



## **Gas- and Coal-based Power Generation to Spur Economic Growth in Pakistan?**

Tusawar Iftikhar Ahmad<sup>1</sup>, Furrukh Bashir<sup>2</sup>, Muhammad Ali Zafar<sup>3</sup>

<sup>1</sup> Assistant Professor, Department of Economics, The Islamia University of Bahawalpur, Pakistan.  
Email: tusawar.iftikhar@iub.edu.pk

<sup>2</sup> Assistant Professor, School of Economics, Bahauddin Zakariya University, Multan, Pakistan.  
Email: furrukh@bzu.edu.pk

<sup>3</sup> M.Phil. Scholar, Department of Economics, The Islamia University of Bahawalpur, Pakistan.  
Email: aliizaffaar@gmail.com

### **ARTICLE INFO**

#### **Article History:**

Received: March 15, 2021  
Revised: May 10, 2021  
Accepted: June 27, 2021  
Available Online: June 30, 2021

#### **Keywords:**

Energy Consumption,  
Economic Growth,  
Power Sector,  
ARDL Approach,  
Pakistan.

### **ABSTRACT**

Energy consumption—in all its forms (traditional, transitional, and modern)—is the lifeline of an economy as well as of a society. Electrical energy (power) is the modern form of energy that is produced from hydel, thermal, nuclear, and other sources. Gas, oil, and coal are the thermal sources of electricity generation. Literature has validated the coal and natural gas consumption-led growth hypothesis for Pakistan. Based on time series data taken for the period 1987-2019, the present study attempts to explore the economic growth implications of oil-, gas-, and coal-consumption in power sector in Pakistan. The data was obtained from World Development Indicators (WDI) and from the Pakistan Economic Survey (PES). Three econometric models were specified to check the short-run and long-run effects of energy consumption (in the form of oil, gas and coal) in power sector on economic growth. Auto-regressive Distributed Lag Model (ARDL) was used for empirical analysis. The results show that the consumption of gas and coal in the power sector have a positive and statistically significant effects on the economic growth of Pakistan. The study advocates for more reliance on gas and coal in power generation as compared to oil for economic growth in Pakistan.



© 2021 The Authors, Published by iRASD. This is an Open Access article under the Creative Commons Attribution Non-Commercial 4.0

Corresponding Author's Email: [tusawar.iftikhar@iub.edu.pk](mailto:tusawar.iftikhar@iub.edu.pk)

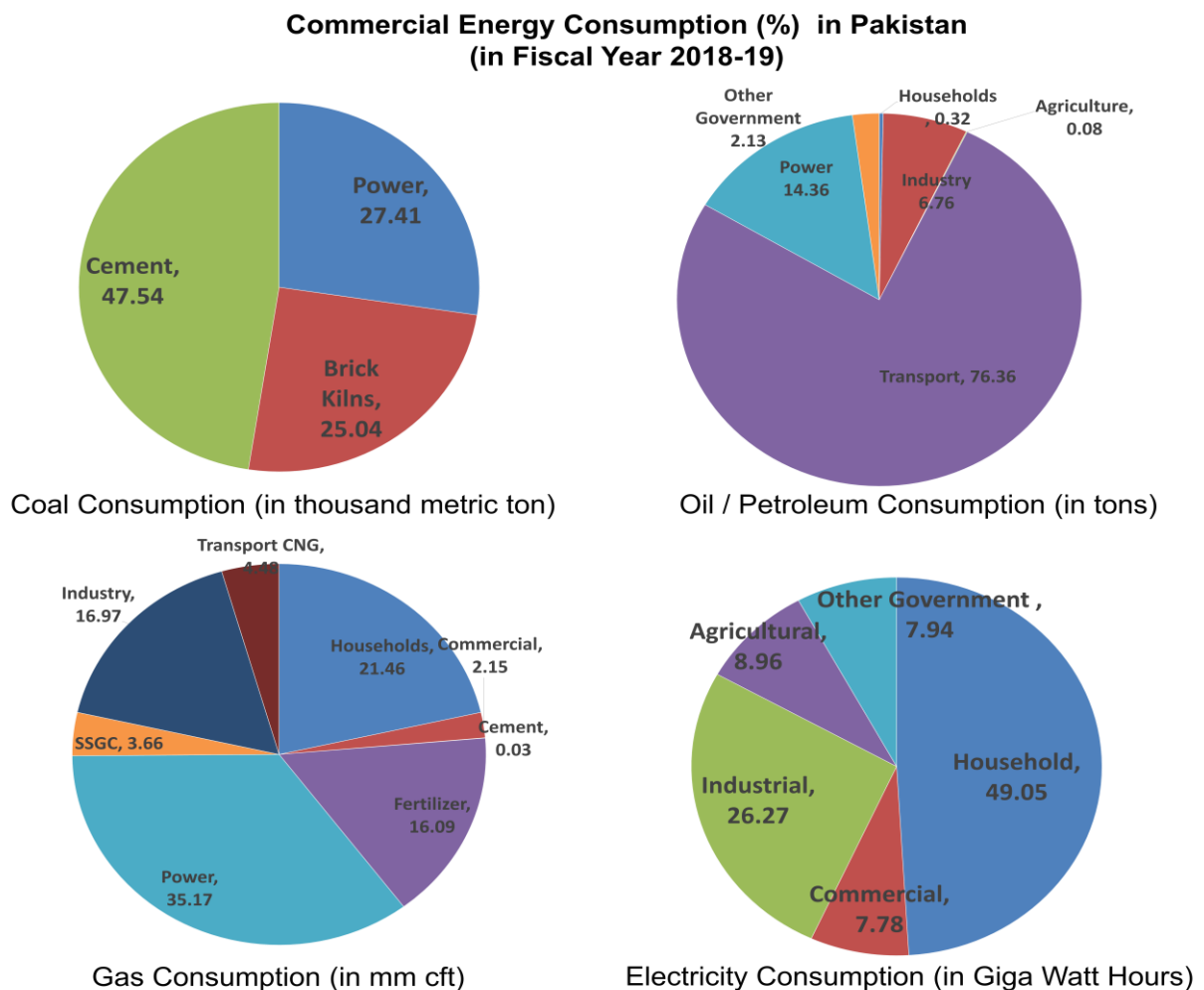
## **1. Introduction**

The literature on energy consumption (EC)-economic growth (EG) nexus has been clustered around four competing hypotheses. According to the growth-hypothesis, the causality (unidirectional) flows from EC toward EG, whereas the conservation-hypothesis is agreed on the reverse flow of the unidirectional causality, i.e., from EG towards EC. According to the feedback-hypothesis, the causality between EC and EG is bidirectional. While the neutrality-hypothesis is based on zero relationship between EC and EG.

Undoubtedly, the optimal and efficient use of energy resources is the real engine of economic growth and material prosperity. As through the optimal usage of energy resources the efficiency of the factors of production (inputs) or the returns to investors could be improved. Over the period of time, sectoral (agriculture, industrial, and services) growth, urbanization, rural electrification, and per capita income rise have increased the demand for energy in Pakistan (Nawaz, Azam, & Bhatti, 2019; Satti, Hassan, Mahmood, & Shahbaz, 2014).

In its energy-mix, Pakistan has less dependence on hydel and nuclear sources as compared to thermal which includes coal, RLNG, and natural gas. Due to introduction of LNG as well as declining of natural gas reserves, the country's reliance on natural gas is gradually on the way to gradual decrease (Government of Pakistan, 2021). While, there exist a large number of studies conducted, across the countries, on the use of natural gas and its effect on the economic growth. In the context of Pakistan, (Aqeel & Butt, 2001; Asghar, 2008; Siddiqui, 2004) found the nonexistence of any causal relationship between natural gas consumption and economic growth. However, Khan and Ahmad (2008) have examined that natural gas consumption has effect on economic growth of Pakistan. Similarly, some studies (Hassan, Tahir, Wajid, Mahmood, & Farooq, 2018; Shahbaz, Tiwari, & Nasir, 2013) have also supported the natural gas consumption-led growth hypothesis for Pakistan.

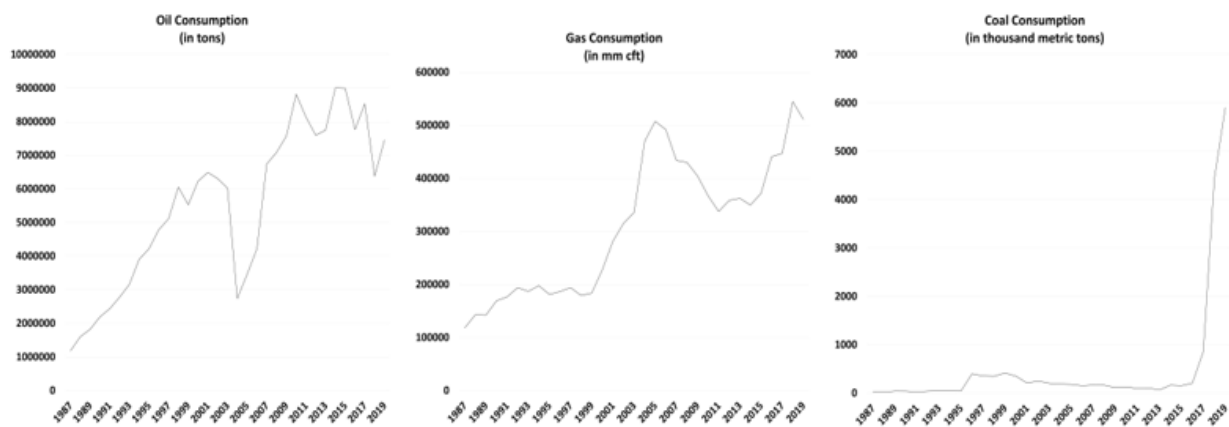
Globally, coal is the most plentiful and less expensive resource of energy (Satti et al., 2014). Also, according to the estimates, the world's resources of coal, gas, and oil would take respectively 14 decades, 5 decades, and 3 decades to deplete. Pakistan's coal reserves at Tharparker have been estimated to be in trillions tones, that is, to be enough to produce electricity in surplus for decades. Moreover, in Pakistan, the cost of generating power by using coal is cheaper than other resources (Government of Pakistan, 2014; SDPI, 2014), especially than oil-based power generation (Satti et al., 2014). Studies like, Shahbaz and Dube (2012) have also revealed a bidirectional causation between coal consumption and economic growth in Pakistan.



**Figure 1**  
(Authors' own calculations based on the values given in Pakistan Economic Survey 2020-21)

Reasonably satisfactory economic growth in Pakistan, during the decade 2004-13, have raised the demand for energy products particularly for electricity consumption (Satti et al., 2014). During the fiscal year 2018-19, Pakistan used respectively more than one-third (35.17 percent), one-fourth (27.41 percent), and more than one-seventh (14.36 percent)

of its total gas, coal, and oil consumption in its power generating sector (see Figure 1). Despite the empirical support on the natural gas consumption-led growth hypothesis for Pakistan (Hassan et al., 2018; Khan & Ahmad, 2008; Shahbaz et al., 2013), last couple of year seems a reduction in the consumption of gas in the power generating sector of Pakistan, while there seems a rise in the consumption of coal and oil (see Figure 2).



**Figure 2: Energy Consumption in Power Sector in Pakistan**  
(Authors’ own calculations based on the values given in Pakistan Economic Survey 2020-21)

It has become an established fact that through the utilization of indigenous energy resources is a way to a nation’s prosperity that may be achieved through accelerating economic growth via lower production costs. Therefore, with reference to the above arguments, it could be hypothesized that that coal consumption is the most significant and economical energy source for Pakistan, as it has been endorsed by a recent study that coal reserve of Pakistan (185.175 billion tons) could significantly uplift the socioeconomic and energy status of the country (Lin & Raza, 2020; Mohsin, Kamran, Nawaz, Hussain, & Dahri, 2021).

Although like many other studies, the current study incorporates the production function with labor and capital due to their prime role and impact on economic growth. Yet, the current study is unique in terms of its way of exploring energy-growth nexus by investigating (one by one) the economic growth implications of the consumption of oil, gas, and coal in the electricity generating sector of Pakistan. To the best of knowledge we could not found literature separately on the oil-, gas-, and coal-based power generation and its implications for economic growth of Pakistan. Hence, the present study is an effort to explore the relationship between oil, gas, and coal consumption in power sector and their effects on economic growth in Pakistan.

**Table 1**  
**Summary of Literature Reviewed on Energy-Growth Nexus**

Author name & Year	Economy Under Study	Dependent Variable	Measure of Dependent Variable	Independent Variables	Data Type /Time Period	Analytical Technique Applied	Result
Odhiambo (2009)	Tanzania	Economic Growth	GDP	Energy consumption	1971–2006	ARDL	Negative
Acaravci and Ozturk (2010)	nineteen European countries	Economic Growth	GDP per capita Growth	Energy consumption, CO2 emissions	1960-2005	ARDL, Granger causality	Negative
Pao and Tsai (2010)	BRIC countries (Brazil, Russia, India, and China)	economic growth	real GDP	CO2 emissions, energy consumption	1971–2005 panel data	(VAR) (ECM) Granger causality	Negative
Payne (2010)	United States	Economic Growth	real income per capita	electricity consumption	1960-2002 Time series	Granger-causality; VAR	(positive or negative)
Ozturk (2010)	Turkey	Economic Growth	Real GDP	Energy consumption	1978-2009 panel data	ARDL	Positive

Fallahi (2011)	USA	Economic Growth	GDP Growth	Energy Use	1960-2005 Time Series	MS-VAR	Negative
Al-Mulali (2011)	MENA countries	Economic Growth	GDP Growth	Oil consumption, CO2 emission	1980-2009 panel model	Granger causality	Positive
Belke, Dobnik, and Dreger (2011)	25 OECD countries	economic growth	Real GDP Growth	Energy consumption	1981 to 2007(panel data)	GMM	Negative
Kum, Ocal, and Aslan (2012)	G-7 countries	Economic Growth	GDP Growth	natural gas energy consumption	1970-2008(panel data)	Granger causality, VAR	Positive
Fuinhas and Marques (2012)	Turkey and four European countries	Economic Growth	GDP	Energy consumption	1965-2009(time series data)	ARDL	Positive
Yildirim and Aslan (2012)	17 highly developed OECD countries	Economic Growth	Real GDP	Energy consumption	1978-2012	Granger causality tests	Negative
Ozcan (2013)	Middle East countries	Economic Growth	GDP Growth	carbon emissions, energy consumption	panel data (1990-2008)	Granger causality	Positive
Shahbaz et al. (2013)	Pakistan	Economic Growth	GDP Growth	Natural gas consumption	2000-2007	ARDL	Positive
Bélaïd and Abderrahmani (2013)	Algeria	economic growth	Per capita GDP	Electricity consumption, oil price, fossil fuel	1971-2010(panel data)	VECM (Vector Error Correction Models)	Negative
Omri (2013)	14 MENA countries	Economic Growth	GDP per capita	CO2 emissions, energy consumption	1990-2011. panel data	GMM	Positive
Bildirici and Bakirtas (2014)	BRICTS countries	Economic Growth	GDP Growth	oil, natural gas and coal consumption	1980-2011(panel data)	ARDL	Positive for oil consumption for all countries
Hamdi, Sbia, and Shahbaz (2014)	Bahrain	Economic Growth	GDP Growth	Electricity	1980-2010	ARDL, Granger causality	Positive
Wolde-Rufael (2014)	15 transition countries	economic growth	GDP per unit	Electricity consumption	1975-2010(panel data)	Granger causality tests	Negative
Shahbaz, Mahalik, Shah, and Sato (2016)	Next-11 (N-11) countries	Economic Growth	real GDP per capita	Energy Consumption, CO2 emissions	Time Series (1972-2013)	VAR, Granger causality	Positive
Aali-Bujari, Venegas-Martinez, and Palafox-Roca (2017)	18 OECD countries	Economic Growth	per capita GDP Growth	Energy Consumption	1977-2014 panel data	Granger causality	Positive
Chandio, Rauf, Jiang, Ozturk, and Ahmad (2019)	Pakistan	Economic Growth	GDP Growth	industrial consumption of electricity, gas, and oil	1983-2017	VECM, ADF, ARDL	Positive

## 2. Data and Methodology

### 2.1 Data and Data Sources

The study identifies the long and short run impact of energy consumption in power sector on economic growth in Pakistan by covering the period of 1987 to 2019. The data has been obtained from Pakistan Economic Survey (PES) and from the World Bank's World Development Indicators (WDI). The dependent variable used in this study is economic growth, while three different core variables are oil consumption in power sector, gas

consumption in power sector, and coal consumption in power sector. The control variables include: labor force participation rate, gross fixed capital formation, personal remittances received, and exports of goods and services.

**Table 2**  
**Variables, Unit of Analysis, and Data Sources**

Variables	Units of Analysis	Sources
<b>Dependent Variable</b>		
GDP (Economic Growth)	GDP (Annual percentage growth)	WDI (2019)
<b>Core Variables</b>		
OIL (oil consumption in power sector)	Oil consumption in tons (in natural log form)	PES (2019)
GAS (gas consumption in power sector)	Gas consumption in mm cubic feet (in natural log form)	PES (2019)
COAL (coal consumption in power sector)	Coal consumption in thousand metric tons (in natural log form)	PES (2019)
<b>Control Variables</b>		
LFPR (Labor force participation rate)	Total (Percentage of total population ages 15+) (national estimate)	WDI (2019)
GFCF (Gross fixed capital formation)	Annual percentage growth	WDI (2019)
REMIT (Personal remittances received)	Percentage of GDP	WDI (2019)
EXP (Exports of goods and services)	Percentage of GDP	WDI (2019)

## 2.2. Model Specifications

The study has constructed three econometric models, in each model the dependent variable (economic growth) and the other control variables are same, while the core/principle variable is different in each model.

The first model in its econometric form can be written as:

$$GDP = \alpha_0 + \alpha_1 OIL + \alpha_2 LFPR + \alpha_3 GFCF + \alpha_4 REMIT + \alpha_5 EXP + \mu \quad (1)$$

The second model in its econometric form can be written as:

$$GDP = \beta_0 + \beta_1 GAS + \beta_2 LFPR + \beta_3 GFCF + \beta_4 REMIT + \beta_5 EXP + \mu \quad (2)$$

The third model in its econometric form can be written as:

$$GDP = \gamma_0 + \gamma_1 COAL + \gamma_2 LFPR + \gamma_3 GFCF + \gamma_4 REMIT + \gamma_5 EXP + \mu \quad (3)$$

$\alpha_0$ ,  $\beta_0$ , and  $\gamma_0$  are the intercepts respectively in the first, second, and third models.  $\alpha_1$ ,  $\beta_1$ , and  $\gamma_1$  are the coefficients indicating change in economic growth due to, respectively, change in oil consumption in power sector, change in gas consumption in power sector, and due to change in coal consumption in power sector (respectively in the first, second, and third models).  $\alpha_2$  to  $\alpha_5$ ,  $\beta_2$  to  $\beta_5$ , and  $\gamma_2$  to  $\gamma_5$  coefficients indicate change in economic growth due to change in labor force participation rate, gross fixed capital formation, personal remittances, exports of goods and services in all the three models, and  $\mu$  indicates error term.

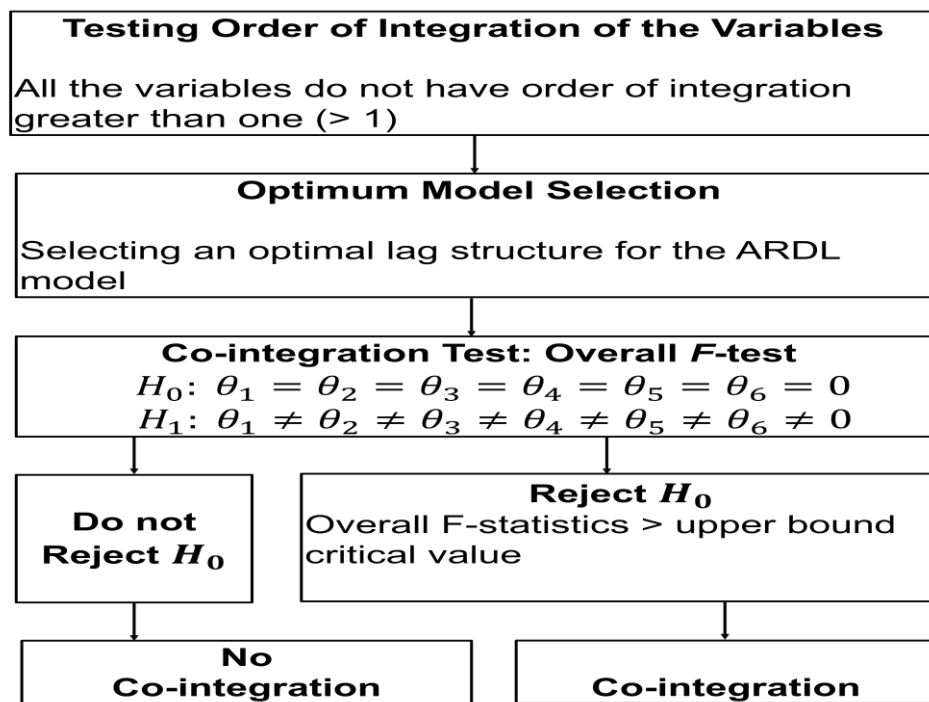
## 2.3. Methodological Framework

Residual-based approach (Engle & Granger, 1987) and the maximum likelihood-based approach (Johansen, 1992; Johansen & Juselius, 1990) are the most popularly used approaches used in the economic literature to investigate the existence of co-integration among the variables. "Knowing the order of integration for each variable" is the first step in investigating the co-integration relationship. "Having similar order of integration by the variables" is the prerequisite of both the above mentioned approaches used for co-integration. The maximum likelihood-approach of Johansen and Julius is more advantageous than residual-based approach, if there are more than two variables in the system with their order of integration 1 or I(1). However, the researchers have to confront with the problem if there is non-fulfillment of this required precondition, i.e, the system containing the variables with dissimilar orders of integration. Therefore, in order to

overcome this problem there has been proposed (M. Pesaran, Shin, & Smith, 1996; M. H. Pesaran, Shin, & Smith, 2001) a new approach known as Autoregressive Distributed Lag (ARDL) for co-integration test. For the newly proposed approach, there is no requirement of classifying the variables on the basis of their orders of integration [into I(0) or I(1)]. Recent studies have also endorsed the use of the ARDL approach over other conventional approaches to test the co-integration. This technique is valid by the same token, whatsoever is the order of integration of the variables (i.e., purely I(0), purely I(1), mutually co-integrated). The fundamental statistical principle behind this technique is the F-statistics in a generalized Dickey–Fuller type regression, by which the significance of lagged levels of the variables (under considered) in a conditional unrestricted error correction model (ECM) is tested (M. H. Pesaran et al., 2001).

Prior to applying co-integration test, it is important to check the stationarity status of data. Mostly time series data exhibit trends which imply toward non-stationarity, hence could become a reason for regression to be spurious. So in order to check the stationarity of data, Augmented Dicky-Fuller (ADF) test was employed both at level and at first difference.

ARDL bounds test has been used to test the co-integration. Bounds test is based on ordinary least square (OLS) estimation of a conditional unrestricted ECM for co-integration analysis (M. H. Pesaran et al., 2001). In order to apply ARDL, the series of the variables must have mixed order of integration (be either I (0) or I (1)). The values of F-statistics (provided by Pesaran, 2001) cannot be interpreted in the presence of variable(s) stationary at second difference (i.e., with order of integration I (2)). ECM shows short run dynamics with long run equilibrium, whereas, the coefficients of ARDL represent the relationship in long run equilibrium.



**Figure 3: Augmented ARDL Bounds Test, Steps and Decision Rule**  
(inspiration from Sam, McNown, and Goh (2019))

Moreover, this empirical estimation technique (used in the current study) has the following advantages: (a) it can easily handle small sample size, (b) co-integration can be tested, whether the variables are stationary at level or at first difference (that is, bounds test can be applied even if the variables have mixed order of integration), (c) different lags for each variable can be included.

In order to find the long-run relationship between the variables the following ARDL bounds testing models (equation 1, 2, 3) have been constructed:

$$\Delta GDP_t = \theta_0 + \theta_1 GDP_{t-1} + \theta_2 OIL_{t-1} + \theta_3 LFPR_{t-1} + \theta_4 GFCF_{t-1} + \theta_5 REMIT_{t-1} + \theta_6 EXP_{t-1} + \sum_{i=1}^q \sigma_1 \Delta GDP_{t-i} + \sum_{i=1}^q \sigma_2 \Delta OIL_{t-i} + \sum_{i=1}^q \sigma_3 \Delta LFPR_{t-i} + \sum_{i=1}^q \sigma_4 \Delta GFCF_{t-i} + \sum_{i=1}^q \sigma_5 \Delta REMIT_{t-i} + \sum_{i=1}^q \sigma_6 \Delta EXP_{t-i} + \mu_t \quad (4)$$

$$\Delta GDP_t = \theta_0 + \theta_1 GDP_{t-1} + \theta_2 GAS_{t-1} + \theta_3 LFPR_{t-1} + \theta_4 GFCF_{t-1} + \theta_5 REMIT_{t-1} + \theta_6 EXP_{t-1} + \sum_{i=1}^q \Omega_1 \Delta GDP_{t-i} + \sum_{i=1}^q \Omega_2 \Delta GAS_{t-i} + \sum_{i=1}^q \Omega_3 \Delta LFPR_{t-i} + \sum_{i=1}^q \Omega_4 \Delta GFCF_{t-i} + \sum_{i=1}^q \Omega_5 \Delta REMIT_{t-i} + \sum_{i=1}^q \Omega_6 \Delta EXP_{t-i} + \mu_t \quad (5)$$

$$\Delta GDP_t = \theta_0 + \theta_1 GDP_{t-1} + \theta_2 COAL_{t-1} + \theta_3 LFPR_{t-1} + \theta_4 GFCF_{t-1} + \theta_5 REMIT_{t-1} + \theta_6 EXP_{t-1} + \sum_{i=1}^q \psi_1 \Delta GDP_{t-i} + \sum_{i=1}^q \psi_2 \Delta COAL_{t-i} + \sum_{i=1}^q \psi_3 \Delta LFPR_{t-i} + \sum_{i=1}^q \psi_4 \Delta GFCF_{t-i} + \sum_{i=1}^q \psi_5 \Delta REMIT_{t-i} + \sum_{i=1}^q \psi_6 \Delta EXP_{t-i} + \mu_t \quad (6)$$

For the short-run ARDL estimates, the following ECM equations would take the forms as given below (equation 4, 5, 6):

$$GDP_t = \sigma_0 + \sum_{i=1}^q \sigma_1 \Delta GDP_{t-i} + \sum_{i=1}^q \sigma_2 \Delta OIL_{t-i} + \sum_{i=1}^q \sigma_3 \Delta LFPR_{t-i} + \sum_{i=1}^q \sigma_4 \Delta GFCF_{t-i} + \sum_{i=1}^q \sigma_5 \Delta REMIT_{t-i} + \sum_{i=1}^q \sigma_6 \Delta EXP_{t-i} + \theta ECT_{t-1} + \mu_t \quad (7)$$

$$GDP_t = \Omega_0 + \sum_{i=1}^q \Omega_1 \Delta GDP_{t-i} + \sum_{i=1}^q \Omega_2 \Delta GAS_{t-i} + \sum_{i=1}^q \Omega_3 \Delta LFPR_{t-i} + \sum_{i=1}^q \Omega_4 \Delta GFCF_{t-i} + \sum_{i=1}^q \Omega_5 \Delta REMIT_{t-i} + \sum_{i=1}^q \Omega_6 \Delta EXP_{t-i} + \theta ECT_{t-1} + \mu_t \quad (8)$$

$$GDP_t = \psi_0 + \sum_{i=1}^q \psi_1 \Delta GDP_{t-i} + \sum_{i=1}^q \psi_2 \Delta COAL_{t-i} + \sum_{i=1}^q \psi_3 \Delta LFPR_{t-i} + \sum_{i=1}^q \psi_4 \Delta GFCF_{t-i} + \sum_{i=1}^q \psi_5 \Delta REMIT_{t-i} + \sum_{i=1}^q \psi_6 \Delta EXP_{t-i} + \theta ECT_{t-1} + \mu_t \quad (9)$$

Where, ECT is the error correction term implying towards the disequilibrium speed of adjustment. If the results of bounds testing validate the co-integration between the variables, the long-run ARDL models would take the following forms (equation 7, 8, 9):

$$GDP_t = \sigma_0 + \sum_{i=1}^q \sigma_1 GDP_{t-i} + \sum_{i=1}^q \sigma_2 OIL_{t-i} + \sum_{i=1}^q \sigma_3 LFPR_{t-i} + \sum_{i=1}^q \sigma_4 GFCF_{t-i} + \sum_{i=1}^q \sigma_5 REMIT_{t-i} + \sum_{i=1}^q \sigma_6 EXP_{t-i} + \mu_t \quad (10)$$

$$GDP_t = \Omega_0 + \sum_{i=1}^q \Omega_1 GDP_{t-i} + \sum_{i=1}^q \Omega_2 GAS_{t-i} + \sum_{i=1}^q \Omega_3 LFPR_{t-i} + \sum_{i=1}^q \Omega_4 GFCF_{t-i} + \sum_{i=1}^q \Omega_5 REMIT_{t-i} + \sum_{i=1}^q \Omega_6 EXP_{t-i} + \mu_t \quad (11)$$

$$GDP_t = \psi_0 + \sum_{i=1}^q \psi_1 GDP_{t-i} + \sum_{i=1}^q \psi_2 COAL_{t-i} + \sum_{i=1}^q \psi_3 LFPR_{t-i} + \sum_{i=1}^q \psi_4 GFCF_{t-i} + \sum_{i=1}^q \psi_5 REMIT_{t-i} + \sum_{i=1}^q \psi_6 EXP_{t-i} + \mu_t \quad (12)$$

### 3. Results and Discussion

According to the unit root test, the variables have order of integration between zero and one.

**Table 3**  
**Augmented Dickey Fuller (Unit Root) Test**

Variables	At Level t-Statistics Prob. Value	At First difference t-Statistics Prob. Value	Decision
GDP	-0.370744 0.9017	-6.782670 0.0000**	I(1)
OIL	-2.774292 0.0733	-5.405546 0.0001**	I(1)
GAS	-1.548101 0.4968	-4.469857 0.0013**	I(1)
COAL	-0.976982 0.7494	-5.364304 0.0001**	I(1)
LFPR	-5.421134 0.0001**	-13.155380 0.0000**	I(0)
GFCF	-3.425948 0.0173*	-6.062461 0.0000**	I(0)
REMIT	-1.249879 0.6397	-5.375638 0.0001**	I(1)
EXP	-5.159300 0.0002**	-6.232035 0.0000**	I(0)

Note: \*\* and \* respective representing that the coefficient is significantly different at p-value 1% and 5%, respectively.

### 3.1. ARDL Bounds Testing Analysis

In ARDL model the calculated value of F-static for first, second, and third model are 10.07958, 11.57557, and 9.562107 respectively. Which are higher than the upper bound critical value at 1%, 2.5%, 5% and 10% level of significance. Hence, validating the existence of co-integration by the rejection of null hypotheses.

**Table 4**  
**ARDL bounds Testing Analysis**

Test for existence of level of relationship in ARDL model

Model Estimated	Model-1	Model-2	Model-3
F-Statistics	10.07958	11.57557	9.562107
Selected Lag Length (Criteria)	2 (AIC)	2 (AIC)	2 (AIC)

In the next step we obtain ECM for the three models. The result of ECM coefficients and short-run results reported in the following table 5. First two columns of the table 5 shows the value of ECM and short-run result of model-1, second two columns show the result of model-2, and last two column of the table shows the result of model-3.

**Table 5**  
**ARDL Models Short-run Results**

Dependent Variable: Economic Growth (GDP)					
Model-1		Model-2		Model-3	
Variable Name	Short-run Results	Variable Name	Short-run Results	Variable Name	Short-run Results
CointEq(-1)	-0.739452*** [-7.825759] (0.0000)	CointEq(-1)	-0.441209*** [-7.723008] (0.0000)	CointEq(-1)	-0.937423*** [-6.375473] (0.0000)
D(OIL)	2.755605 [0.888636] (0.3874)	D(GDP(-1))	0.590801*** [3.087667] (0.0067)	D(COAL)	0.290647 [0.442222] (0.6646)
D(OIL(-1))	-8.021533*** [-3.225810] (0.0053)	D(GAS)	5.827282*** [3.276858] (0.0044)	D(COAL (-1))	-2.768541*** [-3.699343] (0.0021)
D(GFCF)	0.270169*** [5.191026] (0.0001)	D(LFPR)	-0.233829*** [-2.806628] (0.0121)	D(GFCF)	0.247179*** [6.189434] (0.0000)
D(LFPR)	-0.203095* [-1.920659] (0.0728)	D(GFCF)	0.264696*** [6.347536] (0.0000)	D(GFCF (-1))	-0.063099 [-1.588870] (0.1329)
D(EXP)	0.166782 [0.601373] (0.5560)	D(GFCF (-1))	-0.070058* [-1.786111] (0.0919)	D(LFPR)	-0.124202 [-1.725443] (0.1050)
D(EXP(-1))	0.822010** [2.467134] (0.0253)	D(EXP)	0.474889*** [4.349806] (0.0004)	D(REMIT)	0.237401 [0.985745] (0.3399)
D(REMIT)	-0.485652 [-1.475071] (0.1596)	D(REMIT)	-0.153717 [-0.560132] (0.5827)	D(REMIT (-1))	-1.193793*** [-4.288652] (0.0006)
D(REMIT (-1))	-0.503455 [-1.495250] (0.1543)	D(REMIT (-1))	-1.147845*** [-4.220701] (0.0006)	D(EXP)	0.576797*** [4.486436] (0.0004)

Note: The T-statistic values and p-values are respectively given in brackets and in parentheses. \*\*\*, \*\*, \* are representing that the variables are significant at respectively 1%, 5%, and 10%

Error correction term is statistically significant with negative sign in the three models. The coefficient of ECM is -0.739452 for model-1, -0.441209 for model-2, and -0.937423 for model 3 reported in the models is negative and the coefficient is between zero to one. The coefficient of error terms is statistically significant at 1 percent level of significance.

In the next step the long run coefficients of ARDL models are reported. First two columns of the table 6 shows the long-run result of model-1, second two column shows the



result of model-2, and last two column of the table shows the result of model-3 by this we can compare the results of three models easily.

**Table 6**  
**ARDL Models Long-run Results**

Dependent Variable: Economic Growth (GDP)					
Model-1	Model-2		Model-3		
Variable Name	Long-run Results	Variable Name	Long-run Results	Variable Name	Long-run Results
OIL	1.471489 [1.013562] (0.3259)	GAS	2.387047*** [3.385063] (0.0035)	COAL	1.143170*** [2.877416] (0.0115)
LFPR	-0.116758** [-2.123624] (0.0496)	LFPR	-0.149891*** [-3.685640] (0.0018)	LFPR	-0.115092** [-2.573287] (0.0212)
GFCF	0.244059*** [7.516315] (0.0000)	GFCF	0.200963*** [11.002993] (0.0000)	GFCF	0.226681*** [11.574115] (0.0000)
REMIT	0.022370 [0.163716] (0.8720)	REMIT	0.156541** [2.306217] (0.0340)	REMIT	0.439785*** [3.748463] (0.0019)
EXP	0.024897 [0.196882] (0.8464)	EXP	0.194530*** [4.049042] (0.0008)	EXP	0.297713*** [3.745674] (0.0019)

Note: The T-statistic values and p-values are respectively given in brackets and in parentheses. \*\*\*, \*\*, \* are representing that the variables are significant at respectively 1%, 5%, and 10%

The results of long-run estimates show energy consumption (in the form of oil, gas, and coal) in power sector have a positive impact on the economic growth. In model-1 this study takes the energy consumption (in the form of oil) in the power sector which has a positive impact on the economic growth. It means as the consumption of oil increase by one percent in the power sector the economic growth will increased by 1.471489 percent but it is insignificant in the model. In the model-1 other control variables the labor force participation rate, gross fixed capital formation, personal remittances, and exports. The labor force participation has a negative impact on economic growth and gross fixed capital formation has positive impact on the economic growth and significant while the remittances, and exports also have a positive impact on the economic growth but insignificant in this model (Baloch et al., 2021).

In the model-2, this study takes gas a form of energy consumption in power sector. The long-run estimated coefficient of gas is 2.387047 which means it has positive impact on the economic growth. If one percent increase the use of gas it will increase the economic growth by 2.387047 percent. The coefficient of gas is higher as compare to the coefficient of oil. It means the use of gas is more better as compare to oil. In the model-2, the study used same control variables as in model-1. In the second model the labor force participation rate has negative impact on economic growth and significant. While gross fixed capital formation, remittances and exports have positive impact on economic growth and significant. As the oil is imported from the other countries that's why the use of gas is more appropriate as compare to oil (Jianjun et al., 2021).

In the model-3, the study takes coal a form of energy consumption in power sector. The long-run estimated coefficient of coal is 1.143170 which indicates it has positive impact on the economic growth. If one percent increase the use of energy consumption (in the form of coal) it will increase the economic growth by 1.143170 percent. The coefficient of gas is higher as compare to the coefficient of oil and coal. It means the use of gas is more better as compare to oil and coal, but the gas and coal are significant in our results while the oil is insignificant. In the model-3, the study used same control variables as in model-1 and model-2. In the third model the labor force participation rate has negative impact on economic growth and significant. While gross fixed capital formation, remittances and exports have positive impact on economic growth and significant. On the basis of these results we can reject the null hypothesis that there is no effect of coal, labor force participation rate, gross fixed capital formation, remittances, and exports on economic growth and will accept the alternative hypothesis that there is effect of these variables on economic growth because these variables are significant in our results (Nawaz et al., 2021).

At the end in table 7 the diagnostic tests show that the three models satisfy all of the reported diagnostic tests.

**Table 7**  
**Diagnostic Tests Results**

Tests	Model-1	Model-2	Model-3
J-B Normality Test	[1.066027] (0.5868)	[0.833400] (0.6592)	[2.472241] (0.2905)
Breusch-Godfrey Serial Correlation LM Test	[1.159582] (0.3420)	[1.177049] (0.3351)	[4.033073] (0.1057)
Heteroskedasticity Test: ARCH	[1.220818] (0.3480)	[1.624091] (0.1754)	[1.605556] (0.2686)

Note: The [ ] bracket shows the F-statistic value and ( ) bracket shows the prob-value, respectively.

This study applies the Jarque-Bera normality test to check either the models are normally distributed or not. In this study the prob-values of this test is greater than 5% in case of three models which indicate that our models are normally distributed. To check the autocorrelation in the model, the study applies the Breusch-Godfrey Serial Correlation LM test which is also satisfied in the three models. As the prob-value is greater than 5% its mean there is no autocorrelation in the models of this study. This study applies the ARCH test to check the heteroskedasticity in the models, as the prob-value is greater than 5% in our case it means there is no issue of heteroskedasticity in our models.

#### 4. Conclusion and Policy Recommendation

The main purpose of this study is to check the impact of energy consumption in power sector on economic growth in Pakistan. In this study we analyzed the relationship between energy consumption (in the form of oil, gas, and coal) in power sector and economic growth using time series data obtain from World Development Indicator (WDI) and Pakistan Economic Survey (PES) range from 1987 to 2019. In order to explore the relationship between energy consumption (in the form of oil, gas, and coal) in power sector and economic growth Autoregressive Distributed Lag (ARDL) model is employed. Energy consumption (in the form of oil, gas, and coal) in power sector are positively contributed in the economic growth of Pakistan but in case of oil the results are insignificant while the impact of gas and coal is significant. The coefficient of gas is higher as compare to the oil and coal which indicates that the use of gas is more efficient as compare to oil and coal. One of the reason is as Pakistan import oil from the other countries so its use in power sector is costlier as compare to gas and coal. Gas and coal is locally available in Pakistan that's why it is better to use local energy resources in the power sector. By this we will stop the capital outflow which increase the economic growth of Pakistan. The three models used same control variables. Like labor force participation rate, gross fixed capital formation, remittances, and exports are used as control variable in each model. These control variables also have some impact on the economic growth as labor force participation rate has a negative impact on economic growth while the other control variables like gross fixed capital formation, remittances and exports have positive impact on the economic growth.

Pakistan is developing country so decrease in capital outflow will positively affect the level of investment; the consumption level and economic growth. Pakistan should focus on those energy resources (e.g., gas and coal) to use in power sector which are locally available in Pakistan. The use of locally available energy resource like gas and coal will reduce the cost. If we use gas and coal instead of oil (as we import oil from the other countries) it will increase the current account balance of Pakistan so that it can contribute to accumulate economic growth. It suggested that policy makers should make policies to reduce the use of oil in the power sector and stop the capital outflow for the economic growth of Pakistan. Finally, we can say that use of gas and coal in the power sector may be helpful in boosting the economic growth of Pakistan.

## References

- Aali-Bujari, A., Venegas-Martínez, F., & Palafox-Roca, O. (2017). Impact of energy consumption on economic growth in major OECD economies (1977-2014): A panel data approach. *International Journal of Energy Economics and Policy*, 7(2).
- Acaravci, A., & Ozturk, I. (2010). On the relationship between energy consumption, CO2 emissions and economic growth in Europe. *Energy*, 35(12), 5412-5420.
- Al-Mulali, U. (2011). Oil consumption, CO2 emission and economic growth in MENA countries. *Energy*, 36(10), 6165-6171.
- Aqeel, A., & Butt, M. S. (2001). The relationship between energy consumption and economic growth in Pakistan. *Asia-Pacific Development Journal*, 8(2), 101-110.
- Asghar, Z. (2008). Energy-GDP relationship: a causal analysis for the five countries of South Asia. *Applied Econometrics and International Development*, 8(1).
- Baloch, Z. A., Tan, Q., Kamran, H. W., Nawaz, M. A., Albashar, G., & Hameed, J. (2021). A multi-perspective assessment approach of renewable energy production: policy perspective analysis. *Environment, Development and Sustainability*, 1-29. doi:<https://doi.org/10.1007/s10668-021-01524-8>
- Bélaïd, F., & Abderrahmani, F. (2013). Electricity consumption and economic growth in Algeria: A multivariate causality analysis in the presence of structural change. *Energy policy*, 55, 286-295.
- Belke, A., Dobnik, F., & Dreger, C. (2011). Energy consumption and economic growth: New insights into the cointegration relationship. *Energy Economics*, 33(5), 782-789.
- Bildirici, M. E., & Bakirtas, T. (2014). The relationship among oil, natural gas and coal consumption and economic growth in BRICTS (Brazil, Russian, India, China, Turkey and South Africa) countries. *Energy*, 65, 134-144.
- Chandio, A. A., Rauf, A., Jiang, Y., Ozturk, I., & Ahmad, F. (2019). Cointegration and causality analysis of dynamic linkage between industrial energy consumption and economic growth in Pakistan. *Sustainability*, 11(17), 4546.
- Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276.
- Fallahi, F. (2011). Causal relationship between energy consumption (EC) and GDP: a Markov-switching (MS) causality. *Energy*, 36(7), 4165-4170.
- Fuinhas, J. A., & Marques, A. C. (2012). Energy consumption and economic growth nexus in Portugal, Italy, Greece, Spain and Turkey: an ARDL bounds test approach (1965-2009). *Energy Economics*, 34(2), 511-517.
- Government of Pakistan. (2014). Pakistan Vision 2025: One Nation-One Vision, Planning Commission; Ministry of Planning, Development & Reform Islamabad
- In: Planning Commission; Ministry of Planning, Development & Reform Islamabad.
- Government of Pakistan. (2021). *Pakistan Economic Survey 2020-21. Economic Advisor's Wing, Ministry of Finance, Islamabad-Pakistan.*
- Hamdi, H., Sbia, R., & Shahbaz, M. (2014). The nexus between electricity consumption and economic growth in Bahrain. *Economic Modelling*, 38, 227-237.
- Hassan, M. S., Tahir, M. N., Wajid, A., Mahmood, H., & Farooq, A. (2018). Natural gas consumption and economic growth in Pakistan: production function approach. *Global Business Review*, 19(2), 297-310.
- Jianjun, H., Yao, Y., Hameed, J., Kamran, H. W., Nawaz, M. A., Aqdas, R., & Patwary, A. K. (2021). The Role of Artificial and Nonartificial Intelligence in the New Product Success with Moderating Role of New Product Innovation: A Case of Manufacturing Companies in China. *Complexity*, 2021, 14. doi:<https://doi.org/10.1155/2021/8891298>
- Johansen, S. (1992). Cointegration in partial systems and the efficiency of single-equation analysis. *Journal of econometrics*, 52(3), 389-402.
- Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and statistics*, 52(2), 169-210.
- Khan, M. A., & Ahmad, U. (2008). Energy demand in Pakistan: a disaggregate analysis. *The Pakistan Development Review*, 437-455.
- Kum, H., Ocal, O., & Aslan, A. (2012). The relationship among natural gas energy consumption, capital and economic growth: Bootstrap-corrected causality tests from G-7 countries. *Renewable and Sustainable Energy Reviews*, 16(5), 2361-2365.

- Lin, B., & Raza, M. Y. (2020). Coal and economic development in Pakistan: A necessity of energy source. *Energy*, 207, 118244.
- Mohsin, M., Kamran, H. W., Nawaz, M. A., Hussain, M. S., & Dahri, A. S. (2021). Assessing the impact of transition from nonrenewable to renewable energy consumption on economic growth-environmental nexus from developing Asian economies. *Journal of environmental management*, 284, 111999. doi:<https://doi.org/10.1016/j.jenvman.2021.111999>
- Nawaz, M. A., Azam, A., & Bhatti, M. A. (2019). Natural Resources Depletion and Economic Growth: Evidence from ASEAN Countries. *Pakistan Journal of Economic Studies*, 2(2), 155-172.
- Nawaz, M. A., Hussain, M. S., Kamran, H. W., Ehsanullah, S., Maheen, R., & Shair, F. (2021). Trilemma association of energy consumption, carbon emission, and economic growth of BRICS and OECD regions: quantile regression estimation. *Environmental Science and Pollution Research*, 28(13), 16014-16028. doi:<https://doi.org/10.1007/s11356-020-11823-8>
- Odhiambo, N. M. (2009). Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach. *Energy policy*, 37(2), 617-622.
- Omri, A. (2013). CO2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. *Energy Economics*, 40, 657-664.
- Ozcan, B. (2013). The nexus between carbon emissions, energy consumption and economic growth in Middle East countries: a panel data analysis. *Energy policy*, 62, 1138-1147.
- Ozturk, I. (2010). A literature survey on energy-growth nexus. *Energy policy*, 38(1), 340-349.
- Pao, H.-T., & Tsai, C.-M. (2010). CO2 emissions, energy consumption and economic growth in BRIC countries. *Energy policy*, 38(12), 7850-7860.
- Payne, J. E. (2010). Survey of the international evidence on the causal relationship between energy consumption and growth. *Journal of Economic Studies*.
- Pesaran, M., Shin, Y., & Smith, R. (1996). Testing for the 'Existence of a Long-run Relationship'(No. 9622). *Faculty of Economics, University of Cambridge*.
- Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, 16(3), 289-326.
- Sam, C. Y., McNown, R., & Goh, S. K. (2019). An augmented autoregressive distributed lag bounds test for cointegration. *Economic Modelling*, 80, 130-141.
- Satti, S. L., Hassan, M. S., Mahmood, H., & Shahbaz, M. (2014). Coal consumption: An alternate energy resource to fuel economic growth in Pakistan. *Economic Modelling*, 36, 282-287.
- SDPI. (2014). *Pakistan Energy Vision 2035*, Sustainable Development Policy Institute (SDPI), Islamabad, Pakistan. <https://sdpi.org/sdpiweb/publications/files/Pakistan%20Energy%202035-FINAL%2020th%20October%202014.pdf>. Retrieved from
- Shahbaz, M., & Dube, S. (2012). Revisiting the relationship between coal consumption and economic growth: cointegration and causality analysis in Pakistan. *Applied Econometrics and International Development*, 12(1), 1-13.
- Shahbaz, M., Mahalik, M. K., Shah, S. H., & Sato, J. R. (2016). Time-varying analysis of CO2 emissions, energy consumption, and economic growth nexus: Statistical experience in next 11 countries. *Energy policy*, 98, 33-48.
- Shahbaz, M., Tiwari, A. K., & Nasir, M. (2013). The effects of financial development, economic growth, coal consumption and trade openness on CO2 emissions in South Africa. *Energy policy*, 61, 1452-1459.
- Siddiqui, R. (2004). Energy and economic growth in Pakistan. *The Pakistan Development Review*, 175-200.
- Wolde-Rufael, Y. (2014). Electricity consumption and economic growth in transition countries: A revisit using bootstrap panel Granger causality analysis. *Energy Economics*, 44, 325-330.
- Yildirim, E., & Aslan, A. (2012). Energy consumption and economic growth nexus for 17 highly developed OECD countries: Further evidence based on bootstrap-corrected causality tests. *Energy policy*, 51, 985-993.