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# Does Too Much Energy Consumption Harm Economic Growth for Turkish Republics in The Transition Process? New Evidence on Threshold Effects#

**Celil Aydın[1], Ömer Esen[2]***

[1]Department of Economics, Faculty of Economics and Administrative Sciences, Mus Alparslan University, 49250, Muş, Turkey, [2]Department of Economics, Faculty of Economics and Administrative Sciences, Mus Alparslan University, 49250, Muş, Turkey. *Email: o.esen@alparslan.edu.tr

**ABSTRACT**

This paper examines whether the effect of energy consumption on economic growth is dependent on the level of energy intensity for 5 Turkish republics in the transition process over the period 1991-2012. These economies are divided into two groups in the context of their energy balance. The first group comprises all of the Turkish republics in the transition process while the second group is composed of only the net energy exporter countries among them. Using an innovative dynamic panel threshold technique, the estimated threshold of the energy intensity for the first group is 0.68%, while for the second group countries the threshold is 0.44%. The empirical results indicate that the energy consumption rate above the threshold energy intensity level adversely affects the economic growth, but this negative relationship becomes positive one when the energy consumption is below the threshold level. These findings reveal that the energy consumption is beneficial to economic growth only up to a certain threshold of the energy intensity; beyond the threshold level further the consumption tends to adversely affect the growth. In this regard, policy makers in the transition economies should not ignore threshold levels within the context of energy intensity while determining energy policies.

**Keywords:** Dynamic Panel Threshold Analysis, Energy Consumption, Economic Growth, Energy Intensity
**JEL Classifications:** C24, Q43, O11

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## 1. INTRODUCTION

Energy is an important resource in the classification of natural resources and used in all phases of production. It is considered key input and is consumed as output for increasing the welfare level. The important role of energy as a production input was disregarded until the oil crisis of the 1970s. By that time, even the theories of economic growth paid no attention to the role of energy and its effect on growth (Stern and Cleveland, 2004). Following this period, energy was perceived as a factor of production, together with labor and capital. Neoclassical economists like Hamilton (1983) and Burbidge and Harrison (1984) reported some findings supporting that energy has an important place in the development of economies. Attributed with great importance in today's world, energy is considered not only as a production input, but also as one of the most important determinants of the economic, social, and geographic order of the world as a strategic commodity that constitutes the basis for international relations and shapes the world economy and politics (Esen, 2016). Countries' desire to obtain energy resources, gain control over them, or have a say in them indicates that energy is an indispensable commodity in terms of politics. Given that it has such a mission, potential problems in the supply of energy used in production raise serious concerns about the sustainability of economic growth. Having the necessary energy resources, which constitute an extremely important input for sustaining economic growth and ensuring modern living standards, or at least supplying energy from other countries is of critical importance for a country to ensure sustainable economic growth.

The resources used in the generation of energy are limited in both amount and diversity. On the other hand, the distribution of energy resources around the world is not balanced. Some regions have more reserves compared to others in terms of the amount and diversity. Such uneven distribution of energy resources is true not only for the reserves, but also for the consumption levels (Bayrak and Esen, 2014). This leads to the emergence of great competition for the energy supply under reasonable, reliable, and sustainable conditions among the countries in need of energy resources (Öztürkler, 2009). In the world economy, increased production means increased energy consumption and increasing countries' dependence on energy import. Therefore, the issues of ensuring and sustaining stability in energy production and supply constitute the framework of all strategies and plans toward the objective of sustainable growth.

During the era of the former Union of Soviet Socialist Republics, the means of production in the republics of Kazakhstan, Azerbaijan, Turkmenistan, Kyrgyzstan and Uzbekistan—altogether known as the Turkic republics—were structured in a way that they were heavily dependent on each other and Russia. The production process, from raw materials to the end-product, could not be handled in a single country as a whole. The raw materials produced in one country were made into intermediate goods and, most of the time, the end product was produced in Ukraine or Russia (Demirkan, 1993). For the Turkic Republics that took over such a production structure, it became impossible to reach a production capacity sufficient to meet their domestic demands with their current economy during the transition period due to, for example, a lack of existing infrastructure, the use of outdated technology, and undercapitalization. Therefore, these Turkic republics in the transition period resorted to operating their energy resources to transition to a market economy and ease the problems associated with the transition period. During this period, the energy sector was the locomotive of economic growth. The energy sector had a considerable share in the public revenues as well. Energy resources also had a large share in the export revenues. However, due to the existing factor endowment and technological infrastructure, the Turkic republics focused their attention mostly on mineral and raw energy production and their exports, and they had to import most industrial goods from the industrialized countries of the West. During this period, poverty could not be prevented in these republics despite the rapid increase in welfare. Their exports concentrated primarily in energy products, leading to huge instabilities in energy prices and foreign exchange earnings. Therefore, their economic development was adversely affected by the fluctuations in energy prices.

Even today, these countries do not have the necessary economic structure to operate the oil and natural gas reserves with their own equity capital due to, for example, a lack of technology and undercapitalization. Therefore, they have to cooperate with large Western energy companies to exploit their energy resources. However, in order for these Turkic republics to sustain their economic growth, it is of crucial importance to reduce their dependency on a production structure based on the export of labor-intensive goods and original raw materials (especially oil and natural gas) to developed countries; they must also turn to other industries that require intensive capital and advanced technology. This process highlights the importance of energy consumption based on increased production and the relationship between energy consumption and growth.

The effective and efficient use of energy resources is as important as energy consumption for economic development, because the efficient use of energy is one of the ways to create new energy resources. The literature review shows that energy intensity is considered one of the indicators of energy efficiency. A country's energy intensity ratios depend on certain factors, such as the production structure of the economy, scale of the industries, capacity utilization levels, consumption habits of the societies, population, climatic conditions, technological developments, energy policies, and the amount of energy resources. Energy intensity represents the amount of energy used by an economy for each unit value added in a given production process that indicates the intensity of energy usage during the production process (Gomulka, 1990; Fisher-Vanden et al., 2004; Liao et al., 2007). Thus, energy intensity measures the efficiency of energy use by an economy during the production process (Fisher-Vanden et al., 2004). Low energy intensity indicates that existing energy resources are being used in production in a more efficient and effective way by that economy, thereby also showing that the amount of energy consumed to produce a unit of GNP is also low (Kavak, 2005). In this sense, meeting the energy required for growth by consuming less energy would be beneficial for an economy in many ways, such as decreasing dependence on external sources of energy and increasing resistance to external shocks. In such an environment, it becomes necessary to channel the resources to investments with high added value and create an environment that will allow efficient energy use as much as possible. Otherwise, if the contribution of each factor to production (growth) is low, the income level will remain low, thereby restricting new investment opportunities and hampering long-term and steady economic growth.

The relationship between energy consumption and economic growth has become one of the most frequently discussed issues in the economics literature, especially following the oil crises in the 1970s. However, the issue has not been addressed in terms of the transition economies trying to change from centrally planned economies to free markets. This study aims to empirically reveal the effect of energy consumption on economic growth in five Turkic republics undergoing a transition from a centrally planned economy to a free market economy following the collapse of the socialist regime at the end of the 1980s. In line with this purpose, we believe that this study will make a significant contribution to the literature on the foundations of economic growth in transition economies by examining the issue in terms of the transition economies where the states take active roles.

This paper is expected to provide three significant contributions to the literature. (i) The sample of this study includes five Turkish republics that had a socialist economic system in the past, but are currently trying to create their market economies. Although these economies are going through different experiences of market economy, their common ground is the problems caused by poverty and a public sector that is growing and becoming cumbersome. Besides the cumbersome structure inherited from the socialist system, deficiency of existing infrastructures, old technologies, and undercapitalization directly affect productivity and economic growth performance. Hence, the examination of these countries, which are resorting to institutional and structural regulations to get rid of poverty, will make an important contribution to the literature, (ii) previous studies have focused on the energy consumption-economic growth nexus but less on the effects of energy efficiency on growth. Unlike previous studies, this paper investigates the effects of energy consumption on growth on the basis of energy intensity. Level of energy intensity is one of the important factors determining the relationship between energy consumption and growth, (iii) previous studies focusing on the effects of energy consumption on economic growth have developed models based on the assumption that the relationship is linear. However, this paper assumes that the effects of energy consumption on economic growth will be asymmetrical (i.e., there will be a difference between the effect of energy consumption on growth when energy intensity is high and the effect of energy consumption on growth when energy intensity is low). With this assumption, the study employs dynamic panel threshold regression analysis, which is an innovative non-linear model, thereby offering an alternative to the literature. Accordingly, the study provides significant new findings regarding the effects of energy efficiency on the relationship between energy consumption and economic growth.

The literature review shows that most of the studies examining the relationship between energy consumption and economic growth focus on the models and analysis techniques developed with a linear hypothesis based on a causality relationship. The analyses and interpretations based on the assumption that the relationship between energy consumption and economic growth is linear point out the existence of a symmetrical relationship between the increases and decreases in energy consumption and economic growth. These studies view the energy consumption level as an indicator of development and consider that a country produces based on the amount of energy it consumes and achieves a high level of welfare. However, development should be based on the ability to create much more economic value with less energy (i.e., deliver the same production with a lower amount of energy), rather than the energy consumption rates. Energy consumption is important for economic growth as well; however, the consumption must be balanced. Such asymmetry points to a non-linear relationship. The empirical studies conducted thus far provide very little information about whether the relationship is linear—in other words, whether the energy consumption has a threshold level or not.

This study aims to examine the relationship between economic growth and energy consumption, which is considered an indicator for development, in the Turkic republics. In the study, the threshold regression model was used to find the threshold level above which energy consumption adversely affects economic growth. Moreover, the study aims to put the energy consumption-growth debates—built most often on an incorrect theoretical and empirical basis—on solid ground. In the first stage of the study, we will address the relationship in terms of the effect of energy consumption on economic growth and the efficient use of energy. In the subsequent sections, we will first review the theoretical and empirical literature focusing on the relationship between energy consumption and economic growth and then examine the interaction between energy consumption and economic growth in the Turkic republics for the 1990-2012 period in order to determine whether any threshold level exists above which the inefficient use of energy reaches unsustainable levels. In the final stage, the findings will be compared with the findings of other studies in the literature.

## 2. LITERATURE REVIEW

Despite some problems and bottlenecks in the energy field experienced by the countries in the past, energy became an issue of debate only after the great oil crises of the 1970s, which deeply affected the international markets. As a result, the number of studies examining the relationship between energy and economic growth gradually increased. However, most of these studies focused on whether a relationship exists between energy consumption and economic growth and, if it does, what the direction of this relationship is. The literature review shows that the causality relationship between energy consumption and economic growth is handled under four hypotheses. The studies in the first group reported a unidirectional relationship from energy consumption to economic growth (Stern, 2000; Shiu and Lam, 2004; Altınay and Karagöl, 2005; Odhiambo, 2009; Apergis and Payne, 2010; Iyke, 2015). This hypothesis—called the growth hypothesis in the literature—claims that energy is one of the key indicators of economic growth. Such a causality relationship indicates that the examined countries have energy-dependent production structures and they may have serious problems with the sustainability of economic growth in cases where energy demand cannot be met. The studies in the second group found a unidirectional causality from economic growth to energy consumption (Kraft and Kraft, 1978; Cheng and Lai, 1997; Ghosh, 2002; Lise and Montfort, 2007; Mozumder and Marathe, 2007; Herrerias et al., 2013). Their hypothesis is known as the conservation hypothesis and asserts that the countries are not energy-dependent; moreover, energy consumption occurs as a result of increases in economic growth. The studies in the third group suggest that a mutual causal relationship exists between these two variables (Paul and Bhattacharya, 2004; Shahbaz and Lean, 2012; Dagher and Talar, 2012; Wesseh and Zoumara, 2012; Esseghir and Khouni, 2014). Known as the feedback hypothesis, this hypothesis asserts that energy consumption and economic growth mutually affect each other. Pirlogea and Cicea (2012) argue that, for countries with bidirectional energy dependence, it is of crucial importance to pay attention to energy efficiency, reduce energy consumption based on conventional energy resources, move to renewable energy resources, and reduce greenhouse gas emissions. Finally, the fourth group includes those studies that reported no causal relationship between these two variables (Akarca and Long, 1980; Eden and Hwang, 1984; Cheng, 1995; Hondroyiannis et al., 2002; Altınay and Karagöl, 2004; Acaravci and Ozturk, 2010a). Known as the neutrality hypothesis in the literature, this hypothesis asserts that policies toward reducing energy consumption do not have any effect on economic growth.

Although many studies examine the relationship between energy consumption and economic growth, the debates are still ongoing about the direction of the causal relationship between these two variables. In other words, no agreement exists on whether economic growth dictates energy consumption or whether energy consumption is the locomotive of economic growth or no causal relationship exists between these two variables. Many studies in the literature show that the existence and direction of such a relationship varies from one country to another (Erol and Yu, 1987; Soytas and Sari, 2003; Asafu-Adjaye, 2000; Glasure and Lee, 1998; Masih and Masih, 1996; Akinlo, 2008; Wolde-Rufael, 2006; Acaravci and Ozturk, 2010b; Ozturk et al., 2010; Ouedraogo, 2013; Salahuddin et al., 2015).

Most studies on the relationship between energy consumption and economic growth are based on the assumption that a linear causal relationship exists between these two variables. Econometrical models are selected, and analyses are carried out in line with this assumption. Selecting models and carrying out analyses based on the assumption that a linear relationship exists between these two variables automatically means accepting the presupposition that the variables demonstrate similar behaviors independent of the country's production structure. However, energy consumption might have a non-linear effect on economic growth not only in the net energy importing countries, but also in the net exporters of energy. Although energy consumption is considered an indicator of development in the growth and development literature, recent debates have mostly focused on the necessity of treating the ability of creating more economic value with less energy as a development indicator, rather than the energy consumption levels. In parallel with these debates, the number of studies on the possibility of a non-linear relationship between energy consumption and economic growth and the potential asymmetric effect of energy consumption on economic growth has increased.

The empirical studies in the literature on energy and growth provide very little information about whether energy consumption has a non-linear effect on economic growth—in other words, whether the energy consumption has a threshold level or not. Lee and Chang's (2007) study is one of the most important studies based on the assumption of a non-linear relationship; they examine whether energy consumption has linear and non-linear effects on economic growth in Taiwan for the 1955-2003 period by using one-sector and two-sector growth models. Their findings suggest that a non-linear relationship exists between these two variables in the case of Taiwan and this relationship is characterized by a "U-shape" (i.e., first decreasing and then increasing) pattern. A similar study by Huang et al. (2008) separates data extending from 1971 to 2002 into two periods for 82 countries and examines the relationship between energy consumption and economic growth during these periods. The results of their analysis indicate a non-linear relationship between these two variables. Aydin and Esen (2016) investigate whether level of energy intensity is important in the effect of energy consumption on economic growth of Turkey for the period 1975-2013. The findings indicate that there is a non-linear relationship between energy consumption and economic growth in the Turkey economy and the threshold level of energy intensity below which energy consumption significantly promotes economic growth is estimated at 0.191. An energy consumption above this threshold has statistically significant negative effect on economic growth.

## 3. MODEL, DATA SET AND ECONOMETRIC METHOD

This study investigated the relationship between energy consumption and economic growth for the 1991-2012 period in five Turkish republics (Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, and Turkmenistan) in the transition process using dynamic panel data analysis that takes into account the energy intensity threshold level. Such a relationship was examined based on the neoclassical production function used by Ghali and Sakka (2004), Lee and Chang (2007), and Huang et al. (2008). Equation 1 shows the production function, which includes energy consumption as a factor of production like capital stock and labor:

$$\dot{Y}_{it} = \alpha_0 + \alpha_1 \text{ initial}_{it} + \alpha_2 \dot{E}C_{it} + \beta x_{it} + \varepsilon_{it} \quad (1)$$

Where $\dot{Y}$ indicates the real gross domestic product (GDP) growth at time t in country i; indicates the initial level of income; $\dot{E}C$ is the energy consumption rate; x represents other macroeconomic variables that might have an impact on economic growth; and $\varepsilon$ denotes the white noise error term.

The literature review shows that the real GDP is taken as a basis in the international comparisons as it gives important information about the growth performances of economies; however, in comparing the living standards of different countries or examining the changes in the welfare level of a country over time, the real GDP per capita is preferred as it takes into account the number of people living in a country. In this sense, we used the annual growth rate of real GDP per capita (dgdp) as an indicator of living standards. We also used the growth rate of energy consumption per capita (dec) as the independent variable of the model. The energy consumption growth rate was calculated based on the logarithmic difference of energy consumption per capita (tons of oil equivalent). The graphs for the variables are shown in Figure 1.

To control the effects of other macroeconomic variables related to energy consumption on economic growth, we used the following control variables based on the studies of Khan and Senhadji (2001), Drukker et al. (2005), Huang et al. (2008), and Kremer et al. (2013): Percentage of GDP dedicated to investment (igdp), growth of labor force participation rate (dlab), inflation ($\pi$), initial income level (initial), openness (open), foreign trade rate (dtot), standard deviation of openness (sdopen), and standard deviation of foreign trade rate (sdtot). We also used energy intensity (tpes/Y) as the threshold variable. We obtained the data about inflation rates from the International Financial Statistics. The data about the energy intensity rates were obtained from the International Energy Agency, and the data about the other variables were acquired from the database of the World Development Indicators. Table 1 shows the basic data about the variables; Table 2 shows the descriptive statistics.

**Figure 1:** Per capita gross domestic product and energy consumption growth rates across countries

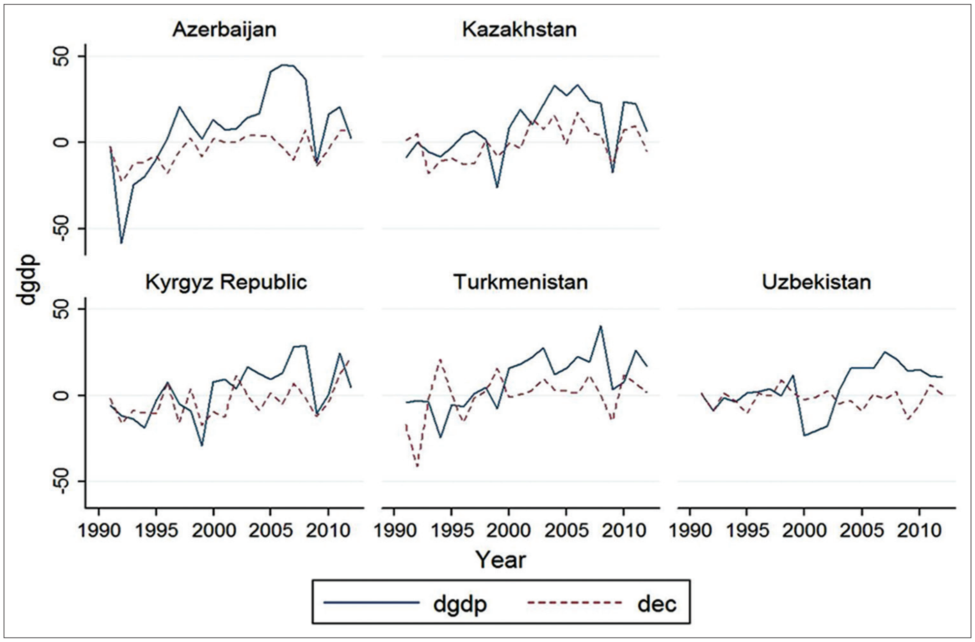



**Table 1: Basic information about the variables**

| Abbreviation | Explanation |
|---|---|
| dgdp | Annual growth rate of real GDP per capita ($) |
| dec | Logarithmic difference of energy consumption per capita (kg of oil equivalent) |
| tpes/Y | Total primary energy consumption as a percentage of GDP measured at purchasing power parity (tons of oil equivalent/$1,000) |
| π | Annual percent changes in the CPI |
| igdp | Percentage of GDP dedicated to investment ($) |
| dlab | Employment/population growth rate |
| initial | GDP per capita of the previous term |
| open | Logarithm of export and import as percentage of GDP |
| sdopen | Standard deviation of openness |
| dtot | Import/export growth rate |
| sdtot | Standard deviation of foreign trade rate |

CPI: Consumer price index, GDP: Gross domestic product

We included the lagged value of GDP per capita in the model as the explanatory variable based on the assumption that production level and structure of an economy are not entirely independent of the previous periods; thus, production levels in the previous period are also reflected in the subsequent periods (Ramirez and Rondán, 2013).

The use of the lagged values of the dependent variable as the explanatory variable in the fixed effects and random effects models used in the static panel data analysis causes the emergence of a relationship between the lagged values of the dependent variable and the error terms. Such a relationship causes the estimation made by fixed and random effects models and the estimators to be inconsistent (Greene, 2000). In such cases, the use of the dynamic panel data method eliminates such a relationship between the lagged values of the dependent variable and the error terms, thereby increasing the reliability of the estimation and the consistency of the estimators.

In this study, we used the dynamic panel threshold model developed by Kremer et al. (2013) by extending Hansen's (1999) static model for endogenous regressors. We chose the initial level of income as the endogenous regressor (initial=dgdpt-1). Our panel threshold model was built on Caner and Hansen's (2004) cross-sectional threshold model, where generalized method of moments (GMM) type estimators are used in order to allow for endogeneity. Equation 2 shows the model.

$$y_{it} = \mu_i + \beta_1' z_{it} I(q_{it} \leq \gamma) + \beta_2' z_{it} I(q_{it} > \gamma) + \varepsilon_{it} \quad (2)$$

Where i represents the units within the scope of the cross-section (i = 1,…,n); t indicates the dimension of the time series for each unit (t = 1,…,T); $y_{it}$ is the dependent variable; $\mu_i$ is the country-specific fixed effect; $\varepsilon_{it} \approx (0,\sigma^2)$ is the independently and identically distributed error term; I(.) is the indicator function indicating the regime; $q_{it}$ is the threshold variable; and ϒ is the threshold value. In addition, $z_{it}$, indicates an m-dimensional vector of explanatory regressors that may include lagged values of the dependent variable and other endogenous variables. The vector of explanatory variables is partitioned into a subset $z_{1it}$ of exogenous variables uncorrelated with $e_{it}$ and a subset of endogenous variables $z_{2it}$ correlated with $e_{it}$ (Kremer et al., 2013).

In the first step of the estimation of the model in equation 2, the individual effects ($\mu_i$) have to be eliminated via a fixed-effects transformation. Therefore, we apply the forward orthogonal deviation method suggested by Arellano and Bover (1995). Equation 3 shows the method.

$$\varepsilon_{it}^{*} = \sqrt{\frac{T-t}{T-t+1}}\left[\varepsilon_{it} - \frac{1}{T-t}(\varepsilon_{i(t+1)} + ... + \varepsilon_{iT})\right] \quad (3)$$

The most distinguishing feature of this method is that it can avoid the serial correlation of the transformed error terms. According to

**Table 2: Descriptive statistics for all variables**

| | tpes/Y | dgdp | dec | π | igdp | dlab | open | dtot |
|---|---|---|---|---|---|---|---|---|
| Mean | 0.467 | 6.779 | −1.562 | 203.421 | 6.879 | 0.175 | 4.449 | 3.182 |
| SD | 0.245 | 17.100 | 9.747 | 464.919 | 25.899 | 1.430 | 0.530 | 25.057 |
| Minimum | 0.090 | −58.133 | −40.981 | −18.930 | −65.217 | −6.840 | 0.000 | −52.132 |
| Maximum | 1.020 | 44.904 | 22.248 | 3100.000 | 111.400 | 5.609 | 5.173 | 77.334 |

GDP: Gross domestic product, SD: Standard deviation

Kremer et al. (2013), this feature allows for the application of the estimation procedure derived by Caner and Hansen (2004) for a cross-sectional model to the dynamic panel data models.

The next step of the estimation procedures involves the use of two-stage least squares (2SLS) to estimate the energy intensity threshold level. To this end, following Caner and Hansen (2004), we first estimate a reduced form regression for the endogenous variables ($z_{2it}$) as a function of the instruments ($X_{it}$). The endogenous variables ($z_{2it}$) are then replaced in the structural equation by the predicted values $\hat{z}_{2it}$. Finally, the model in equation 2 is estimated via least squares for a fixed threshold (ϒ). This step is repeated for the subsets of the threshold variable q. Among the threshold values, the threshold value with the smallest sum of squared residuals (S[γ]) is selected as the most appropriate threshold value ($\hat{y}$). Equation 4 shows this procedure (Hansen, 2000. p. 578).

$$\hat{y}=\arg\min S_n(\gamma) \quad (4)$$

In accordance with the studies by Hansen (1999), Caner and Hansen (2004), and Kremer et al. (2013), the critical values are estimated to determine the 95% confidence interval of the energy intensity threshold value. Equation 5 is used to estimate these critical values:

$$\Gamma=\{\gamma:LR(\gamma)\leq C(\alpha)\} \quad (5)$$

In equation 5, C(α) is the 95% percentile of the asymptotic distribution of the likelihood ratio statistic LR(γ). According to Hansen (1999), the underlying likelihood ratio is adjusted to account for the number of time periods used for each cross-section. In the dynamic panel model, after the appropriate threshold value ($\hat{y}$) is determined, the slope coefficients are estimated by the GMM for the previously determined instruments and the previous estimated threshold. Equation 6 shows the dynamic panel threshold model formed with GMM to examine the effect of energy intensity threshold value on the relationship between energy consumption and economic growth.

$$dgdp_{it}=\mu_1+\beta_1 dec_{it}\, I[(tpes/Y)_{it}\leq\gamma]+\delta_1\, I[(tpes/Y)_{it}\leq\gamma]+\beta_2 dec_{it}\, I[(tpes/Y)_{it}>\gamma]+\varnothing z_{it}+\varepsilon_{it} \quad (6)$$

Where $dec_{it}$ represents the growth rate of energy consumption per capita for both regime types and $z_{it}$ represents the vector of control variables. Tpes/Y denotes the threshold variable. $\beta_1$ and $\beta_2$ indicate the regime-dependent slope coefficients, and $\delta_1$ indicates the fixed regime coefficient. Following Bick (2010) and Kremer et al. (2013), we used the initial income level ($z_{2it}$) as the endogenous variable.

According to Roodman (2009), the use of all lags of the dependent variable as instruments in the dynamic panel analysis makes the coefficient estimation both unbiased and consistent. Therefore, based on the study by Arellano and Bover (1995), we used all the lags of the dependent variable as instruments. Besides, in dynamic panel model, estimator is consistent when T/N→c for $0<c\leq 2$ (Alvarez and Arellano, 2003). In cases where c is <2, the bootstrap method should be used in order to make the estimator consistent.

## 4. FINDINGS

In Table 3, Model 1 shows the results of the dynamic panel threshold model applied to examine the relationship between economic growth and energy consumption in 5 Turkic republics in transition. Among these five countries, Azerbaijan, Kazakhstan, Uzbekistan, and Turkmenistan were found to be net energy exporting countries with important oil and natural gas reserves, while Kyrgyzstan was found to import some of its energy despite its high hydropower potential. Because it is a net energy importing country, Kyrgyzstan was left out of the analysis, and the relationship between energy consumption and economic growth was examined again together with the role of the energy intensity threshold value. The findings are shown in Model 2.

The upper part of Table 3 shows the estimated energy intensity threshold level and the corresponding 95% confidence interval. The middle part of the table shows the effect of energy consumption per capita on economic growth for both regime types. $\hat{\beta}_1$ denotes the marginal effect of energy consumption per capita on economic growth in the low energy intensity regime, while $\hat{\beta}_2$ indicates the marginal effect of energy consumption per capita on economic growth in the high-energy intensity regime. Low-energy intensity regime indicates the case when the energy intensity level is below the estimated threshold value, while high-energy intensity regime indicates the case when the energy intensity level is above the estimated threshold value.

As shown in Table 3, the estimated threshold values for energy intensity were found to be 0.68 and 0.44 for Models 1 and 2, respectively (via 2SLS). Figure 2 shows the sum of the squared errors of the threshold values for both models. In Model 1, the lower limit for the threshold value at the 95% confidence level is 0.26 and the upper limit is 0.71. In Model 2, the lower limit is 0.24 and the upper limit is 0.72. The findings show that, in general, energy intensity increases in the first stages of economic development; however, it shows a declining tendency in the developed economies due to the increasing share of the service (tertiary) sector in economic growth during the development process. In the underdeveloped or developing economies, increased energy intensity is an expected consequence of industrialization.

In countries that have achieved a certain level of industrialization, the economic structures turning toward more low energy-intensive industries together with technological developments that allow for the efficient use of energy may cause a decrease in the energy intensity (Leach et al., 1986).

**Table 3: Energy consumption and economic growth**

| Estimated threshold value (tpes/Y) | Model 1 | Model 2 |
|---|---|---|
| $\hat{\gamma}$ | 0.68*** | 0.44*** |
| 95% confidence interval | [0.26, 0.71] | [0.24, 0.72] |
| Effect of energy consumption per capita (dec) | | |
| $\hat{\beta}_1$ | 0.816*** | 1.298*** |
| | (0.136) | (0.292) |
| $\hat{\beta}_2$ | −0.588* | −0.217 |
| | (0.357) | (0.222) |
| Effect of control variables | | |
| $initial_{it}$ | −1.774 | 7.843* |
| | (4.901) | (4.426) |
| $igdp_{it}$ | 0.076** | 0.085** |
| | (0.047) | (0.057) |
| $dlab_{it}$ | 0.073 | −0.574 |
| | (0.773) | (0.652) |
| $tot_{it}$ | 0.157*** | 0.167*** |
| | (0.044) | (0.051) |
| $sdtot_{it}$ | −60.031*** | −20.872 |
| | (22.085) | (19.983) |
| $open_{it}$ | 3.728*** | 2.772** |
| | (1.103) | (1.260) |
| $sdopen_{it}$ | 24.467 | 19.320 |
| | (27.175) | (51.087) |
| $\pi_{it}$ | −0.010*** | −0.015*** |
| | (0.003) | (0.004) |
| $\hat{\delta}_1$ | 14.969*** | 5.220 |
| | (4.291) | (3.88) |
| Number of observations | | |
| $tpes/Y \leq \hat{\gamma}$ | 86 | 37 |
| $tpes/Y \leq \hat{\gamma}$ | 24 | 51 |
| Number of countries | 5 | 4 |

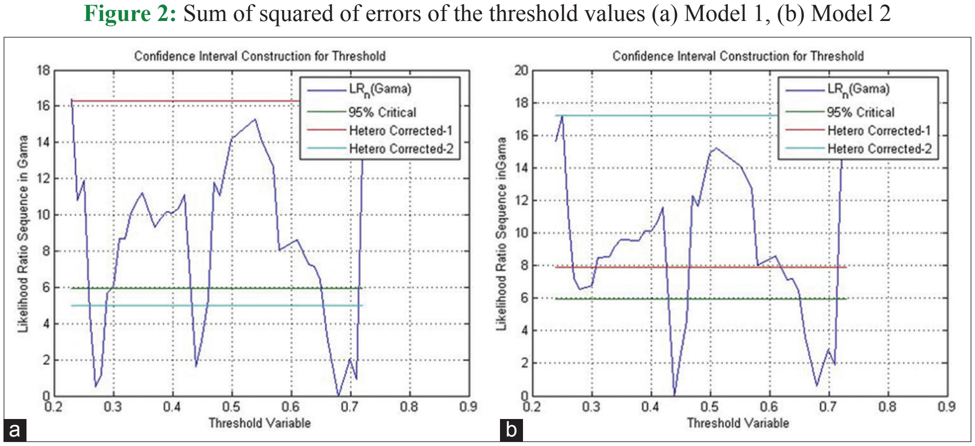
The table shows the results for the dynamic panel threshold model. All available lags of the dependent variable were used as instruments in the analysis. Standard errors are given in parentheses. *,**,*** indicate significance at 10%, 5% and 1% levels, respectively. P values are obtained using 1000 bootstrap replications, GDP: Gross domestic product

According to Model 1, the regime-dependent coefficients are statistically significant ($\hat{\beta}_1$=0.816 and $\hat{\beta}_2$=−0.588), meaning that energy consumption per capita has a positive marginal effect on economic growth in the low energy intensity regime, but a negative marginal effect in the high energy intensity regime. In other words, the rate of energy consumption per capita below the threshold level affects economic growth positively. If the rate is above the threshold value, then it affects economic growth negatively. If we examine the regime-dependent coefficients, we can see that the effect of energy consumption per capita on economic growth is higher in the low energy intensity regime.

For Model 2, $\hat{\beta}_1$ was found to be statistically significant (1.298), while $\hat{\beta}_2$ was not (−0.217). Thus, energy consumption per capita has a positive marginal effect on economic growth in the low energy intensity regime. Although the relationship between energy consumption and economic growth is not statistically significant in the high energy intensity regime, the effect has been found to be negative. In other words, the rate of energy consumption per capita below the threshold level affects economic growth positively. If the rate is above the threshold value, then it affects economic growth negatively. If we examine the regime-dependent coefficients, we can see that the effect of energy consumption per capita on economic growth is in the low energy intensity regime.

A comparison of Models 1 and 2 shows that the energy intensity threshold level is 0.68 in the five countries studied and 0.44 in the net energy exporting countries. According to the energy intensity levels, the coefficient of the effect of energy consumption per capita on economic growth is 1.298 in the net energy exporting countries in the low energy intensity regime. This rate was 0.816 when all five countries in transition were included in the analysis. On the other hand, in the high energy intensity regime, the coefficient of this effect is 0.588 in all five countries and −0.217 in the energy exporting countries. Thus, the marginal positive effect of energy consumption per capita on economic growth is higher in the energy exporting countries compared to the five countries in transition in the low intensity regime. In the high-energy intensity regime, the marginal negative effect of energy consumption per capita on economic growth is higher in the five countries in transition than in the energy exporting countries.

**Figure 2:** Sum of squared of errors of the threshold values (a) Model 1, (b) Model 2



## 5. CONCLUSION AND DISCUSSION

Energy is one of the basic requirements for economic and social development of a country. However, the uneven distribution of energy resources around the world has caused many countries to rely heavily on outside sources to meet their energy needs. Energy demands of such countries increase depending on their developing economies and changing socio-economic structures. Because the Turkic republics are rich in energy reserves, the world's increasing energy demand turns out to be advantageous for these countries. Therefore, the energy industry constitutes the basis of the economies of these countries. The revenues from the energy industry have a large share in both public and export revenues. Moreover, such energy potential provides these countries with a great advantage in achieving economic growth and expanding into international markets. The high energy potential in the region provides the opportunity to attract foreign capital to these countries.

After gaining independency, the Turkic republics started to use their high energy potential to provide the necessary resources for the transition process and deal with the problems associated with this process of change. Since then, the energy trade has been an "engine of growth" for these countries. However, such energy potential cannot be viewed as a resource that will make a contribution only to the export potential. The resources obtained from the energy industry must be channeled to the production activities and investments required for economic development, and production must be moved to industries with high added value that require high technology. In this way, energy demand will show an increase in these countries as the economy grows and living standards improve. This process brings attention to the importance of energy consumption based on economic growth and the relationship between energy consumption and economic growth.

In this sense, in the present study, the relationship between energy consumption and economic growth and the effects of energy intensity threshold value on this relationship were examined using annual data for the 1991-2012 period for five Turkic republics undergoing a transition from a centrally planned economy to a free market economy following the collapse of the Soviet Union at the end of the 1980s. To this end, we used the dynamic panel threshold model developed by Kremer et al. (2013) by extending Hansen's (1999) static model for endogenous estimators.

The findings prove that a non-linear relationship exists between energy consumption and economic growth in the transition economies in the long term. They further reveal that an energy consumption rate above a certain energy intensity level will affect economic growth adversely in these transition economies. The estimated threshold value was found to be 0.68 for all transition economies examined in this study and 0.44 in the net energy exporting countries. The findings support the assumption that energy consumption below the threshold value has an increasing effect on economic growth. Moreover, we believe that this study will guide future studies by revealing the importance of the energy intensity threshold level in the relationship between energy consumption and economic growth.

This paper show that energy efficiency efforts have significant potential savings associated with them and are a cost-efficient way to reduce the emissions. The effective and efficient use of energy in all phases, from energy generation to consumption, as well as the necessary steps to ensure its effective and efficient use, are a must for achieving a sustainable competitive economic structure in all countries, even if they are net energy exporters rich in resources or net energy importers lack of resources. Therefore, even if the majority of the Turkic republics in transition do not have problems in terms of energy reserves, they should still realize strategies and policies that include measures to increase the efficiency and effectiveness of the use of energy resources in order to speed up their economic development, achieve their sustainable growth targets, and improve their living standards.

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