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Correlations between energy consumption per capita, growth rate, industrialisation, trade volume and urbanisation: the case of Turkey

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Abstract

This study examines the relationship of energy consumption per capita with growth rate, industrialisation, trade volume and urbanisation in Turkish economy throughout the 1980–2015 period using the Engle-Granger, Fully modified ordinary least squares (FMOLS), canonical cointegration regression (CCR) and dynamic ordinary least squares (DOLS) methods. Analysis results revealed a long-run equilibrium relationship between the change in energy consumption per capita and growth rate, industrialisation, trade volume and urbanisation. Urbanisation, industrialisation, growth rate and trade volume positively influence the change in energy consumption per capita.

Keywords: Energy consumption, Engle-Granger method, fully modified ordinary least squares (FMOLS) method, canonical cointegration regression (CCR), dynamic ordinary least squares (DOLS) method.

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1. Introduction

The most important objectives pursued by countries in their energy policies include increasing energy efficiency, reducing energy intensiveness and paying attention to energy saving. In modern energy policies, the aim is to develop systems that use energy in the most efficient ways and build an infrastructure that can generate and transmit the highest amount of energy, rather than increasing the amount of energy used by each individual or energy consumption per capita.

A vital requirement for energy policies concerns robust forecasting of energy demands. Main variables underlying energy demand forecasts include economic growth (capital accumulation, employment, increase in productivity, etc.), population (population growth rate, migration, actively working population, etc.), energy prices, technological advances, energy policies (tax policies, incentives, etc.) and consumer behaviour energy saving. Since the energy demand in Turkey is usually met through imported sources, it is extremely important to carry out robust energy demand forecasts in formulating energy policies.

The present study intends to examine the relations between the change in energy consumption per capita and growth rate, industrialisation, trade volume and urbanisation.

The study consists of three sections. Following the introduction, section two presents a review of the relevant literature. Section three builds a related econometric model, which is predicted using the Engle-Granger, fully modified ordinary least squares (FMOLS), canonical cointegration regression (CCR), and dynamic ordinary least squares (DOLS) methods. The conclusion part interprets analysis results.

2. Literature review

Correlations between magnitudes such as urbanisation, industrialisation, trade volume, economic growth and energy consumption usually depend on the economic conditions of countries. Thus, studies investigating into the interaction between such variables found different analysis results with different countries and data sets pertaining to different time spans. In their study dealing with the 1971–2008 period for Tunis, Shahbaz and Lean (2012) discovered a long-run equilibrium relationship between energy consumption and economic growth, industrialisation and urbanisation, while Shahbaz, Hye, Tiwari and Leitão (2013) investigated the short and long-run relations between economic growth, financial development, trade openness, CO_2 emission and energy consumption in Indonesia. Similarly, Shahbaz, Khan and Tahir (2013) examined the relationship between energy consumption, economic growth, financial development and trade deficit for the case of Chinese economy; whereas, Islam et al. (2013) studied the correlation between energy consumption, economic growth, financial development and population in Malaysian economy. Drawing upon the data pertaining to the Southern Asian economic for the 1980–2009 period so as to analyse the dynamic relations between energy consumption, trade and GDP, Shakeel et al. (2013) found that there exists a short-run feedback relationship between energy consumption and real GDP, as well as between exports and real GDP. Likewise, Khan, Khan, Zaman, and Arif (2014) analysed the relationship between energy consumption, economic growth, FDI, relevant energy price and financial development using the data from the 1975–2011 period for the country groups under study. Using panel data and causality tests, Hossain (2011) examined the relations between CO_2 emission, energy consumption, economic growth, trade openness, and urbanisation rate for nine newly industrialising countries (Brazil, China, India, Malaysia, Mexico, Philippines, South Africa, Thailand, and Turkey) in the 1971–2007 period. Al-mulali and Lee (2013) used the 1980–2009 data of GCC (Gulf Cooperation Council) countries to investigate the correlation between energy consumption, financial development, economic growth, urbanisation and overall trade. Further, Polat, Uslu and San (2011) used the Granger causality test to analyse the relationship between electricity consumption, employment and economic growth for Turkey during the 1950–2006 period. In a similar vein, drawing upon annual data for Turkey pertaining to the 1960–2012 period, Lebe and Akbaş (2015) studied the impact of financial development, economic growth, urbanisation and industrialisation upon energy consumption. The analysis revealed that it was economic growth, industrialisation and financial development, respectively, which had the greatest impact upon energy consumption in Turkey, while urbanisation did not have much effect.

The relationship between energy consumption and economic growth turned into a hot topic following the oil price shock of the 1970s, which brought about great deal of research in the literature. In this respect, Rufael (2004) analysed the relationship between electricity consumption and economic growth in 17 African countries throughout the 1971–2001 period. Odhiambo (2008) discovered a long-run equilibrium relationship between overall energy consumption and economic growth in the 1971–2006 period in Tanzania, while Fuinhas and Marques (2012) found out the same relationship for Portugal, Italy, Greece, Spain and Turkey for the 1965–2009 period. Examining the 1974–2004 data for Turkish economy to shed light upon the relationship between economic growth and electricity consumption, Karagöl, Erbaykal and Ertuğrul (2007) reported a positive correlation between electricity consumption and economic growth in the short run. Similarly, analysing the relationship between electricity consumption and growth in Malaysia to ascertain whether the country's growth was based on energy, Chandran, Sharma and Madhavan (2010) found a causality running from electricity consumption to economic growth. Erdoğan and Gürbüz (2014) detected a long-run equilibrium relationship between energy consumption and economic growth for Turkey during the 1970–2009 period. On the other hand, Özata (2010) investigated into the causality relationship between energy consumption and GNP in Turkey for the 1970–2008 period. In another study, Korkmaz and Develi (2012) examined the causality and cointegration relations between energy consumption, energy production and GDP for the 1960–2009 period in Turkey. Finally, Gövdere and Can (2015) analysed the relation between energy consumption and economic growth for Turkey during the 1970–2014 period.

3. Empirical analysis

Using the 1980–2015 data in Turkish economy, this study examines the relations between the change in energy consumption per capita, growth rate, industrialisation, trade volume and urbanisation. The data concerning the variables *'energy consumption per capita, growth rate, industrialisation, trade volume and urbanisation'* were all retrieved from the electronic database of the World Bank. What follows is the econometric model constructed:

$$ENJ_t = \alpha_0 + \alpha_1 TIC_t + \alpha_2 SAN_t + \alpha_3 KENT_t + \alpha_4 BUY_t + \varepsilon_t \qquad (3.1)$$

where

ENJ: Percentage increase in annual energy consumption per capita (Kilogram oil equivalent) (%)

TIC: Trade volume (Total imports and exports/GDP) (%)

SAN: Industrialisation defined as industrial added value (difference between industrial output and input/GDP) (%)

KENT: Urbanisation (Urban population / total population) (%)

BUY: Growth rate (%)

The results are expected to positively estimate α_1, α_2, α_3 and α_4 coefficients.

The relations between energy consumption and other variables are explained below:

Due to high energy costs, goods manufactured by energy-dependent economies have less competitive advantage, which results in constant deficits in their terms of foreign trade. Specifically, the oil-driven energy crisis arising in the 1970s resulted in significant problems in the economies of industrialising and non-industrialised countries. Developing countries came to consume more and more energy with increasing industrialisation rates. Lack of efficient technological equipment in energy use, as well underdeveloped service sector lead to higher energy consumption per unit output in these countries. In developing countries, inadequate capacity increase despite the rapid growth in energy demand (i.e., insufficient energy supply) create circumstances that undermine economic competitiveness, such as disruption of industrial production and escalating energy prices (Saatçioğlu and Küçükaksoy, 2015). On the other hand, industrialisation is defined as the growth in industrial activity with greater production leading to greater energy consumption. Increased use of new equipment and techniques as a result of industrialisation and thereby manufacturing of new products all require greater use of energy (Sadorsky, 2012).

The rapid growth in population and urbanisation in countries is another factor accounting for the boost in energy demand. There are several ways whereby urbanisation affects energy consumption. First of all, urbanisation increases energy consumption by influencing the amount of output. Furthermore, it contributes to energy consumption by concentrating economic activity in urban and metropolitan areas. Urbanisation increases energy consumption as it diverts production from less energy-intensive agricultural activities to more energy-intensive manufacturing industry. As a result of growing urbanisation, people use more and more motorised vehicles, as well as products such as refrigerators and air conditioners, all of which result in increased energy consumption. Similarly, increased use of energy-intensive materials in infrastructure in urban areas also leads to greater energy consumption.

Thanks to the advantages offered by economies of scale, which refers to the larger-scale production of enterprises, the rise in foreign trade volume and thus in exports brings about lower costs and enhanced production. Flourishing foreign trade stimulates competitiveness, thereby contributing to greater employment and labour productivity and consequently growth through technological advances (Aytaç and Akduğan, 2012: 56). By improving the distribution of income, foreign trade fosters both growth and development. Underdeveloped countries in particular attain growth through export revenues, which they also use to import industrial and capital goods much needed for development. Hence, foreign trade plays a key role in the process of economic development (Ersungur and Doru, 2014: 229). Consequently, it not only positively impacts upon economic growth, but also results in a greater need for energy consumption.

While it is possible to have a bidirectional causality between energy consumption and economic growth (feedback hypothesis), the two variables may also lack any correlation (neutrality hypothesis). The Conservation hypothesis holds that energy saving policies designed to minimise energy consumption and waste do not adversely affect real GDP. This hypothesis only holds true when an increase in real GDP leads to increased energy consumption. However, economic growth might slow down as a result of political instability, poor management of resources and shrinking demand for goods and services including energy consumption. This in turn would negatively affect energy consumption. On the other hand, the growth hypothesis contends that, complementary to labor and capital in the process of production, energy consumption impacts upon economic growth either directly or indirectly (Apergis and Payne, 2009).

As is evident from the above discussion, urbanisation, industrialisation, trade volume and economic growth mutually supportive variables related to energy consumption.

3.1. Unit root tests

Using ADF unit root test, this study investigates stationarity of the series. ADF test results are shown in the table below.

Table 1. ADF test results

Variables	Level		First-order difference	
ENJ	-2.11*	k:2	-7.476**	k:1
	(model without constant)		(model without constant)	
TIC	-1.87*	k:0	-5.52**	k:0
	(model with constant)		(model with constant)	
SAN	-2.082*	k:1	-5.068**	k:1
	(model with constant)		(model with constant)	
KENT	-2.616*	k:1	-7.035**	k:1
	(model with constant)		(model with constant)	
BUY	-2.06. *	k:1	-4.045**	k:4
	(model without constant)		(model without constant)	

*Series is not stationary ($\alpha_{0.01=}$-2.63)

**Series is stationary ($\alpha_{0.01=}$-2.63)

k represents the lag order.

Variables ENJ and BUY are I(1) at $\alpha_{0.01}$ in the model without constant. Since I(0) was found at $\alpha_{0.05}$ and $\alpha_{0.10}$ in 'constant + trend' and 'constant + slope' models; the results of these models were not used.

As seen in Table 1, all variables were found to be first-order difference stationary. Hence, Engle-Granger (1987), FMOLS, CCR and DOLS methods were used to estimate model (3.1).

The results obtained by Engle-Granger two-step estimation method are as shown below:

$$ENJ_t = -5.143 + 0.00175KENT_t + 0.127SAN_t + 0.0066TIC_t + 0.78BUY_t \quad (3.2)$$

p → (0.45) (0.99) (0.45) (0.94) (0.0000)

R^2=0.65 F=14.05(p:0.000) ADF_U= -6.51(p:0.000) dw=2.11 F_{white}=0.34 (p:0.97)

ARCH(1 lag)=0.32(p:0.57) BG(1 lag)=0.47(p:0.49) (p denotes the probability value)

In model (3.2), urbanisation, industrialisation and trade volume positively affect the change in energy consumption per capita; however, the coefficients were not statistically significant (probability value (*p*) is above 0.10). Still, the growth rate coefficient is significant. When the other variables are constant, a 1% increase in growth rate leads to a 0.78 % increase in the change in energy consumption per capita. Growth rate is the most important variable that affects the change in energy consumption per capita. The overall model (F = 14.05) is significant. It does not have any autocorrelation (dw, BG tests) and heteroscedasticity (White, ARCH tests) problems. Model (3.2) is shown to be a long-run equilibrium model (ADF_U = -6.51).

3.2. Fully modified ordinary least squares

There is ample research in the literature about the asymptotic properties of cointegrating vector estimators and the results in general showed that asymptotic properties are not affected by endogeneity or serial correlation. Moreover, practitioner researchers lack enough data to prove asymptotic theory. Therefore, it has become more important to examine the small-sample performance of alternative cointegrating vector estimators. In addition, overall results suggest that methods that overlook short-run dynamics are largely biased with small samples (Mantolva, 1995)[*].

[*]Using Monte Carlo simulations, Mankiw and Shapiro (1986) showed that test statistics can no longer have a standard distribution when regressors in a regression equation used for estimation are almost continuous and endogenous. Later, Cavanagh (1995), Stambaugh (1999) and Moreira (2004), Lewellen (2004) and Campeland and Yogo (2006) proposed alternative methods to show similar cases.

FMOLS method generates consistent small-sample estimates and allows for checks to ensure result reliability. The FMOLS method is based on Phillips and Hansen's (1990) study.

To attain asymptotic efficiency, the FMOLS technique modifies Ordinary Least Squares to account for serial correlation effects and test for endogeneity resulting from cointegrating relationships (Rukhsana and Shahbaz, 2008). For this, it applies semi-parametric correction procedure. The resulting FMOLS estimator is asymptotically unbiased and efficient.

The FMOLS technique is a single-equation method which assumes a single cointegrating vector. It is a suitable estimator for cases in which the series are cointegrated at first difference I(1).

Given the variables in the constructed model, steps for the FMOLS method can be shown as follows.

As a starting point, we estimate $\left[ENJ_t, X_t^{'} \right]$, the (d+1) dimensional time series vector process based on the co-integrating equation:

$$ENJ_t = X_t^{'}\beta + D_{1t}^{'}\gamma_1 + u_{1t} \tag{3.3}$$

where $D_t = \left[D_{1t}^{'}, D_{2t}^{'} \right]^{'}$ stands for deterministic trend regressor and $X_t^{'} = [KENT_t, SAN_t, T\dot{I}C_t, BUY_t$ represents the stochastic regressors derived in the following equation, where d is 4.

$$X_t = \Gamma_{21}^{'} D_{1t} + \Gamma_{22}^{'} D_{2t} + \varepsilon_{2t} \tag{3.4}$$

$$\Delta\varepsilon_{2t} = u_{2t} \tag{3.5}$$

In the study, D1t involved only constant. D2t is a deterministic trend; however, Eq. (3.3) does not contain any deterministic trend. Therefore, the FMOLS estimator is:

$$\hat{\theta}_{FMOLS} = \begin{bmatrix} \hat{\beta} \\ \hat{\gamma}_1 \end{bmatrix} = \left(\sum_{t=1}^{T} Z_t Z_t^{'} \right)^{-1} \left(\sum_{t=1}^{T} Z_t ENJ_t^{+} - T \begin{bmatrix} \hat{\lambda}_{12}^{+} \\ 0 \end{bmatrix} \right) \tag{3.6}$$

where $Z_t = \left(X_{t,}^{'} D_t^{'} \right)^{'}$ dir.

Let $\hat{\Omega}$ and $\hat{\Lambda}$ be long-run covariance matrices obtained by using the residuals

$\hat{u}_t = \left(\hat{u}_{1t}, \hat{u}_{2t}^{'} \right)^{'}$ then modified data can be defined as follows:

$$ENJ_t^{+} = ENJ_t - \hat{w}_{12}\hat{\Omega}_{22}^{-1}\hat{u}_2 \tag{3.7}$$

An estimated bias correction term:

$$\hat{\lambda}_{12}^{+} = \hat{\lambda}_{12} - \hat{w}_{12}\hat{\Omega}_{22}^{-1}\hat{\lambda}_{22} \tag{3.8}$$

With Bartlett kernel and Newey–West fixed bandwidth = 4.000, we obtain the following result:

ENJt = -6.188 + 0.0258KENTt + 0.123SANt + 0.008TICt + 0.80BUYt (3.9)

p → (0.265) (0.803) (0.362) (0.91) (0.0000)

R2=0.65 Long-run variance: 4.023 (p denotes the probability value)

3.3. Canonical cointegration regression

Devised by Park (1992), the CCR technique was developed to estimate and test the coefficients of the variables in a cointegration model. CCR is closely related to FMOLS; however, FMOLS method first corrects $\{y_t\}$ to derive $\{y_t^+\}$; on the other hand, CCR procedure corrects $\{x_t\}$ and $\{y_t\}$ simultaneously. Park (1992) demonstrated that the endogeneity problem can be eliminated and asymptotic bias can be corrected by CCR transformations. Thus, CCR based estimations are fully efficient like FMOLS and have an unbiased, normal asymptotic distribution. Like FMOLS, CCR is also a single-equation method.

Thus, CCR estimator is obtained as follows (Belke & Czudajy, 2010):

$$\hat{\theta}_{CCR}=\begin{bmatrix}\hat{\beta}\\ \hat{\gamma}_1\end{bmatrix}=\left(\sum_{t=1}^{T}Z_t^{*}Z_t^{*'}\right)^{-1}\sum_{t=1}^{T}Z_t^{*}ENJ_t^{*} \tag{3.10}$$

where $$Z_t^{*}=\left(X_{t,}^{'}D_t^{'}\right)^{'},\; X_t^{*}=X_t-\left(\hat{\Sigma}^{-1}\hat{\Lambda}_2\right)^{'}\hat{u}_t \tag{3.11}$$

$$ENJ_t^{*}=ENJ_t-\left(\hat{\Sigma}^{-1}\hat{\Lambda}_2\tilde{\beta}+\begin{bmatrix}0\\ \hat{\Omega}_{22}^{-1}\hat{w}_{21}\end{bmatrix}\right)^{'}\hat{u}_t \tag{3.12}$$

$\hat{\beta}$, denotes the estimates of the cointegrating equation coefficients obtained by using static OLS, $\hat{\Lambda}_2$ represents the second column of $\hat{\Lambda}$, and $\hat{\Sigma}$, stands for the estimated contemporaneous covariance matrix of the residuals (Hamilton, 1994, pp. 618–625).

Hence, for the same Bartlett kernel and Newey-West fixed bandwidth = 4.000 used in FMOLS, the model estimated using the CCR technique is as shown below:

$ENJ_t = -5.767 + 0.0328KENT_t + 0.106SAN_t + 0.0181TIC_t + 0.817BUY_t$ (3.13)

p→ (0.218) (0.769) (0.381) (0.829) (0.0000)

R^2=0.649 Long-run variance:4.023 (*p* denotes the probability value)

The models obtained using the FMOLS and CCR methods were found to have similar coefficients.

3.4. Dynamic ordinary least squares

DOLS technique was developed by Saikkonen (1991) and Stock-Watson (1993). DOLS is a simple method allowing to build an asymptotically efficient estimator that eliminates the feedback in the cointegrating system. It contains the variables with first difference so that the small-sample bias resulting from the correlation between error term and I(1) variables can be eliminated (Caporale & Chui, 1999). Below is the augmented cointegrating equation including the lags and leads of ΔX_t so that the cointegrating equation error term is orthogonal to the stochastic regressor innovations:

$$ENJ_t=X_t^{'}\beta+D_{1t}^{'}\gamma_1+\sum_{j=-q}^{r}\Delta X_{t+j}^{'}\delta+v_{1t} \tag{3.14}$$

On the other hand, DOLS estimation procedure works under the assumption that the added lags and leads of ΔX_t completely eliminate the long-run correlation between u_{1t} and u_{2t}. Thus, the resulting estimator is then given by $\hat{\theta}_{DOLS} = \left(\hat{\beta}', \hat{\gamma}_1'\right)'$ and displays the same asymptotic distribution as those derived with the FMOLS and the CCR estimation procedures (Belke and Czudajy, 2010:20).

With 1 lag, 1 lead, and Bartlett kernel and Newey–West fixed bandwidth = 4.000, the DOLS technique uses long-term variance estimations to generate the following result:

$$ENJ_t = -9.68 + 0.033KENT_t + 0.141SAN_t + 0.037TIC_t + 0.814BUY_t \quad (3.15)$$

p→ (0.677) (0.91) (0.605) (0.812) (0.0103)

R^2=0.768 Long-run variance: 4.554 (p denotes the probability value)

4. Conclusion

This study examines the long-run relations between the change in energy consumption per capita and growth rate, industrialisation, trade volume, and urbanisation. To this end, it used the Engle–Granger, FMOLS, CCR, and DOLS methods.

It was found that the single-equation estimation methods including Engle-Granger, FMOLS, CCR and DOLS yielded results that confirmed economic expectations. While growth rate, urbanisation, industrialisation and trade volume positively impact the change in energy consumption per capita, their coefficients were not found to be statistically significant. Yet, growth rate turned out to be the principal variable affecting the change in energy consumption per capita. According to the Engle-Granger method, a 1% increase in growth rate increases the change in energy consumption per capita by 0.78%, while the same amount of increase results in a 0.80% increase in the same variable according to the FMOLS method. It was found that a 1% increase in growth rate increases the change in energy consumption per capita by 0.817% using the CCR method and by 0.814% using the DOLS method.

Improvements in industrialisation enhance economic growth with greater trade volume significantly contributing to industrialisation and economic growth. Defined as the population shift from rural to urban areas and change in favour of the latter, urbanisation is considered among factors with impact upon economic growth. Hence, economic growth of a country, taken as a whole together with industrialisation, trade volume and urbanisation, affects energy consumption per capita. In a similar vein, the analysis results also revealed that when compared to the variables of industrialisation, trade volume and urbanisation, growth rate is a more significant variable accounting for the change in energy consumption per capita.

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