is the natural log of real service value added per capita and εi is the error term.

Estimation technique

Estimation procedure comprises of four steps: in the initial step we will examine the random walk problem existing in a data series by using unit root test, it will also update about the order of integration related to data series. The equations from (2 to 3) will serve the purpose. These equations are presented as below:

$$MZ_a = (T^{-1} y_T^d - \hat{\lambda}^2)[2T^{-2} \sum_{t=1}^{T} y^d{}_{t-1}]^{-1} \quad (2)$$

$$MSB = \left[\frac{T^{-2} \sum_{t=1}^{T} y^d{}_{t-1}}{\hat{\lambda}^2} \right]^{\frac{1}{2}} \quad (3)$$

[1] http://data.worldbank.org/

[2] http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-worldenergy.html

$$MZ_t = MZ_a \; x \; MSB \qquad (4)$$

As per Ng–Perron test uses the GLS de-trending method; therefore, it becomes more robust than that of the conventional unit root tests for instance: ADF test of Dickey and Fuller (1981) and test by Philips and Perron (1988) discards the difficulty of distortions in the case of the disturbance term which has large and negative MA or AR roots. The approach by Pesaran (2001) is suitable for the small data set. We can apply it, if variables are having mixed order of integration. We are in favor of co integration if our calculated F-statistics is greater than upper critical bound (UCB) and vice versa. There is no decision about co integration between the variables if our calculated F-statistics is lying between lower and upper critical bounds. The F-statistics is calculated using the following version of the unrestricted error correction method

$$\Delta LGDP_{it} = \alpha_{C_{11}} + \alpha_{11} LGDP_{t-1} + \alpha_{12} LCoal_{t-1} + \alpha_{13} LP_{t-1} + \alpha_{14} LU_{t-1} + \alpha_{15} LFD_{t-1} + \alpha_{16} LSER_{t-1} + \beta_{11} \sum_{k=1}^{q} \Delta LGDP_{t-k}$$

$$+ \beta_{12} \sum_{k=1}^{q} \Delta LCoal_{t-k} + \beta_{13} \sum_{k=1}^{q} \Delta LP_{t-k} + \beta_{14} \sum_{k=1}^{q} \Delta LU_{t-k} + \beta_{15} \sum_{k=1}^{q} \Delta LFD_{t-k} + \beta_{16} \sum_{k=1}^{q} \Delta LSS_{t-k} + \nu_t \qquad (5)$$

Where, Δ is used as a difference operator and ν_t is the error term. (Morley, 2006) said that if long term relationship among the variables exists then there must be estimate of the causal relationship between the variables also. We can apply the VECM Granger causality approach to investigate about the direction of causality among coal consumption and economic growth in both short run and in long run. We have developed the following equations (6–11) in order to find out the causality directions by using the VECM Granger causality framework, which is:

$$\Delta LGDP_t = \alpha_{C_{11}} + \delta_{11} \sum_{k=1}^{q} \Delta LGDP_{t-k} + \delta_{12} \sum_{k=1}^{q} \Delta LCoal_{t-k} + \delta_{13} \sum_{k=1}^{q} \Delta LP_{t-k} + \delta_{14} \sum_{k=1}^{q} \Delta LU_{t-k} + \delta_{15} \sum_{k=1}^{q} \Delta LFD_{t-k}$$

$$+ \delta_{16} \sum_{k=1}^{q} \Delta LSS_{t-k} + \gamma_{11} ECM_{t-1} + \varepsilon_{11,} \qquad (6)$$

$$\Delta LCoal_t = \alpha_{C_{21}} + \delta_{11} \sum_{k=1}^{q} \Delta LGDP_{t-k} + \delta_{12} \sum_{k=1}^{q} \Delta LCoal_{t-k} + \delta_{13} \sum_{k=1}^{q} \Delta LP_{t-k} + \delta_{14} \sum_{k=1}^{q} \Delta LU_{t-k} + \delta_{15} \sum_{k=1}^{q} \Delta LFD_{t-k}$$

$$+ \delta_{16} \sum_{k=1}^{q} \Delta LSS_{t-k} + \gamma_{21} ECM_{t-1} + \varepsilon_{21,} \qquad (7)$$

$$\Delta LP_t = \alpha_{C_{31}} + \delta_{11} \sum_{k=1}^{q} \Delta LGDP_{t-k} + \delta_{12} \sum_{k=1}^{q} \Delta LCoal_{t-k} + \delta_{13} \sum_{k=1}^{q} \Delta LP_{t-k} + \delta_{14} \sum_{k=1}^{q} \Delta LU_{t-k} + \delta_{15} \sum_{k=1}^{q} \Delta LFD_{t-k}$$

$$+ \delta_{16} \sum_{k=1}^{q} \Delta LSS_{t-k} + \gamma_{31} ECM_{t-1} + \varepsilon_{31,} \qquad (8)$$

$$\Delta LU_t = \alpha_{C_{41}} + \delta_{11} \sum_{k=1}^{q} \Delta LGDP_{t-k} + \delta_{12} \sum_{k=1}^{q} \Delta LCoal_{t-k} + \delta_{13} \sum_{k=1}^{q} \Delta LP_{t-k} + \delta_{14} \sum_{k=1}^{q} \Delta LU_{t-k} + \delta_{15} \sum_{k=1}^{q} \Delta LFD_{t-k}$$

$$+ \delta_{16} \sum_{k=1}^{q} \Delta LSS_{t-k} + \gamma_{41} ECM_{t-1} + \varepsilon_{41,} \qquad (9)$$

$$\Delta LFD_t = \alpha_{C_{51}} + \delta_{11}\sum_{k=1}^{q}\Delta LGDP_{t-k} + \delta_{12}\sum_{k=1}^{q}\Delta LCoal_{t-k} + \delta_{13}\sum_{k=1}^{q}\Delta LP_{t-k} + \delta_{14}\sum_{k=1}^{q}\Delta LU_{t-k} + \delta_{15}\sum_{k=1}^{q}\Delta LFD_{t-k}$$

$$+\delta_{16}\sum_{k=1}^{q}\Delta LSS_{t-k} + \gamma_{51}ECM_{t-1} + \varepsilon_{51}, \quad (10)$$

$$\Delta LSS_t = \alpha_{C_{61}} + \delta_{11}\sum_{k=1}^{q}\Delta LGDP_{t-k} + \delta_{12}\sum_{k=1}^{q}\Delta LCoal_{t-k} + \delta_{13}\sum_{k=1}^{q}\Delta LP_{t-k} + \delta_{14}\sum_{k=1}^{q}\Delta LU_{t-k} + \delta_{15}\sum_{k=1}^{q}\Delta LFD_{t-k}$$

$$+\delta_{16}\sum_{k=1}^{q}\Delta LSS_{t-k} + \gamma_{61}ECM_{t-1} + \varepsilon_{61}, \quad (11)$$

where, ECM_{t-1} shows lagged error correction term. Engle and Granger (1987) had a view that the first differences of Vector Auto Regression (VAR) are not reliable. (Bannerjee, 1998) introduced the lagged term of error correction term in the equation of the ARDL to improve the efficiency, reliability the consistency of the results.

Results and Discussion

The study incorporated the Ng–Perron unit root test which is appropriate for small dataset; it provides efficient and reliable results as compared to the ADF and PP test. Table 1 report the results of Ng–Perron unit root test for studied variables and confirmed non-stationary at level. The variables become stationary with intercept and trend i.e. economic growth, coal consumption, population, urbanization, fiscal deficit and service sector are confirming the unique order of integration. Hence, the results indicate the applicability of ARDL bounds testing to analyze the long run relationship between the variables.

Table 1: Unit root analysis

Ng-Perron test						
Dependent Variable	I (0)					
	lnGDPt	lnCoalt	lnPt	lnUt	lnFDt	lnSSt
MZa	-2.3845	-5.4461	-8.2145	-10.7354	-6.5914	-12.4628
MZt	-1.5071	-3.9967	-1.4332	-2.1629	-1.9537	-3.1451
MSB	0.1954	0.3458	0.1137	0.9683	0.2478	0.5324
MPT	7.4951	3.5167	9.6457	2.8474	3.5649	1.8161
Dependent Variable	I (1)					
	lnGDPt	lnCoalt	lnPt	lnUt	lnFDt	lnSSt
MZa	-	-	-	-	-	-
MZt	-5.1384	-2.7949	-2.4519	-3.8124	-3.5284	-5.1626
MSB	0.1184	0.1625	0.1347	0.1942	0.1024	0.1781
MPT	0.9814	1.451	0.7054	1.5648	1.4235	0.8141
**,* indicates the significance at 1% and 5% respectively						

Table 2 presents the result of co-integration; F-statistics is 4.563 which confirmed the existence of co-integration; long run relationships exist between economic growth, coal consumption, population, urbanization, fiscal deficit and service sector. Furthermore, the error term of specified model proves to be normally distributes, there is no strong evidence of heteroscedasticity and serial correlation.

Table 2: ARDL bound test

Significance level	F-statistics		W-statistics	
	Lower bound	Upper bound	Lower bound	Upper bound
5%	2.9819	4.3270	17.8914	25.9618
10%	2.4864	3.7057	14.9182	22.2340
Model			LGDP = f(LCoal, LP, LU, LFD,	
F-statistics			5.247*	
W-statistics			28.225*	
Serial correlation			0.359	
Normality			0.299	
Heteroscedasticit			0.182	

Table 3 provides the long run estimated analysis of ARDL test, which confirms the unidirectional flow of economic growth to coal consumption. In long-run, coal consumption has no impact on economic growth. Moreover, the economic growth has no impact on any of the variable. Surprisingly, the coal is statistically insignificant in all of the cases, which states that coal consumption have no impact on economic growth, population, urbanization, fiscal deficit and service sector. Population have no long0run impact on economic growth, fiscal deficit and service sector, whereas, positive and statistically significant impact on coal consumption and urbanization. The findings states that higher population leads to increase the urbanization and coal consumption, the reasons for increase in coal consumption can be the rise in electricity demand.

Table 3: Long-run estimation (ARDL)

	GDP	Coal	P	U	FD	SS
GDP		0.514**	3.323	2.528	0.196	0.097
Coal	1.374		0.163	-0.513	0.368	0.714
P	0.463	1.396**		2. 423**	0.487	0.973
U	3.164	0.517	0.749*		0.388	0.347**
FD	-1.948*	1.326	1.020	0.746		1.601
SS	0.417**	0.528	0.668	0.097	0.943	
**,* indicates the significance at 1% and 5% respectively						

Urbanization has confirmed the significant impact on population and service sector, while insignificant for economic growth, coal consumption and fiscal deficit. The estimated results confirm the unidirectional relationship from fiscal deficit to economic growth and from service sector to economic growth.

Table 4 displays the results of VECM Granger causality to examine the causal relationship between economic growth, coal consumption, population, urbanization, fiscal deficit and service sector. (Granger, 1969) stated that in the presence of co-integration there must be unidirectional or bidirectional causality between the variables. The results confirm bidirectional causal relationship between economic growth and coal consumption; the finding is in line with (Satti et al., 2014) and confirmed the significant role of coal consumption for economic growth. The finding of VECM further confirms the bidirectional relationship between economic growth and population.

Furthermore, a feedback effect has also revealed between urbanization and service sector; similar finding has confirmed by (Satti et al., 2014), the value added in service sector attracts the population to move from rural areas to urban areas. Afterward, a unidirectional causality find from service sector to economic growth and population to urbanization. The values added in service sector has the ability to boost the economic growth and its importance cannot be neglected. The error correction term (ECT) displays the results of long term relationship, the value of GDP is 0.4841 which interpret that about 48.41% disequilibrium corrected each year. In case of coal consumption, 58.86% disequilibrium corrected every year; fiscal deficit corrected by 188.46% each year.

Table 4: The VECM Granger causality

Sources of causation (independent variables)							
Dependent Variables	Short-run ΔGDP	ΔCoal	ΔP	ΔU	ΔFD	ΔSS	Long-run ECT
Full panel							
ΔGDP		5.638**	2.854**	1.995	3.387	0.143*	-0.4841*
ΔCoal	3.574**		2.444	0.285	1.221	3.564	-0.5886*
ΔP	5.354**	0.523		0.574	0.574	1.453	-1.0331
ΔU	4.748	4.782	1.581*		2.109	3.429*	-0.9364
ΔFD	1.332	1.097	1.381	0.836		0.661	-1.8846*
ΔSS	3.227	1.909	0.672	1.354*	4.517		-0.3280
**,* indicates the significance at 1% and 5% respectively							

Conclusion and Policy Implications

The study examines the relationship between economic growth and coal consumption; in addition to this we incorporated other significant determinants of economic growth in India by covering the time period 1980 to 2016. Initially, to examine the unit root in the variables, the Ng–Perron test is used which provides efficient results as compare to the ADF and PP unit root test. Hence the unique order stationary in the variables confirms the applicability to ARDL bound testing approach.

The ARDL approach is also applied in order to analyze the long run relationship between studies variables. Furthermore, the VECM Granger causality test is used to examine the direction of causality between the two main variable, coal consumption and economy growth. The result has confirmed the cointegration between economic growth, coal consumption, population, urbanization, service sector value added and fiscal deficit. The VECM results have confirmed bidirectional causal relationship between economic growth and coal consumption; the finding is in line with (Satti et al., 2014) and confirmed the significant role of coal consumption for economic growth. The finding of VECM further confirms the bidirectional relationship between economic growth and population. Furthermore, a feedback effect has also revealed between urbanization and service sector; similar finding has confirmed by (Satti et al., 2014), the value added in service sector attracts the population to move from rural areas to urban areas. Afterward, a unidirectional causality find from service sector to economic growth and population to urbanization.

The empirical findings of this paper disclosed that, in long rum and short run, bidirectional causality is present between Indian economic growth and coal consumption. Thus, present study suggests that the government should be responsible enough to pay attention towards the exploration of economical energy alternatives such as coal that can help in economic growth and can bring

economic stability in the region. In addition, the Indian government should promote the service sectors to boost the economic growth. The government should also take some actions to promote the coal exploration industry to explore more coal reserves that increase the supply in order to enhance the growth activities. The dependency on coal instead of oil also prevents the economy from sudden oil price shocks that cause the inflation and increase the payments on oil imports.

References

Alam, S., Butt, M.S., 2002. Causality between energy and economic growth in Pakistan: an application of cointegration and error-correction modeling techniques. Pac. Asia J. Energy 12, 151–165.

Aqeel, A., Butt, M.S., 2001. The relationship between energy consumption and economic growth in Pakistan. Asia Pac. Dev. J. 8, 101–110.

Bannerjee, A., Dolado, J., Mestre, R., 1998. Error-correction mechanism tests for cointegration in single equation framework. Time Ser. Anal. 19 (3), 267–283.

Behname, M., 2011. Studying the Relationship between Coal Consumption and Economic Growth in the GreaterMiddle East. Department of Economics of the University of Shiraz, Iran East (Retreived From: http://ssrn.com/abstract=1867871).

Bloch, H., Rafiq, S., Salam, R., 2012. Coal consumption, CO2 emission and economic growth in China: empirical evidence and policy responses. Energy Econ. 34, 518–528.

Chandran, V.G.R., Tang, C.F., 2013. The dynamic links between CO2 emissions, economic growth and coal consumption in China and India. Appl. Energy 104, 310–318.

Dickey, D.A., Fuller, W.A., 1981. Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica 49 (4), 1057–1072.

Energy Information Administration, 2009. Annual Report 2008. U.S. Department of Energy.

Engle, R., Granger, C., 1987. Co-integration and error correction: representation, estimation and testing. Econometrica 55 (2), 251–276.

Granger, C.W.J., 1969. Investigating causal relationships by econometricmodels and crossspectral methods. Econometica 37, 424–438.

Hu, J.L., Lin, C.H., 2008. Disaggregated energy consumption and GDP in Taiwan: a threshold co-integration analysis. Energy Economics 30, 2342–2358.

Jin, T., Kim, J., 2015. Relationship between coal consumption and economic growth for OECD and non-OECD countries. Resources, Conservation and Recycling 19, 326-332.

Jinke, L., Li, Z., 2011. A causality analysis of coal consumption and economic growth for China and India. Nat. Res. 2, 54–60.

Kumar, S., Shahbaz,M., 2012. Coal consumption and economic growth revisited: structural breaks, cointegration and causality tests for Pakistan. Energy Explor. Exploit. 30 (3), 499–522.

Li, R., Leung, G.C., 2012. Coal consumption and economic growth in China. Energy Policy. 40, 438–443.

Morley, B., 2006. Causality between economic growth and migration: an ARDL bounds testing approach. Econ. Lett. 90, 72–76.

Nasiru, I., 2012. Coal consumption and economic growth in Nigeria: a two-step residualbased test approach to cointegration. Eur. Sci. J. 8 (9), 140–155.

Ng, S., Perron, P., 2001. Lag length selection and the construction of unit root test with good size and power. Econometrica 69, 1519–1554.

Odhiambo, N, M., 2016. Coal consumption and economic growth in South Africa: An empirical investigation. Energy & Environment. 27, 215-226.

Pesaran, M.H., Richard, J., Shin, Y., 2001. Bounds testing approaches to the analysis of level relationships. J. Appl. Econ. 16, 289–326.

Phillips, P.C.B., Perron, P., 1988. Testing for a unit root in time series regression. Biometrika 75, 335–346.

Satti, S.L., Hassan, M.S., Mahmood, H., Shahbaz, M., 2014. Coal consumption: An alternate energy resource to fuel economic growth in Pakistan. Econ. Modelling. 36, 282-287.

Shahbaz, M., Dube, S., 2012. Revisiting the relationship between coal consumption and economic growth: cointegration and causality analysis in Pakistan. Appl. Econ. Int. Dev. 12 (1), 1–13.

Shahbaz, M., Sarwar, S., Chen, W., & Malik, M. N. (2017). Dynamics of electricity consumption, oil price and economic growth: Global perspective. Energy Policy, 108, 256-270.

The World Bank. (2017). GDP growth (annual %). Retrieved from https://data.worldbank.org/: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

The 2013 Human Development Report, 2013. The Rise of the South: Human Progress in a Diverse World. http://hdr.undp.org/en/reports/global/hdr2013/.

Wolde-Rufael, Y., 2010. Coal consumption and economic growth revisited. Appl. Energy. 87, 160–167.

World Bank, 2013. World Development Indicators [CD Rom 2013].World Bank,Washington, D.C., USA.

Yilmaz, A.O., Uslu, T., 2007. The Role of Coal in Energy Production-Consumption and Sustainable Development of Turkey. Energy Policy. 35, 1117-1128.

Yoo, S.H., 2006. Causal relationship between coal consumption and economic growth in Korea. Applied Energy. 83, 1181–1189.

Yuan, J.H., Kang, J.G., Zhao, C.H., Hu, Z.G., 2008. Energy consumption and economic growth: evidence from China at both aggregated and disaggregated levels. Energy Economics. 30, 3077–3094.

Zhang, Y. and Li, W., 2007. Study on causal relationship between coal consumption and economic growth in China. Resources & Industries 9, 89–93.