Causal Relationship Between Coal Consumption and Economic Growth in Turkey

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Abstract

Coal constitutes an important factor for the Turkey's economic growth. In this paper an attempt is made to examine the short- and long-run causality between coal consumption and Gross National Product for Turkey using annual data covering the period 1970-2014. Tests for unit roots, cointegration, and Granger causality based on error correction model are applied. In this study was found that exists bidirectional Granger causality between coal consumption and economic growth in the short and long run.

Keywords: Coal Consumption, Economic Growth, Causality, Cointegration

Türkiye'de Kömür Tüketimi ve Ekonomik Büyüme Arasındaki Nedensellik İlişkisi

Özet

Kömür, Türkiye'nin ekonomik büyümesi için önemli bir faktördür. Bu makalede, Türkiye'nin 1970-2014 dönemindeki yıllık verilerle kömür tüketimi ve GSMH arasındaki kısa ve uzun dönemli nedensellik ilişkisi araştırıldı. Birim kök, eşbütünleşme ve hata düzeltme modelinin temel alındığı Granger nedensellik testleri uygulandı. Çalışmada, kısa ve uzun dönemde kömür tüketimi ve ekonomik büyüme arasında iki yönlü nedensellik bulundu.

Anahtar Sözcükler: Kömür Tüketimi, Ekonomik Büyüme, Nedensellik, Eşbütünleşme

1. Introduction

It is generally recognized that the energy including coal plays a significant role in economic development, because it enhances the productivity of capital, labour and other factors of production. In the past two decades, numerous studies have been conducted to examine the relationship between energy consumption and economic growth. Many studies have shown that the energy consumption is positively correlated with economic growth. For example Kraft & Kraft (1978), Ghosh (2002), and Mozumder & Marathe (2007) found unidirectional causality running from GNP to energy consumption. Shiu & Pun (2004) reported unidirectional causality running from energy consumption to GNP. Jumbe (2004) found bidirectional causality between energy consumption and GNP. However, Akarca & Long (1980), Erol & Yu (1987a), Yu & Choi (1985), and Yu & Hwang (1984) found no causal relationship between GNP and energy consumption.

In the literature on the causal relationship between the consumption of energy, including coal, and economic growth, there are a number of evidences to support bidirectional or unidirectional causality between energy consumption and economic growth. Despite the expanding literature on the study of causal relationships between energy consumption and economic growth, there have been few studies the causal relationship between coal consumption and economic growth. Recently, Yang (2000) found unidirectional causality running from economic growth to coal consumption in Taiwan. Yoo (2006) found unidirectional long-run causality from economic

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growth to coal consumption, and bidirectional strong causality from coal consumption to economic growth in Korea.

The direction of causation between coal consumption and economic growth has significant policy implications. If, for example, there is unidirectional causality running from coal consumption to economic growth, reducing coal consumption could lead to a fall in economic growth. On the other hand, if a unidirectional causality runs from economic growth to coal consumption, it could imply that policies for reducing coal consumption may be implemented with little or no adverse effects on economic growth. And lastly, no causality in either direction would indicate that policies for increasing coal consumption do not affect economic growth (Yoo, 2006: 1183).

The purpose of this paper is, therefore, to investigate the causality between coal consumption and economic growth, and to obtain policy implications from the results. The paper is organized in the following fashion. Section 2 describes the econometric methodology. Section 3 presents variable definitions, data sources and presents empirical study. Final section contains the conclusions.

2. Econometric Methodology

2.1. ADF Unit Root Test

The first econometric step is to test if the series are non-stationary. The classical regression model requires that the dependent and independent variables in a regression be stationary in order to avoid the problem of what Granger and Newbold (1974) called ‘spurious regression.’ Non-stationarity or the presence of a unit root can be tested using the Dickey and Fuller (1979, 1981) tests. To test if a sequence y_t contains a unit root, three different regression equations are considered.

$$\Delta y_t = m_o + m_2.t + \gamma.y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + u_t \quad (1)$$

$$\Delta y_t = m_o + \gamma.y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + u_t \quad (2)$$

$$\Delta y_t = \gamma.y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + u_t \quad (3)$$

The first equation includes both a drift term and a deterministic trend; the second excludes the deterministic trend; and the third does not contain an intercept or a trend term. In all three equations, the parameter of interest is γ. If γ = 0, the y_t sequence has a unit root. The estimated *t*-statistic is compared with the appropriate critical value in the Dickey-Fullertables to determine if the null hypothesis is valid (Dua & Pandit, 2002: 859).

2.2. Tests of Cointegration

Engle and Granger (1987) show that if two nonstationary time series are cointegrated, then the standard Granger causality tests are misspecified. Therefore, before testing for causality, it is necessary to test for cointegration.

Cointegration is a property of two nonstationary time series and implies a long-term equilibrium relationship between the two variables. The notion of cointegration can be expressed as follows. If the time series x_t and y_t are both nonstationary in levels , but the first differences of the variables are stationary, it is said both variables are integrated of order one, I(1). Their linear combinations are generally also I(1). However, if there is a linear combination of x_t and y_t that is stationary, it is said the two variables are cointegrated. If the two variables are cointegrated, then there is some underlying long-term relationship between them (Arbelaez, Urrutia & Abbas, 2001: 245-247).

The cointegration test is based in the methodology developed by Johansen (1991), and Johansen and Juselius (1993). Johansen's method is to test the restrictions imposed by cointegration on the unrestricted variance autoregressive, VAR, involving the series.

The mathematical form of a VAR is

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + Bx_t + \varepsilon_t \quad (4)$$

Where y_t is an *n*-vector of non-stationary *I(1)* variables, x_t is a *d*-vector of deterministic variables, $A_1,.., A_p$ and *B* are matrices of coefficients to be estimated, and ε_t is a vector of innovations that may be contemporaneously correlated with each other but are uncorrelated with their own lagged values and other right-hand side variables. We can rewrite the VAR as (Eq. (5)):

$$\Delta_{yt} = \Pi_{yt-1} + \sum \Gamma_i \Delta_{yt-i} + B_{x_t} + u_t \tag{5}$$

where ,

$$\Pi = \sum A_i - I_t \quad \text{and} \quad \Gamma_i = -\sum A_j \tag{6}$$

Granger's representation theorem asserts that if the coefficient matrix n has reduced rank r<n, then there exist *n* x *r* matrices α and β each with rank r such that $\pi = \alpha\,\beta'$ and $\beta' y_t$ is stationary . Here, *r* is the number of cointegrating relations and each column of β is a cointegrating vector. For *n* endogenous non-stationary variables, there can be from 0 to *n* — 1 linearly independent, cointegrating relations.

A critical consideration in a cointegration test is the structure of the model to be specified. Previous analyses of forest products markets have largely ignored the potential impact of alternative specifications, particularly the presence of an intercept and/or a deterministic trend in a cointegrating equation. However, the presence of these variables can affect the asymptotic properties of the testing statistics, making the Likelihood Ratio for the reduced rank test lack the usual x^2 distribution. To obtain valid results, we will explore a variety of specifications of the VAR (Yin & Xu, 2003: 307).

2.3. Vector Error Correction Modeling (VECM)

The purpose of the VECM is to focus on the short-run dynamics while making them consistent with the long-run solution. If a number of variables are found to be cointegrated with at least one cointegrating vector, then there always exists a corresponding error-correction representation which implies that changes in the dependent variable can be formulated as a function of the level disequilibrium in the cointegration relationship and fluctuations in other explanatory variables. In other words the error-correction term in the VECM provides an additional channel for the detection of Granger causality.

The Granger causality can be detected through the statistical significance of the t-test for the lagged error-correction term and/of the F-test applied to the joint significance of the sum of lags of each explanatory variable. The non-significance of both the t and F tests in the system indicates econometric exogeneity of the dependent variable. In addition to indicating the direction of causality amongst variables, the VECM also allows us to discriminate the short-run and long-run Granger causality. The F-test of the explanatory variables (in their first differences) indicates the short-run causal effects, whereas the long-run causal relationship is implied through the significance of the t-test of the error-correction term, since it contains long-run cointegration information between the variables, because it is derived from the long-term cointegrating relationship(s). The coefficient of the lagged error-correction term, however, is a short-term adjustment coefficient and represents the proportion by which the long-term disequilibrium (or imbalance) in the dependent variable is being corrected in each short period. Non-significance or elimination of any of the lagged error-correction terms affects the implied long-term relationships, and may be a violation of theory. The non-significance or elimination of any of the differenced variables, which reflect only short-term relationships, however, does not involve such violations because theory typically has nothing to say about short-term relationships (Alam, Ahmed & Butt, 2003: 454).

3. Data and Empirical Results

3.1. Data

The data used in this study consist of annual time series of real GNP and coal consumption for Turkey 1970 to 2014. The real GNP data was obtained from the National Statistical Office in

Turkey. Coal consumption data was obtained from the Turkish Ministry of Energy and Natural Resources.

GNP: Gross National Product (1.000.000$),

COAL: Coal Consumption (1000 Ton).

3.2. Result of Unit Roots and Co-integration Test

The results of the unit root tests for the series of COAL and GNP variables are shown in Table 1. The ADF test provides the formal test for unit roots in this study. The p-values corresponding to the ADF values calculated for the two series are larger than 0.05. This indicates that the series of all the variables are non-stationary at 5% level of significance and thus any causal inferences from the two series in levels are invalid.

Table 1. Results of ADF Test for Unit Roots

Variables	Trend and Intercept	CV(LL)*
COAL	-1,995638(0)	-2,963972
GNP	-2,234865(0)	-2,963972

* CV stands for critical values, which are at the 5% level. The critical values are calculated from MacKinnon. LL stands for lag length. The lag lengths are selected using the Schwarz Bayseian criterion.

When the data are first differenced, the null of nonstationarity can be rejected for all series at the 5% level (Table 2). This indicates that COAL and GNP are I(1).

Table 2. Results of ADF Test for Unit Roots According to First Difference

Variables	Trend and Intercept	CV(LL)*
COAL	-7,735628(0)	-2,967767
GNP	-7,682973(0)	-2,967767

** CV stands for critical values, which are at the 5% level. The crşitical values are calculated from MacKinnon. LL stands for lag length. The lag lengths are selected using the Schwarz Bayseian criterion.*

The variables are integrated of the same order, the next step was to test for cointegration using Johansen's maximum likelihood procedure. The results of the Johansen maximum likelihood cointegration tests are presented in Table 3.

Table 3. Results of Johansen's Cointegration Test

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.417586894	17.6458	15.41	20.04	None *
0.195378619	4.3864	3.76	6.65	At most 1 *

* Denotes rejection of the hypothesis at 5%(1%) significance level

The eigenvalues are presented in the first column, while the second column (Likelihood Ratio) gives the LR test statistic:

$$Q_r = -T\sum_{i=r+1}^{k}\ln(1-\lambda_i) \tag{7}$$

for r = 0,1,...,k-1 where λ_i is the i-th largest eigenvalue. Q_r is the so- called trace statistic and is the test of $H_1(r)$ against $H_1(k)$.

To determine the number of cointegrating relations r, subject to the assumptions made about the trends in the series, we can proceed sequentially from r = 0 to r = k-1 until we fail to reject. The first row in the upper table tests the hypothesis of no cointegration, the second row tests the hypothesis of one cointegrating relation.

The trace statistic does not reject any of the hypotheses at the 5% level. Note that Eviews displays the critical values for the trace statistic reported by Osterwald-Lenum (1992), not those tabulated in Johansen and Juselius (1990). Johansen also proposes an alternative LR test statistic, known as the maximum eigenvalue statistic, which tests (r) against (r+1). The maximum eigenvalue statistic can be computed from the trace statistic as

$$Q_{max} = -T \ln(1-\lambda_i) \quad (8)$$

According to the results of the Johansen maximum likelihood cointegration tests, the maximal eigenvalue statistic (LR) is 17.6458, which is great the 95 per cent critical value of 15.41. Therefore, indicate that there is cointegration relationship between COAL and GNP.

3.3. Results of Error-Correction Model

If two variables are non-stationary, but they become stationary after first-differencing, and co-integrated, the ECMs for the Granger-causality test can be specified accordingly as follows:

$$\Delta COAL_t = a_0 + \sum_{i=1}^{m} a_{1i}\Delta COAL_{t-i} + \sum_{i=1}^{n} a_{2i}\Delta GNP_{t-i} + \lambda ECM_{t-1} + u_t \quad (9)$$

$$\Delta GNP_t = b_0 + \sum_{i=1}^{m} b_{1i}\Delta GNP_{t-i} + \sum_{i=1}^{n} b_{2i}\Delta COAL_{t-i} + \theta ECM_{t-1} + \varepsilon_t$$

(10)

where Δ is the difference operator, m and n are the numbers of lags, a's and b's are parameters to be estimated and, λ and θ are the error correction term, which is derived from the long run co-integration relationship.

The results of the tests error correction model are presented in Table 4.

Table 4. The Result of Error Correction Model

	Lag Lengths	F Statistics	t statistics for ECM_{t-1}
Δ GNP- Δ COAL	m=1 n=1	9.7548*	-2.5745*
Δ COAL- Δ GNP	m=1 n=1	10.1356*	-2.6653*

Notes: The lag lengths are chosen by using *Schwarz* 's information criterion. * Denotes the rejection of the null hypothesis at 5% level of significance.

According to results of the Table 4, short-run causality is found to run from coal consumption to real GDP. In addition, the reverse short-run causality also exits. That is, there is bidirectional short-run Granger causality between coal consumption and economic growth. The coefficient of the ECM is found to be significant in Eq. (9) and in Eq. (10), which indicates that long-run Granger-causality from GNP to coal consumption and from coal consumption to GNP exists. Thus, according to the overall results, we can conclude that there is bidirectional causality between coal consumption and economic growth.

4. Conclusion

This paper has investigated the existence and direction of Granger causality between coal consumption and GNP in Turkey using the annual data covering the period 1970-2014. In the first stage, the stationarity of the data is investigated. On the basis of the ADF statistics, the null hypothesis of a unit root cannot be rejected. Stationarity is obtained by running the similar test on the first difference of the variables. This indicates that both the series are I(1). In the second stage, Johansen maximum likelihood procedure is used to detect cointegration. Hence, the value of Likelihood Ratio Statistic indicate that there is cointegration relationship between coal consumption and GNP. Finally, this paper examined the causal relationship between coal consumption and GNP. Empirical results showed that there are bidirectional short-run causality between coal consumption and economic growth, bidirectional long-run causality between economic growth and coal consumption. This study lends support to the argument that economic growth stimulates coal consumption. Intuitively, increased real GDP requires further coal consumption.

The finding of causality from coal consumption and to economic growth has important implications for policy analysts and forecasters in Turkey. A high level of coal consumption leads to a high level of real GDP, though there are many other factors contributing to economic growth, and coal is only one of such factors. Coal now constitutes a critical factor in sustaining the well-being of the Turkey people as well as the nation's economic growth. Moreover, production in industries such as electricity generation, and iron and steel manufacture demands a substantial amount of coal. Therefore, the constraints on coal consumption may restrain the economic growth in Turkey. In other words, a coal consumption growth policy should be adopted in such a way that it stimulates economic growth.

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