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Coal Consumption and Economic Growth in Turkey

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ABSTRACT: This aim of this paper is to use asymmetric causality tests to examine the coal consumption and Gross Domestic Product (GDP) relationship in Turkey based on data from 1980 to 2006. To investigate this relationship, a multivariate system is employed by including fixed capital formation and labor force variables into the model. The empirical results obtained from asymmetric causality tests show no causality for coal consumption and GDP relationship in Turkey. The results indicate that coal consumption does not affect growth; hence, energy conservation policies may be pursued without adversely affecting growth in Turkey. Thus, neutrality hypothesis is confirmed for Turkey. This means that a decrease in coal consumption does not affect economic growth and vice versa. In this case, policymakers should explore the feasibility of either decreasing the coal consumption or increasing the efficiency of coal consumption.

Keywords: Economic growth; coal consumption; asymmetric causality; Turkey
JEL Classifications: O; Q43

1. Introduction

The relationship between economic growth (EG) and energy consumption (EC) has been investigated extensively in the energy economics literature over the last three decades. There are a number of studies that support unidirectional or bidirectional causality between EG and EC relationship. However, no consensus has been expressed by the various researchers regarding the direction of causality between EC and EG (Ozturk, 2010). Despite the expanding literature of causal relationships between EC and EG, there are a few studies specifically addressing the causal relationship between coal consumption (CC) and EG. Coal is very important amongst the energy sources, and it is the primary factor for the industrial revolution (Jinke et al., 2008; Yildirim et al., 2012). It is also the most abundant energy source in the world, and it has a unique role as a reliable energy source (World Coal Association, 2006).

This empirical study focuses on an analysis of CC and EG relationship in Turkey. Focus on aggregated EC would yield only weighted effect; therefore, studies must examine detailed data based on the effect of the consumption of particular energy sources, such as natural gas, coal, and oil on EG. Coal is the vital energy source for Turkey and it is the largest reserve in Turkey's fossil resources (Yilmaz, 2008). Turkey has nearly 1.3 billion tons of hard coal and 12.3 billion tons of lignite reserves. In addition, coal is a creditable energy source that alone accounts for 65% (in 2007) of total electricity generation in Turkey. Manufacturing 75% of world lignite productions, Turkey is one of the 9 (Germany, Russia, Greece, Canada, USA, Czech Republic, Australia, Poland and Turkey) lignite manufacturing countries (Turkey Coal Enterprises, 2008).

As mentioned above, the relationship between EC and EG has been examined extensively but no consensus could be reached. The directions of causal relationship between EC and EG can be categorized under four hypotheses (Ozturk, 2010). First, "growth hypothesis" emphasizes that EC has an important role in EG, and the causality of relationship is from EC to GDP. If such is the case, the reduction in EC may have a detrimental impact on EG. Second, the "conservation" hypothesis supports the unidirectional causality from EG to EC. In this situation, energy conservation policies which reduce EC have no effect on EG. The other hypothesis, the "neutrality", asserts that EC should not have a significant impact on EG, and it supports no causality between EG and EC. The implication of this hypothesis is that EC conservation policies will have no effect on EG. The last is "feedback" hypothesis, which suggests bidirectional causality for EC and EG relationship; in this case, EC increases (decreases) result in GDP increases (decreases). Table 1 presents few but essential studies that examined the causal relationship between CC and EG.

Table 1. Summary of literature on coal consumption-economic growth nexus.

Author(s)	Country - Period	Methodology	Variables	Conclusion(s)
Sari and Soytas (2004)	Turkey (1969–1999)	VAR; generalized forecast error variance decomposition	CC; GDP	CC explains up to 8% of forecast error variance of real GDP
Yoo (2006)	Korea (1968–2002)	Johansen–Juselius; co integration	CC; GDP	Feedback Hypothesis
Jinke et al. (2008)	China, India, Japan, South Africa, South Korea (1980–2005)	Engle–Granger; co integration	CC; GDP	China, Japan; Conservation Hypothesis, India, South Africa and South Korea; Neutrality Hypothesis
Jinke et al. (2009)	Japan, China, India, South Africa (1980-2005)	Granger Causality	CC; GDP	Japan and China; Conservation Hypothesis India and South Africa; Neutrality Hypothesis
Ziramba (2009)	South Africa (1980-2005)	ARDL bounds test; Toda–Yamamoto; Granger-causality	CC; IP	Neutrality Hypothesis
Wolde-Rufael (2010)	China, India, Japan, Korea, South Africa, US (1965–2005)	Toda–Yamamoto; Granger-causality generalized forecast error variance decomposition	CC; GDP	China, Korea; Conservation Hypothesis India, Japan, South Africa, US; Growth Hypothesis
Apergis and Payne (2010a)	25 OECD Countries (1980-2005)	Multivariate panel error correction model	CC; GDP	Feedback Hypothesis
Apergis and Payne (2010b)	15 emerging market economies (1980–2006)	Panel causality tests	CC; GDP	Feedback Hypothesis
Li and Leung (2012)	China (1985-2008)	Panel co integration; error-correction modeling	CC; GDP	For China Coastal and Central regions; Feedback Hypothesis For China Western region; Conservation Hypothesis

Note: The abbreviations are as follows: coal consumption (CC), real GDP (GDP), autoregressive distribution lag (ARDL).

Jinke et al. (2008) suggest no causality between CC and EG in South Korea; in contrast, Yoo (2006) finds bidirectional causality and Wolde-Rufael (2010) finds unidirectional causality from GDP to EC. For China, Apergis and Payne (2010b) assert bidirectional causality between CC and EG, while Jinke et al. (2008, 2009) and Wolde-Rufael (2010) find unidirectional causality from GDP to CC. On the other hand, Li and Leung (2012) support unidirectional causality from GDP to CC for China Western Region, and bidirectional causality for China Coastal and Central Regions. In the case of India, Jinke et al. (2008, 2009) support neutrality hypothesis, while Wolde-Rufael (2010) suggests unidirectional causality from GDP to CC, and Apergis and Payne (2010b) assert bidirectional causality. For Japan, Jinke et al. (2008, 2009), reveal unidirectional causality from EG to CC, whereas Wolde-Rufael (2010) provides unidirectional causality from CC to EG. The results also vary for South Africa; no causal relationship between CC and GDP has been reported by Jinke et al. (2008, 2009), while Wolde-Rufael (2010) finds unidirectional causality from CC to GDP. On the other hand, Apergis and Payne (2010b) find bidirectional causality between CC and GDP relationship. As a summary, the conclusions from these studies are mixed and no consensus has been reached in the literature.

This study extends the existing literature specifically on the causal relationship between CC and EG in Turkey for 1980-2006 period using a multivariate system. To our knowledge, there is no study which has investigated the GDP–CC relationship in Turkey by using asymmetric causality test in the literature. The rest of the paper is organized as follows: section 2 describes the data, methodology and the results from empirical analysis, and the last section presents conclusion and policy implications of the paper.

2. Data, Methodology and Results

The Gross Domestic Product, Gross Fixed Capital Formation and Labor Force variables data's has been obtained from OECD database and the final coal consumption data has been obtained from the International Energy Agency (IEA) database.

The augmented Dickey and Fuller (1979) (ADF) and the Phillips and Perron (1988) (PP) tests are used to test the common components of CC, real GDP, capital and labor force. Depending on the results, all the common components turn out to be integrated of order one, I(1). Table 2 presents unit root test results.

Table 2. Unit root test results

	Level				**Differences**			
	Augmented Dickey and Fuller		**Phillips and Perron**		**Augmented Dickey and Fuller**		**Phillips and Perron**	
	Without trend	**With trend**	**Without trend**	**With trend**	**Without trend**	**With trend**	**Without trend**	**With trend**
Coal consumption	1.8835 [5] (-3.7880)	-2.0640 [0] (-4.3560)	1.5871 [4] (-3.7114)	-1.9202 [1] (-4.3560)	-6.368*** [0] (-3.7240)	-4.783*** [4] (4.4678)	-6.379*** [1] (-3.7240)	-6.957*** [3] (-4.3743)
Real GDP	1.4833 [0] (-3.7114)	-3.0624 [3] (-4.4163)	1.6531 [1] (-3.7114)	-1.2677 [2] (-4.3560)	-4.743*** [0] (-3.7240)	-5.172*** [0] (-4.3743)	-4.770*** [2] (-3.7240)	-5.171*** [1] (-4.3743)
Capital	-2.8204 [0] (-3.7114)	-2.7589 [0] (-3.2334)	-2.8558 [2] (-3.7114)	-2.8571 [2] (-4.3560)	-6.126*** [0] (-3.7240)	-6.136*** [0] (-4.3743)	-6.108*** [1] (-3.7240)	-6.059*** [2] (-4.3743)
Labor force	-1.0167 [2] (-3.7378)	-2.8784 [0] (-4.3560)	-0.5780 [25] (-3.7114)	-2.8784 [0] (-4.3560)	-5.639*** [1] (-3.7378)	-5.658*** [1] (-4.3943)	-10.37*** [17] (-3.7240)	-14.77*** [24] (-4.3743)

Note: The notation *** implies significance at 1% significance level. In parentheses, critical values at 1% are presented and optimal lags are in bracelet by Hatemi J Criteria.

In the literature, Schwarz (1978) Bayesian information criterion and the Hannan and Quinn (1979) information criterion are the best criteria and previous studies show that these two different criteria has a better performance than the other, depending on the characteristics of the true VAR model. Hatemi-J Criteria (HJC) is used to select true lag order submitted by Hatemi-J (2003). The following information criterion is used to select the optimal lag order *(p)*:

$$HJC = \ln\left(\left|\hat{\Omega}_j\right|\right) + j\left(\frac{n^2 \ln T + 2n^2 \ln(\ln T)}{2T}\right), j = 0,....,p. \quad (1)$$

Where $\left|\hat{\Omega}_j\right|$ is the determinant of the estimated variance–covariance matrix of the error terms in the VAR model based on lag order *j, n is* the number of equations in the VAR model, and *T* is the number of observations.

$$y_{1t} = y_{1t-1} + \varepsilon_{1t} = y_{10} + \sum_{i=1}^{t} \varepsilon_{1i} \quad (2)$$

and $y_{2t} = y_{2t-1} + \varepsilon_{2t} = y_{20} + \sum_{i=1}^{t} \varepsilon_{2i}$ (3)

where t =1,2,…T, the constants $y_{1,0}$ and $y_{2,0}$ are the initial values, and the variables ε_{1i} and ε_{2i} signify white noise disturbance terms. Positive and negative shocks are defined as the following: $\varepsilon_{1i}^{+} = \max(\varepsilon_{1i},0), \varepsilon_{2i}^{+} = \max(\varepsilon_{2i},0), \varepsilon_{1i}^{-} = \min(\varepsilon_{1i},0)$ and $\varepsilon_{2i}^{-} = \min(\varepsilon_{2i},0)$ respectively.

Therefore, one can express $\varepsilon_{1i} = \varepsilon_{1i}^{+} + \varepsilon_{1i}^{-}$ and $\varepsilon_{2i} = \varepsilon_{2i}^{+} + \varepsilon_{2i}^{-}$ It follows that

$$y_{1t} = y_{1t-1} + \varepsilon_{1t} = y_{1,0} + \sum_{i=1}^{t} \varepsilon_{1i}^{+} + \sum_{1=i}^{t} \varepsilon_{1i'}^{-} \quad \text{and} \quad y_{2t} = y_{2t-1} + \varepsilon_{2t} = y_{2,0} + \sum_{i=1}^{t} \varepsilon_{2i}^{+} + \sum_{i=1}^{t} \varepsilon_{2i'}^{-}$$

Finally, the positive and negative shocks of each variable can be defined in a cumulative form as $y_{1t}^{+} = \sum_{i=1}^{t} \varepsilon_{1i}^{+}$, $y_{1t}^{-} = \sum_{i=1}^{t} \varepsilon_{1i}^{-}$, $y_{2t}^{+} = \sum_{i=1}^{t} \varepsilon_{2i}^{+}$ and $y_{2t}^{-} = \sum_{i=1}^{t} \varepsilon_{2i}^{-}$. Note that, by construction, each positive as well as negative shock has a permanent impact on the underlying variable.

In the following, the case of testing for causal relationship between positive cumulative shocks is examined. Assuming that $y_t^{+} = (y_{1t}^{+}, y_{2t}^{+})$, the test for causality can be implemented by using the following vector autoregressive model of order p, VAR *(p)*:

$$y_t^{+} = v + A_1 y_{t-1}^{+} + \ldots + A_p y_{t-1}^{+} + u_t^{+} \qquad (4)$$

The null hypothesis that kth element of y_t^{+} does not Granger-cause the ωth element of y_t^{+} is tested after selecting the optimal lag order. That is, the following hypothesis is tested:

H_0 : the row ω, column k element in A_r equals zero for $r = 1, \ldots, p$. (5)

In order to define a Wald test in a compact form, we make use of the following denotations:

$Y := (y_t^{+}, \ldots, y_T^{+})$ $(n \times T)$ matrix,

$D := (v, A_1, \ldots, A_p)$ $(n \times (1+np))$ matrix,

$$Z_t := \begin{bmatrix} 1 \\ y_t^{+} \\ y_{t-1}^{+} \\ . \\ . \\ . \\ y_{t-p+1}^{+} \end{bmatrix} \text{((1+}np\text{)x1) matrix, for } t=1, \ldots, T,$$

$Z := (Z_0, \ldots, Z_{T-1})$ $((1 + np) \times T)$ matrix, and $\delta := (u+1, \ldots, u+T)$ $(n \times T)$ matrix.

The null hypothesis of non-Granger causality, $H_0 : C\beta = 0$, is tested by the following test method:

Wald = $(C\beta)' [C((Z'Z)^{-1} \otimes S_U)C']^{-1}(C\beta)$, (6)

where β = vec(D) and vec indicates the column-stacking operator; $\otimes$ represents the Kronecker product, and C is a $p \times n(1 + np)$ indicator matrix with elements ones for restricted parameters and zeros for the rest of the parameters. S_U is the variance–covariance matrix of the unrestricted VAR model estimated as $S_U = \frac{\xi'_U \xi_U}{T-q}$, where q is the number of parameters in each equation of the VAR model. When the assumption of normality is fulfilled, the Wald test statistic above has an asymptotic x^2 distribution with the number of degrees of freedom equal to the number of restrictions to be tested (in this case equal to p).

The bootstrapping simulation technique is employed for the possibility of autoregressive conditional heteroskedasticity (ARCH) effects. The bootstrap critical values are produced for three different significant levels. The bootstrap simulations are implemented by using statistical software components written in GAUSS by Hatemi-J (2012). Table 3 presents the results of tests for causality using the bootstrap simulations.

Table 3. The results of tests for causality using the bootstrap simulations

Coal consumption does not Granger cause growth				**Growth does not Granger cause coal consumption**			
MVALD	**%1 CV**	**%5 CV**	**%10 CV**	**MVALD**	**%1 CV**	**%5 CV**	**%10 CV**
0.337	10.576	5.309	3.228	1.042	10.218	5.235	3.838

MVALD statistic values were compared to %1, %5 and %10 bootstrap critical values. According to results, no causality relationships were found between coal consumption and economic growth in Turkey. Thus, neutrality hypothesis is confirmed for Turkey. In other words, coal consumption has no effect on economic growth and vice versa.

3. Conclusion

Coal is a reliable energy source and the most economical of fossil fuels; therefore, it keeps its favorable position. Despite the expanding literature on the study of causal relationships between energy consumption and GDP, as mentioned before, there has been no empirical work using asymmetric causality test on coal consumption (CC) and economic growth (EG) relationship for Turkey. The originality of this paper is mainly related to this fact. This study tests specifically the causal relationship between CC and EG by using asymmetric causality techniques for Turkey over the period 1980–2006. Asymmetric causality tests indicate no Granger causality between CC and EG in Turkey. This means that CC does not stimulate EG, or energy saving would not have a negative impact on EG in Turkey, and it suggests neutrality hypothesis. In this case, policymakers should explore the feasibility of either decreasing the CC or increasing efficient coal consumption. Finally, this is the first paper which examines the causal links between CC and EG by using asymmetric causality test for Turkey. Further research can extend this analysis with other tests, utilizing various economic factors, with a view to determining other factors that influence CC and GDP.

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