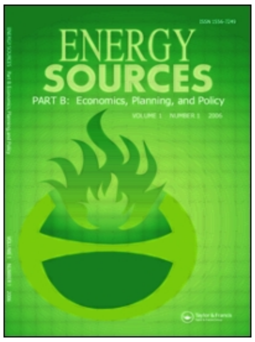

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Revisiting the Relationship Between Natural Gas Consumption and Economic Growth in Turkey

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The objective of this study is to re-analyze the relationship between natural gas consumption (NGC) and economic growth (GR) for Turkey in a multivariate framework by including capital and labor as additional variables because several papers suggest that a bivariate model can suffer from omitted-variables bias. As compared to the findings of Isik (2010), who previously investigated the short- and long-run relationships between GR and NGC using a bivariate model, we find that the magnitude of the coefficient estimate of NGC become substantially smaller in the long-run and the sign of short-run estimate of NGC shift to negative after accounting for capital and labor as well. In addition to that covered by Isik (2010), we investigate the direction of causality between GR and NGC using the vector error correction model Granger causality approach, and reveal the evidence of feedback hypothesis for Turkey.

Keywords: economic growth, energy consumption, Granger causality, natural gas consumption

INTRODUCTION

A number of empirical studies have investigated the relationship between energy consumption (EC) and economic growth (GR) for a variety of countries and regions since the seminal work of Kraft and Kraft (1978), who found unidirectional causality running from GR to EC. However, subsequent articles in the energy-growth literature have provided different directions of causality. Referring to them, there are four common hypotheses: *feedback hypothesis* occurs if there is a bi-directional causality between EC and GR (Asafu-Adjaye, 2000; Ozturk et al., 2010; Farhani and Ben Rejeb, 2012); *conservation hypothesis* happens when there is a one-way causality running from economic growth to energy consumption (Cheng and Lai, 1997; Lotfalipour et al., 2010; Akinwale et al., 2013); *growth hypothesis* exists only if EC causes GR (Masih and Masih, 1996; Soytas and Sari, 2003; Behmiri and Manso, 2013); *neutrality hypothesis* arises when there is no linkage among them (Yu and Hwang, 1984; Ozturk and Acaravci, 2010).

As is obvious from the mentioned articles, a consensus about the causal relationship between EC and GR has not been obtained yet. Why should we know whether or not EC links to GR? Policymakers in a country should know because the estimation result guides them to formulate

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proper economic policies and economic strategies.[1] For example, the Turkish government will encourage energy use if growth hypothesis exists, whereas it will aim to run conservative energy policies if an evidence of conservation hypothesis is found.

The second relevant and important question is, Why do empirical studies reveal various directions of causality, even for the same country? Although the differences in estimation results can be caused by a variety of factors such as applying different econometrics techniques and time periods, they mostly occur because of the omitted-variable bias problem. This problem appears when a regression is established neglecting one or more relevant factors, making the coefficient estimates of independent variables biased and inconsistent (Wooldridge, 2009). In addition, no-causality in a bivariate model can arise because of omitted variables (Lutkepohl, 1982) and obviously EC is not the only determinant factor in GR (Lean and Smyth, 2010).

In this study, we use natural gas consumption (NGC) as proxy for EC, because only Isik (2010), to the best of the author's knowledge, has used NGC to examine the relationship between EC and GR for the case of Turkey. Furthermore, Isik (2010) used a bivariate model to analyze the short-and long-run effects of EC on GR, which apparently suffers from the omitted-variable bias problem. Using the Autoregressive distributed lag approach to cointegration and the vector error correction model Granger causality techniques, the primary objective of this article is to explore short- and long-run estimates as well as the causality relationship in a multivariate framework by including capital and labor as additional variables to show how the results are different than in Isik (2010). This exercise is similar in spirit to Wolde-Rufael (2009) who indicated that introduction of labor and capital changed the causality direction in 13 countries which were previously investigated using a bivariate model by Wolde-Rufael (2005). In addition, Loizides and Vamvoukas (2005), and Odhiambo (2008) suggested that the direction of causality as well as the magnitude of the estimates could change after accounting for capital and labor.

There are several additional reasons why we prefer to employ NGC. First, NGC has gradually grown up and become an important energy sector in Turkey such that the amount of NGC increased from 26 billion cubic feet in 1987 to 346 billion cubic feet in 1997 and 1,598 billion cubic feet in 2012. Also, the fraction of NGC in the total EC went up from 1% to 11% and 32% in the same years according to the US Energy Information Administration. Moreover, NGC in Turkey on the average increased by 15% annually; one of the highest rates in the world. Besides, the linkage between NGC and GR not only guides the government to create appropriate NGC policies but also indirectly plays a crucial role in the destiny of electricity consumption in Turkey because the fraction of natural gas in sources used to generate electricity has substantially risen from 5.7% in 1987 to 43.6% in 2012 (Ministry of Energy and Natural Resources of the Republic of Turkey).

The rest of the present study is organized as follows. The next section provides a brief literature review, the third section explains the data and methodology, the fourth section reveals the empirical results, and the last section summarizes and discusses the findings of the paper.

A BRIEF LITERATURE REVIEW

Isik (2010) found NGC to have positive and negative impacts on GR in the short-run and the long-run, respectively. Apergis and Payne (2010) revealed a long-run relationship between GR, NGC, capital (K), and labor (L), and found a bi-directional causality between NGC and GR employing panel VECM for 67 countries from 1992–2005. Lean and Smyth (2010) found two-way causality between GR and EC applying the ARDL approach to cointegration and the Granger causality tests for Malaysia, and controlling for labor and capital for the years 1971–2006. Halicioglu (2011) investigated the linkage between aggregate output, EC, export, K, and L for the case of Turkey over the

[1]It is commonly accepted that countries wish to have higher rates of economic growth.

years 1968–2008 using the ARDL approach to cointegration and the Granger causality techniques, and showed that the causality run from EC to GR in the long-run and feedback hypothesis existed in the short-run. Shahbaz et al. (2013a) showed that there existed a long-run relationship and feedback hypothesis between NGC, GR, K, and L in the case of France using the ARDL and the VECM Granger methods for the period 1970–2010. Shahbaz et al. (2013b) found the evidence of growth hypothesis for Pakistan in a multivariate framework using K and L as well as energy use and gross domestic product (GDP) per capita.

METHODOLOGY AND DATA

Several articles have included NGC (or EC) as an additional factor into the production function (Narayan and Smyth, 2008; Apergis and Payne, 2010; Shahbaz et al., 2013a,b). Following the literature, we investigate the short- and long-run relationships and the direction of causality between NGC and GR in a conventional neo-classical production function where NGC, K, and L are considered as separate factors:

$$GR_t = f\left(NGC_t,\ K_t,\ L_t\right) \tag{1}$$

where GR is the natural logarithmic values of real GDP per capita and serves as proxy for economic growth, NGC is the natural logarithmic values of natural gas consumption per capita, K is the natural logarithmic values of real gross capital formation per capita, and L is the natural logarithmic values of labor force per capita. The data on NGC are drawn from the Ministry of Energy and Natural Resources of the Republic of Turkey and on the other variables are obtained from the World Bank's World Development Indicators for the period 1995–2012.[2] The descriptive statistics and correlation analysis of the variables are presented in Table 1. It is shown that GR is highly correlated with NGC and K.

To address how including K and L in the model changes the direction of causality and the magnitude of estimates in the short- and long-run as compared to that of Isik (2010), we perform the ARDL approach to cointegration test and the Granger causality in VECM framework for Eq. (1).

TABLE 1
Descriptive Statistics (a) and Correlation Analysis (b)

Variables	*GR*	*NGC*	*K*	*L*
(a)				
Max	3.92	−3.29	3.27	−0.43
Min	3.65	−4.23	2.90	−0.48
Mean	3.80	−3.67	3.08	−0.45
Std. Dev.	0.07	0.32	0.11	0.02
Skewness	0.26	−0.31	0.25	−0.18
(b)				
GR	1.00			
NGC	0.94	1.00		
K	0.92	0.77	1.00	
L	−0.23	−0.40	−0.15	1.00

[2]The data are available at http://data.worldbank.org.

ARDL Approach to Cointegration Method

The ARDL bounds test for cointegration is introduced by Pesaran and Shin (1999) and Pesaran et al. (2001), and superior to the cointegration tests developed by Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990) in many aspects:

i. It provides consistent and unbiased long-run estimates even if the data are small and independent variables are endogenous;
ii. Each time-series can have a different appropriate lag length;
iii. It allows us to simultaneously obtain the long-run and short-run elasticity estimates of the dependent variables with respect to the independent variables in one regression;
iv. It can be employed irrespective of whether the series are integrated in different orders unless the order of integration is greater than one, i.e. I(2).

In other words, ARDL bounds test for cointegration provides efficient and consistent results when the variables are integrated in order zero, I(0), and one, I(1). We thus apply one of the most popular methods, the Augmented Dickey-Fuller unit root test (ADF), to confirm that the variables GR, NGC, K, and L are either I(0) or I(1). Dickey and Fuller (1979) present the ADF as:

$$\Delta X_t = \alpha + \beta X_{t-1} \sum_{i=1}^{n} \theta_i \Delta X_{t-i} + \rho T + \mu_t \tag{2}$$

where μ_t is a normally distributed white noise error term, T is a deterministic time trend, X_{t-1} is the lagged value of a time-series variable (i.e. GR), ΔX_{t-i} are the lagged values of the first differenced series, and α, β, θ, ρ are the estimated parameters. An appropriate lag length is selected based on the Akaike Information Criterion (AIC).

After analyzing the ADF, the next step is to set up the ARDL based on the standard log-linear functional specification with an unrestricted error correction mechanism (UECM). The UECM integrates the short-run dynamics with the long-run equilibrium without losing any long-run information. The UECM for Eq. (1) is written by:

$$\begin{aligned}\Delta GR_t = {} & C_0 + \sum_{i=1}^{k} a_i \Delta GR_{t-i} + \sum_{i=0}^{l} \beta_i \Delta NGC_{t-i} + \sum_{i=0}^{m} \gamma_i \Delta K_{t-i} + \sum_{i=0}^{n} \delta_i \Delta L_{t-i} \\ & + \emptyset_1 GR_{t-1} + \emptyset_2 NGC_{t-1} + \emptyset_3 K_{t-1} + \emptyset_4 L_{t-1} + \varepsilon_t \end{aligned} \tag{3}$$

where Δ is the first difference operator; α, β, γ and δ are the coefficients on GR, NGC, K, and L, respectively; ε is a white noise error term; k, l, m, and n are the optimal lag lengths selected based on the AIC. The potential presence of cointegration between GR, NGC, K, and L is examined based the joint F-statistics. The null hypothesis of no cointegration, H_o:$\emptyset_1 = \emptyset_2 = \emptyset_3 = \emptyset_4 = 0$, is tested against the alternative hypothesis, H_a:$\emptyset_1 \neq \emptyset_2 \neq \emptyset_3 \neq \emptyset_4 \neq 0$. Because the distribution of test statistics under the null is non-standard, Pesaran et al. (2001) produce critical value bounds for the F-test. If calculated F-statistics fall below the lower critical bound, I(0), the null hypothesis cannot be rejected; in contrary, if calculated F-statistics exceed the upper critical bound, I(1), the null will be rejected in favor of the alternative hypothesis and thus the series are said to be cointegrated.

Once Eq. (3) is solved through the ARDL approach, the short-run effects of each time-series are posed by the coefficient estimates of the first-differenced series. For instance, the short-run effects of NGC are judged by the estimates of β_i.In addition, the long-run effects of NGC, K, and L are posed by the estimates of $\emptyset_2, \emptyset_3$and$\emptyset_4$, which are normalized by the estimate of $\emptyset_1$.[3]

[3]The Microfit 5.0 strtistical package is used to obtaion the estimated coefficients in ther ARDL approach. For a detailed explanation about normalization, please see the MIFT5.0 manual prepared by pesaranand pesaran (2009).

Causality Analysis

Granger (1988) argues that there should be at least one-way causality if two or more variables are cointegrated. Although the ARDL approach to cointegration explores whether the time-series are cointegrated, it does not reveal the causality direction between them. To obtain the linkage between variables, we follow Granger causality in the VECM framework proposed by Engle and Granger (1987):

$$\Delta GR_t = C_0 + \sum_{i=1}^{p} \zeta_i \Delta GR_{t-i} + \sum_{i=0}^{q} \vartheta_i \Delta NGC_{t-i} + \sum_{i=0}^{r} \xi_i \Delta K_{t-i} + \sum_{i=0}^{s} \psi_i \Delta L_{t-i} + \Phi_1 ECM_{t-1} + \omega_{2t} \quad (4)$$

where Δ is the first difference operator; ζ, ϑ, ξ and ψ are the coefficients on GR, NGC, K, and L; $\omega$is a white noise error term; k, l, m, and n are the optimal lag lengths selected based on the AIC; ECM_{t-1} is the lagged error correction mechanism attained from the long-run equilibrium relationship; Φ stands for the speed of adjustment to the long-run equilibrium. The VECM Granger approach can be tested in three ways:

- A short-run Granger causality is conducted testing the significance of the sum of the lagged differences of the right hand-side variables based on the Wald-test statistics. For example, the short-run causality between GR and NGC is investigated by testing the null hypothesis of no-causality, H_0: $\vartheta_i = 0$, against the alternative hypothesis of non-causality, H_a: $\vartheta_i \neq 0$.
- A long-run Granger causality is conducted testing the significance of ECM_{t-1} based on the Wald-test statistics. For example, the long-run causality between GR, NGC, K, and L is investigated by testing H_0: $\Phi_1 = 0$ against H_a: $\Phi_1 \neq 0$.
- A strong causality between GR, NGC, K, and L is conducted by testing H_0: $\vartheta_i = \xi_i = \psi_i = \Phi_1 = 0$against H_a: $\vartheta_i \neq \xi_i \neq \psi_i \neq \Phi_1 \neq 0$.

EMPIRICAL RESULTS

Unit Root Tests

The ADF test is employed to pose whether or not the variables economic growth, energy consumption, capital, and labor are either I(0) or I(1) because the ARDL approach to cointegration will not be an accurate estimator when the order of integration of a variable is greater than one, i.e. I(2). Table 2 represents that the time-series are not stationary in their levels but stationary in their first differences.[4] As the variables are found to be I(1), we can confidently apply the ARDL method to test the presence of cointegration among the variables in Eq. (3).

Cointegration Test

The calculated F-statistic from the ARDL approach to cointegration is reported in Part (a) in Table 3. The optimal lag length is selected based on the AIC. The null hypothesis of no cointegration can be rejected for the case where GR is the dependent variable, and NGC, K, and L are the explanatory variables because the calculated F-statistic is far greater than the upper critical bound, I(1). Thus, a long-run relationship exists between GR, NGC, capital, and labor.

[4]Note that the null hypothesis of including a unit root can be rejected when the absolute value of the ADF-test statistic is greater than the absolute value of the critical point.

TABLE 2
ADF Test Results

Levels				*First Differences*			
Variables	*ADF-test Statistics*	*Lag Length*	*5%-Critical Values*	*Variables*	*ADF-test Statistics*	*Lag Length*	*5%-Critical Values*
GR	−2.27	1	−3.91	ΔGR	−3.10*	0	−1.94
NGC	−1.26	0	−3.76	ΔNGC	−1.95*	0	−1.94
K	−0.65	0	−3.76	ΔK	−4.10*	0	−1.94
L	−1.39	1	−3.91	ΔL	−2.11*	1	−2.01

Note: * denotes the significant 5% level. Critical values are computed by stochastic simulations for the indicated lagged numbers using 1,000 replications. An option of trend and intercept is used for the levels and an option of no-trend and no-constant is used for the first differences.

At the second stage, the short- and long-run coefficients on NGC, K, and L are estimated from the ARDL model as the variables are found to be cointegrated. Part (b) in Table 3 reports the short-run and long-run coefficient estimates of NGC, K, and L. Since all variables are transformed into the form of natural logarithmic values, coefficients on NGC, K, and L formally equal to the elasticities of GR with respect to NGC, K, and L. Results in Part (b) indicate that a 1% increase in NGC reduces GR by 0.15% and 0.01% in the long-run and short-run, respectively. As compared to the findings of Isik (2010), the magnitude of the effect of NGC on GR is smaller in the long-run, and more interestingly its short-run effect shifts to negative after introducing K and L into the regression. The changes in the estimates are consistent with Odhiambo (2008).

Considering the lagged error correction termECT_{t-1}, the negative and statistically significant coefficient estimate confirms the existence of the long-run relationship between GR, NGC, K, and L. In addition, the coefficient on ECT_{t-1} implies that deviations from the long-run equilibrium are corrected by nearly 6% in each year, which is substantially smaller than in Isik (2010) but in line with that found by Shahbaz et al. (2013a).

Part (b) in Table 3 also presents that the estimated ARDL model passes necessary diagnostic tests. We find no evidence of serial correlation, autocorrelation, misspecification and heteroskedasticity. The last identification related to the goodness of fit of the model is stability tests. For this purpose, we perform cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) tests. As seen in Figure 1, the estimated parameters are stable over time since the plot of CUSUM and CUSUMQ test statistics fall within the boundaries.[5]

Granger Causality Test

Accompanying the evidence of the long-run relationship between GR, NGC, K, and L, it is of interest for researchers to perform the Granger causality test to present a clear picture for policymakers to regulate economic policies and energy strategies by understanding the direction of causality. Because they are concluded to be cointegrated, VECM Granger causality can be applied to reveal the direction of causality between the variables as well as to decompose the direction of causality into short-run and long-run effects. The short-run causality is tested based on the statistical significance of the partial Wald-statistics related with the explanatory variables. The long-run causality is performed by the statistical significance of the $ECT_{t\text{-}1}$ using the Wald-statistic. The strong-causality

[5]The straight lines stand for the critical bounds at the 5% significance level.

TABLE 3
Cointgration Test Results (a) and Long- and Short-run Estimates (b)

(a)

			5% Critical Values#	
Estimated Model	*Lag Length*	*F-Statistics*	*I(0)*	*I(1)*
f(GR/NGC, K, L)	(1,0,1,0)	17.59*	3.23	4.35

(b)

Long-run Analysis				
Variables	*Coeff.*	*Std. Error*	*T-ratio*	*Prob.*
NGC	−0.15*	0.07	−2.25	0.04
K	0.96**	0.11	8.17	0.00
L	−0.82	0.95	−0.87	0.40
Short-run Analysis				
Variables	*Coeff.*	*Std. Error*	*T-ratio*	*Prob.*
NGC	−0.01*	0.01	−2.18	0.04
K	0.29**	0.02	19.12	0.00
L	−0.04	0.07	−0.72	0.48
ECT(-1)	−0.06*	0.03	−2.32	0.03
R^2	0.97			
F-statistic	137.05**			0.00
DW-statistic	2.22			
Short-run Diagnostic Test				
Test	*Prob.*			
Serial Corr.	0.52			
Normality	0.79			
ARCH	0.27			
RESET	0.08			

Note: * denotes the significance at the 5% level. ** denotes the significanc at the 1% level.
Critical values are taken from Pesaran et al. (2001).

is analyzed by the statistical significances of both the independent variables and the ECT_{t-1} based on the Wald-statistic.

The results of Granger causality in the VECM approach are represented in Table 4. P-values based on the Wald-test imply that there is a bi-directional causality between GR and NGC in the long-run and short-run, which indicate the evidence of feedback hypothesis in the case of Turkey. The result of the strong-causality also confirms the direction of causality in Turkey. This finding is in line with Apergis and Payne (2010), Lean and Smyth (2010), Halicioglu (2011) and Shahbaz et al. (2013a). While neither capital nor labor Granger causes NGC, K Granger causes economic growth. In the case of capital as the dependent variable, there is a long-run causality as well as strong causality running from GR, NGC and L to K at the 1% level; short-run causality only runs

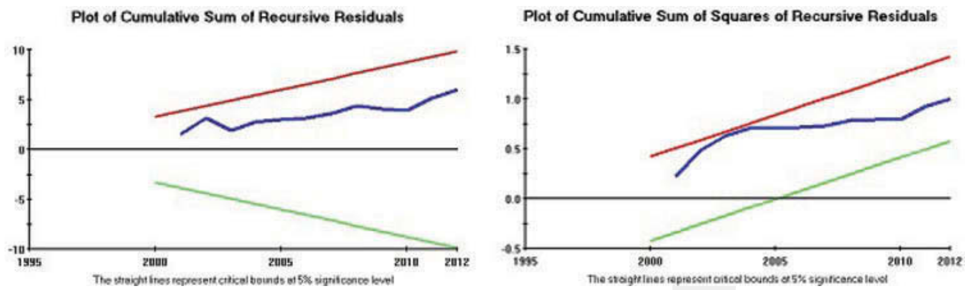

FIGURE 1 CUSUM and CUSUMQ stability tests.

TABLE 4
The Granger Causality Test Results

Dependent	*Short-run Causalities*				*Long-run Causality*	*Strong Causality*
Variable	*ΔGR*	*ΔNGC*	*ΔK*	*ΔL*	*ECT(-1)*	*Joint*
ΔGR	–	4.72* (0.03)	32.99** (0.00)	0.51 (0.47)	5.38* (0.02)	41.88** (0.00)
ΔNGC	5.17* (0.02)	–	3.28 (0.07)	3.60 (0.06)	5.98* (0.02)	13.01** (0.01)
ΔK	30.28** (0.00)	5.42* (0.02)	–	0.54 (0.46)	8.11** (0.00)	45.47** (0.00)
ΔL	0.99 (0.31)	13.49** (0.00)	0.55 (0.45)	–	3.99* (0.04)	14.75** (0.01)

Note: ** and * denote the significance at 1% and 5% levels, respectively. P-values are in parenthesis.

from GR and NGC to capital. Finally, there is a long-run causality running from GR, NGC and K to L at the 5% level, but only NGC Granger causes L in the short-run.

CONCLUSIONS

For the case of Turkey, only one article has analyzed the relationship between NGC and GR. Because the article by Isik (2010) employed a bivariate model and several articles have suggested that bivariate models can suffer from omitted-variables bias, the objective of this study is to re-analyze the relationship between NGC and GR for Turkey in a multivariate framework by including capital and labor as additional variables. As compared to the findings of Isik (2010), we find that the magnitude of the coefficient estimate of NGC become substantially smaller in the long-run and the sign of short-run estimate shift to negative after accounting for capital and labor as well. In addition to that covered by Isik (2010), we investigate the direction of causality between GR and NGC using a VECM Granger causality approach. An evidence of feedback hypothesis is found for Turkey in line with Apergis and Payne (2010), Lean and Smyth (2010), Halicioglu (2011) and Shahbaz et al. (2013a). This study suggests that energy strategies and economy policies initiated to replace NGC must begin in a short time since short- and long-run estimates of NGC on GR are found to be negative. The Turkish government should concentrate on producing energy through other types of sources such as wind, biofuels, and solar.

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