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DO ENERGY PRICES AND INDUSTRIALIZATION AFFECT ENERGY INTENSITY? THE CASE OF TURKEY UNDER STRUCTURAL BREAKS

Enerji Fiyatları ve Sanayileşme Enerji Yoğunluğunu Etkiliyor mu? Yapısal Kırılmalar Altında Türkiye Örneği

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Abstract

This study differs from other studies with the research of the energy density of Turkey, which imports more than half of its energy demand. While GDP per capita in Turkey increased by 347% in 2019 compared to 1968, energy consumption per capita increased by 324% in parallel with this. In other words, efficient use of energy in Turkey continues to be a big problem despite technological developments. Therefore, it is considered important to reduce energy intensity in Turkey, which is dependent on foreign energy. In this study, the relationship between GDP per capita, industrialization and energy prices, and energy intensity in the 1968-2019 period in the Turkish economy is investigated. The unit root process was determined by Perron (1989) and Zivot and Andrews (1992) tests, which allow structural breaks as an empirical method, and Gregory and Hansen (1996), a structural break cointegration test, was used. Empirical findings have shown that there is a long-term relationship between the variables. The Fully Modified Least Squares Method (FMOLS) estimator was used as the cointegration estimator. According to the cointegration estimation results, the increase in economic growth and energy price increases reduces energy intensity. However, higher industrialization leads to more intensive use of energy.

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JEL Codes: Q43; L52; P22; O47

Öz

Bu çalışmanın diğer çalışmalardan farkı, enerji talebinin yarısından fazlasını ithal ederek gerçekleştiren Türkiye'nin enerji yoğunluğunun araştırılmasıdır. Türkiye'de 2019 yılında kişi başı GSYİH 1968 yılına göre %347 artış göstermişken, buna paralel olarak kişi başı enerji tüketimi %324 oranında artış göstermiştir. Diğer bir ifadeyle, Türkiye'de enerjinin verimli kullanımı teknolojik gelişmelere rağmen halen büyük bir sorun olmaya devam etmektedir. Dolayısıyla enerji konusunda dışa bağımlı olan Türkiye'de enerji yoğunluğunun azaltılması önemli görülmektedir. Bu çalışmada Türkiye ekonomisinde 1968-2019 döneminde kişi başına düşen GSYİH, sanayileşme ve enerji fiyatları ile enerji yoğunluğu arasındaki ilişki araştırılmaktadır. Ampirk yöntem olarak yapısal kırılmalara izin veren Perron (1989) ve Zivot ve Andrews (1992) testleriyle birim kök süreç tespit edilmiş ve yapısal kırılmalı eşbütünleşme testi olan Gregory ve Hansen (1996) testi kullanılmıştır. Ampirik bulgular, değişkenler arasında uzun dönemli bir ilişkinin olduğunu göstermektedir. Eşbütünleşme tahmincisi olarak Tam Değiştirilmiş En Küçük Kareler Yöntemi (FMOLS) tahmincisi kullanılmıştır. Eşbütünleşme tahmini sonuçlarına göre, ekonomik büyüme ve enerji fiyatlarındaki artışlar enerji yoğunluğunu azaltmaktadır. Ancak yüksek sanayileşme, daha yoğun enerji kullanımına yol açmaktadır.

Anahtar Kelimeler: Enerji yoğunluğu, sanayileşme, enerji fiyatları, ekonomik büyüme, Türkiye

JEL Kodları: Q43; L52; P22; O47

1. Introduction

The economic development performance of countries has traditionally been measured predominantly by gross domestic product (GDP) per capita. However, this definition contains a deficiency in terms of the sustainability of economic development. Today, it is known that quality of life does not depend only on economic income (Ediger, 2009: 18). Although it is known that some physical and social conditions are effective in the economic development process, this situation is sometimes overlooked. The human life index, which includes both economic and social variables, is among the most frequently used variables in measuring economic development (UNDP, 1990). In the human development index calculations, firstly, variables related to education, income, and health were used. However, the index was updated and started to include variables such as resource consumption and environmental degradation (Desai, 1994; Neumayer, 2001). Ediger and Tatlidil (2006) tried to add energy and environmental aspects to HDI by using four indicators primary energy consumption per capita, electrical energy consumption per capita, GDP produced per unit energy consumption (energy intensity), and CO2 emissions per capita. Energy is one of the most critical sectors in national economies. So much so that energy is accepted as the most important input among the economic growth and development goals. Energy has become a very strategic sector in terms of macroeconomic targets, especially in energy importing countries such as Turkey.

The energy intensity indicator is used to measure the efficiency in the use of energy input in national economies, both at the industrial level and at the country level. Energy intensity generally moves inversely with income level. In other words, as economic development increases, energy intensity decreases (Cermikli and Tokatlioglu, 2015: 3). Galli (1998), who studied developing Asian economies, revealed that there is a same-sided relationship between income level and energy intensity. This is explained by the increased energy intensity due to industrialization and urbanization. Therefore, while there are movements in the same direction as the income level, up to a certain critical value level, there is an inverse relationship after a certain level.

Fossil fuels are used as the main energy source in many countries as well as in Turkey. However, this energy source is mostly imported. Therefore, policies have been developed recently to reduce the use of fossil fuels (Ediger et al., 2006). To prevent this situation and to reduce import dependency, the use of renewable energy is encouraged. Although renewable energy is costly in the first stage, it is clean and causes foreign exchange savings in the long term. Therefore, it constitutes one of the issues that are emphasized by policymakers. Renewable energy investments are not at the desired level in national economies, except for some developed countries. This situation causes an increase in the share of the public budget allocated to energy imports in countries such as Turkey, which imports non-renewable energy resources to a large extent. Therefore, increases in energy prices harm the economies of the relevant countries.

The most effective way for fossil fuel importing countries such as Turkey to reduce their import dependency is to reduce the use of fossil fuels without harming the economic and social development of the country. For this purpose, it is necessary to reduce the amount of energy used, in other words, the energy density, to obtain a unit of GDP. However, the course of energy intensity in national economies is not in the form of a linear function. The energy density course, which is generally in the form of an inverted U, increases in the period when the weight of industrialization increases and then decreases. The high energy density in a country's economy can be the most important indicator of inefficient energy use. On the other hand, low or high energy density can also reveal the development of the economy of the relevant country. The indicator in question can also provide information about economic and social variables such as industrialization, urbanization, and development of countries. Turkey, which is above the OECD average in terms of energy intensity, uses inefficient energy compared to developed countries. Ediger and Huvaz (2006) stated that there was an improvement in density due to the increasing industrialization with the increasing urbanization in the 1980s in Turkey.

In this study, the effects of energy prices and industrialization on energy intensity are investigated by using the 1968-2019 period data of the Turkish economy. In the study, unit root with structural break and cointegration tests with a structural break is used. The main motivation of this study is the fact that there is a current and wide data set on the Turkish economy and a unit root with structural break and cointegration tests. Researching energy density is another source of motivation for Turkey, which realized approximately 150 billion dollars (74%) of its 202.7 billion dollars imports in 2019 as energy imports (Gurler et al., 2020:94). In this respect, it is considered that the study will contribute to the literature. In the following section, selected studies on the subject are given. Then, the data set and the method were introduced and empirical findings were presented. Finally, the study is concluded by making evaluations in the light of empirical findings.

2. Literature[2]

[2]There is still confusion in Türkiye regarding the definitions of energy parameters related to the more efficient and effective use of energy. 'Energy Efficiency' or 'Energy Productivity' is the equivalent of 'Energy Productivity' in English and is an input-output parameter used for energy systems, that is, 'quantitative output of goods and services produced in exchange for a unit of energy input.
And the measurement of its quality'. In this context, the application areas of the concept of Energy Productivity cover a very different set of areas, ranging from the rate of energy entering and exiting the energy conversion machines in the technological sense to the amount of GDP produced by countries in economic terms in return for one unit of energy consumption. In this last context, Energy Productivity (P=1/I) is the opposite of Energy Intensity (I=1/P), known as Energy Intensity in English, which is measured as the total amount of energy consumed to obtain a unit of GDP. Therefore, the improvement of Energy Productivity is possible by reducing the amount of energy used to obtain goods and services with the same quantitative and qualitative characteristics, or by obtaining goods and services that are superior in quantitative and qualitative aspects with the same amount of energy. 'Energy Productivity' is the equivalent of 'Energy Efficiency' and means 'less energy use to provide the same level of energy service', that is, more efficient and effective use of energy. Energy efficiency is a broader concept and includes Energy Productivity.

In the literature, there are many studies on energy demand and energy efficiency. However, it is determined that there are fewer studies on energy density. Energy density is the ratio that shows how much energy is used to produce one unit of output. Energy intensity, which is a simple indicator for calculating energy efficiency at both the industry level and the country level, is generally inversely related to the income level. It is seen that studies on energy density are generally examined in terms of determining the variables that increase or decrease energy density. The relationships between energy intensity and per capita income, energy prices, and technological developments are examined. It is seen that the variables mentioned in the literature and energy efficiency are frequently discussed. It is determined that studies on energy intensity are handled within the scope of time series and panel data analysis, and in panel data analysis studies, it is determined that the cross-section units consist of countries or sub-sectors (Greening et al., 1997: 388). When the studies on energy density are examined, it is generally accepted that energy density is low in developed country economies and higher in developing countries. The main reason for this situation is considered to be more research and development and advances in technology. Another important factor in reducing energy intensity is that the relevant country or sector moves away from the energy-intensive industry. It is claimed that energy intensity will decrease with the move away from the energy-intensive sector. Advances in technology, increasing income levels, and high energy prices play an important role in reducing energy intensity by improving energy efficiency.

Fisher-Vanden et al. (2006) investigated the decreases in energy intensity in the medium and large-scale industrial sector for the Chinese economy in the 1997-1999 period. The authors stated that the main reason for this decline was technological developments. It has been revealed that developments in technology increase energy efficiency and decrease energy density. On the other hand, it was concluded that the research and development activities of the companies and the relative changes in energy prices caused a decrease in the energy intensity of the relevant companies. Ma and Stern (2008) investigated the causes of changes in energy intensity in the Chinese economy during the 1980-2003 sample period. The logarithmic mean Divisia Index (LMDI) method was used in the analysis. The findings, similar to Fisher-Vanden et al. (2006), showed that the main reason for the decreases in energy density was technological developments. The authors also revealed that the increase in energy intensity after 2000 was the regression that occurred in the process of technological development. Yuan et al. (2009) investigated the factors that determine energy intensity in the Chinese economy. As a result of the analysis made using the Cobb-Douglass production function, there is an increase in the number of outputs per workforce. However, it has been revealed that this increase leads to an increase in energy intensity as it increases the fossil fuel use per workforce more. In other words, it has been obtained that with the increase in industrialization, the energy density also increased. In the study, it was concluded that technological developments lead to the effects of lowering energy density. This situation shows that the increase in output in the sectors where technology is the pioneer in industrialization will cause the effects of reducing the energy intensity.

Ediger and Huvaz (2006) stated in their study that there was a sectoral transition from agriculture to industry in the post-1980 period when urbanization increased in the Turkish economy. It was concluded that the energy density decreased with this change. In their study, Cermikli and Tokatlioglu (2015) investigated the relationship between technological development and energy intensity in the economies of 27 high-income countries and 17 countries from the middle-income group during the 1990-2011 period. The level of technology and the level of technological development differ in the country groups included in the analysis. It has been concluded that the energy intensity is lower in countries with a high technological development rate.

Therefore, sustainable economic growth is important for every economy. These growths are generally realized by energy consumption. However, the type and share of the energy source used are important. If the increasing economic growth is due to fossil fuels, this economy is performing dirty growth. If the demand for fossil fuels cannot be met by the own resources of the economy, growth occurs in a foreign-dependent manner in energy. However, high growth with the increase in the use of renewable energy will lead to a decrease in energy density (on the contrary, increase in efficiency) by reducing foreign dependency on energy as well as clean growth (Salim et al., 2019)). On the other hand, the use of renewable energy shows that it is more effective and more efficient than non-renewable energy sources for sustainable and clean economic growth (Doğan et al., 2020: 1). Efficiency improvements in the field of energy are very important for any country and are due to the improvement of industrialization, which is the wheel of economic growth, as well as many variables (Bashir et al., 2020:233). Increasing industrialization is reflected in energy input costs, which bring high costs in production, increasing the use of efficient technologies and reducing energy-intensive use. On the other hand, one factor that will cause a change in energy density is the changes in energy prices. It is considered that positive shocks in energy prices in energy-importing economies will cause a decrease in energy demand. On the other hand, this situation is thought to cause an increase in energy costs and a change in energy density according to the effect of reducing production (Wang et al., 2021: 9; Shahzad et al., 2021: 9).

3. Dataset, Econometric Methodology and Findings

In this section, the relationship between energy intensity and real GDP, real energy price index, and industrialization for Turkey is discussed empirically.

3.1. Data

In the study, energy density (lnEI), which is the dependent variable, was taken as the ratio of energy use (kg of oil equivalent) to GDP (constant 2010 US$). The energy price (lnPRC) data from the independent variables were obtained from Brent Petrol as annual energy prices, converted into real terms using annual consumer price indices from inflationdata.com, and the real energy price index for Turkey was obtained by multiplying the annual real exchange rate average data from the CBRT. (Antonietti and Fontini, 2019:899). Real GDP is taken as real GDP per capita, and industrialization is taken as Industry added value (constant 2010 US$). Energy intensity data (energy use) has been compiled by taking data from the International Energy Agency and (GDP) World Bank. Real GDP per capita and industrialization data were obtained from the World Bank. The sample period analyzed is 1968-2019. The natural logarithms of all variables are used in the model.

3.2. Methodology

In this part of the study, unit roots tests are tested with Perron (1989) and Zivot and Andrews (1992) tests, which allow structural breaks, and the cointegration relationship is investigated. In the case of cointegration, estimations are made for the long-term coefficients and the error correction term.

3.2.1. Perron (1989) Unit Roots Test

In the unit-roots test brought to the literature by Perron (1989), he states that the shocks caused by the Great Depression and Oil Crises that occurred in 1929 and 1973 will cause structural change. In this case, under the Ho hypothesis, three models such as

$$y_t = \mu + \alpha y_{t-1} + \delta_1 D(TB)_t + e_t \qquad \text{(Model A)}$$
$$y_t = \mu + \alpha y_{t-1} + \delta_2 DU_t + e_t \qquad \text{(Model B)}$$
$$y_t = \mu + \alpha y_{t-1} + \delta_1 D(TB)_t + \delta_2 DU_t + e_t \qquad \text{(Model C)}$$

are considered (Perron, 1989:1364). While Model A expresses the unit root process in which the alternating structural break occurs at the level, Model B expresses the process in which the structural break occurs at both the level and the slope. In addition, while the basic hypothesis for Model A is that it has a unit root with a change in the level, Model B has a unit root due to a shock in the slope, and in Model C, both the slope and the level. Where $D(TB)_t$ ve $DU_t$are dummy variables that take into account structural breaks in level and slope, respectively.

The Perron unit root test results are shown in Table 1.

Table 1: Perron Unit Root Test Results

Variables	Model A			Model C		
	Test Statistic	Lag Length	Break Date	Test Statistic	Lag Length	Break Date
Level						
lnEI	-3.580	0	2010	-3.870	0	1993
lnGDP	-2.455	1	2009	-4.468	1	1993
lnPRC	-2.228	0	2008	-3.804	0	1999
lnIND	-2.793	1	2009	-4.267	1	1993
1st Difference						
lnEI	-6.363***	1	2005	-6.316**	1	1982
lnGDP	-4.708	0	2001	-4.477	0	2002
lnPRC	-6.630***	0	2002	-6.631***	0	2002
lnIND	-5.003**	0	2001	-4.627	0	2002
Critical Values	%1=-5.92, %5=-5.23, %10=-4.92			%1=-6.32, %5=-5.59, %10=-5.29		

Note: Critical Values were obtained from Perron (1989).

When Table 1 is examined, besides Model A, which includes the change in level, the unit root test results calculated for Model C, which includes the change in both level and slope, are also included. Since statistical values of all variables for both Model A and Model C are less than the absolute critical values, not all series are stationary at the level. That is, all variables become stationary after taking the first difference.

3.2.2. Zivot and Andrews (1992) Unit Roots Test

In structural break unit root tests, determining the break date externally, that is, assuming independent, is not consistent for the tests to be followed. Therefore, Perron (1989) was criticized for the fact that the break date was determined externally and led to the development of internally determined unit root tests.

In the unit root test developed by Zivot and Andrews (1992), the structural break date is determined internally. In this test

$$y_t = \mu + \beta t + \alpha y_{t-1} + \theta_1 DT(\varphi) + \sum_{i=1}^{k} c_i \, \Delta y_{t-i} + e_t \qquad \text{(Model A)}$$
$$y_t = \mu + \beta t + \alpha y_{t-1} + \theta_2 DU(\varphi) + \sum_{i=1}^{k} c_i \, \Delta y_{t-i} + e_t \qquad \text{(Model B)}$$
$$y_t = \mu + \beta t + \alpha y_{t-1} + \theta_1 DU(\varphi) + \theta_2 DU(\varphi) + \sum_{i=1}^{k} c_i \, \Delta y_{t-i} + e_t \qquad \text{(Model C)}$$

models are discussed (Zivot and Andrews, 1992: 254).

Model A is the constant, Model B is the trend, and Model C is the process in which there is a structural break in both the constant and the trend. In addition, the basic hypothesis for Model A is that it has a unit root with a change in the constant, while in Model B it has a unit root in the trend, and in Model C, it has a unit root due to a shock that occurs in both the constant and the trend. Where, DT and DU are constant terms and trends are dummy variables in which structural break is taken into account, respectively. Δy_{t-i} was created and added to the model to eliminate the autocorrelation that may occur in the error terms.

Zivot and Andrews (1992) unit root test results are shown in Table 2

Table 2: Zivot and Andrews Unit Root Test Results

Variables	Model A			Model C		
	Test Statistic	Lag Length	Break Date	Test Statistic	Lag Length	Break Date
			Level			
lnEI	-3.643	0	2011	-3.830	0	2001
lnGDP	-2.443	1	1988	-4.557	1	1994
lnPRC	-2.216	0	2009	-4.081	0	1999
lnIND	-2.816	1	2010	-4.336	1	1994
			1st Difference			
lnEI	-4.726*	4	1994	-4.604*	4	2004
lnGDP	-4.864*	0	2002	-4.483	0	2002
lnPRC	-6.728***	0	2002	-6.745***	0	2002
lnIND	-5.188**	0	2002	-4.705*	0	2002
Critical Values	%1=-5.34, %5=-4.93, %10=-4.58			%1=-5.57, %5=-5.08, %10=-4.82		

Note: Critical Values were obtained from Zivot and Andrews (1992)

When Table 2 is examined, the unit root test results calculated for Model A, which includes the change in the constant and the change in both the constant and the trend, are also included. Since the statistical values of all variables for both Model A and Model C are less than the absolute critical values, all series have unit roots at the level. In addition, it is seen that all variables are stationary at a 10% significance level after taking the first difference.

3.2.4. Gregory-Hansen (1996) Cointegration Test

In the cointegration test introduced by Gregory and Hansen (1996), the structural break is allowed, and this break is determined internally. As in structural break unit root tests, three different models,

$$y_{1t} = \mu_1 + \mu_2\varphi_{tr} + a^T y_{2t} + \varepsilon_t \qquad \text{(Model A)}$$
$$y_{1t} = \mu_1 + \mu_2\varphi_{tr} + \beta t + a^T y_{2t} + \varepsilon_t \qquad \text{(Model B)}$$
$$y_{1t} = \mu_1 + \mu_2\varphi_{tr} + a_1^T y_{2t} + a_2^T y_{2t}\varphi_{tr} + \varepsilon_t \qquad \text{(Model C)}$$

are used in the Gregory-Hansen (1996) cointegration test to investigate the long-term relationship between the series. Where, μ_1 and μ_2 are the constant breakages, a_1 is the bending coefficient before the breakage occurs, and a_2 is the change in the slope parameter after the breakage occurs (Gregory and Hansen, 1996: 103).

Phillips test statistical equations used for Gregory-Hansen (1996) cointegration test are in the form of

$$\begin{aligned} Z_a^* &= inf_{\tau e T} Z_a(\tau) \\ Z_t^* &= inf_{\tau e T} Z_t(\tau) \\ ADF^* &= inf_{\tau e T} ADF(\tau) \end{aligned} \qquad (1)$$

(Gregory and Hansen, 1996: 106). The Z_a^*, Z_t^* and ADF^* test statistics obtained in these tests are compared with the critical values found in the study of Gregory and Hansen (1996). Then, the basic hypothesis that there is no cointegration relationship is tested (Tirasoglu and Yildirim, 2012: 115).

The cointegration relationship in the model was tested with the Gregory-Hansen (1996) cointegration test and the results are shown in Table 3.

Table 3: Gregory-Hansen (1996) Cointegration Test Results

	Test Statistics	Lag	Break Date	Critical Values
ADF	-7.006***	3	1975	1%=-6.92, %5=-6.41, %10=-6.17
Zt	-4.921	-	2002	
Za	-33.388	-	2002	1%=-90.35, %5=-78.52, %10=-72.56

Note: ***(1%) is level of significance.

Table 5 shows that the ADF test statistic is greater than the critical values at the 1% significance level and that there is a long-term relationship between energy intensity and GDP, energy prices, and industrialization for Turkey.

3.2.5. Estimation of Cointegration Coefficients

Gregory-Hansen (1996) shows that there is a long-term relationship between the variables as a result of the cointegration test. Therefore, the long-term coefficient estimation will be made. For this, long-short term coefficient estimation will be made using the Fully Modified Ordinary Least Squares (FMOLS) estimator developed by Phillips and Hansen (1990), which allows structural changes to be included in the model as dummy variables. The FMOLS estimator is an important estimator for the relationship between the explanatory variables and the residuals and for eliminating the deviations that may occur due to the internality problem (Nazlioglu, 2010: 99). A cointegration relationship was found in the model and FMOLS estimation results for long-short term coefficient estimation are shown in Table 4.

Table 4: FMOLS Long-Term Coefficient Estimation Results

Dependent Variable	lnGDP	lnPRC	lnIND	C
lnEI	-0.751*** (0.045)	-0.020** (0.009)	0.821*** (0.074)	-7.076*** (0.771)

Note: **(5%) and ***(1%) are levels of significance. Values in parentheses are standard error values.

According to FMOLS results in Table 4, the coefficient of real GDP and energy prices variables, in the long run, was negative and significant, while the coefficient of industrialization variable was positive and significant. When considered as a coefficient, a 1% increase in GDP reduces energy density by about 0.75%, while a 1% increase in energy prices reduces energy density by about 0.02%. A 1% increase in industrialization increases energy density by about 0.82%.

Therefore, while GDP is the primary determinant of energy intensity for Turkey, the increase in income will bring along technological developments and reduce the intensive use of energy with efficient/effective use of energy. For Turkey, which imports most of its energy, the increase in energy prices will ensure that the energy to be used is used more economically, efficiently, and effectively. Industrialization, on the other hand, is the cogwheels that enable the growth of developing countries, so the increase in these areas will increase the use of energy.

Short-term coefficient estimation was made in the model, then FMOLS error correction model was run, and the results are shown in Table 5.

Table 5: FMOLS Short-Term Coefficient Estimation Results

Dependent Variable	ECT_{t-1}	ΔlnGDP	ΔlnPRC	ΔlnIND
ΔlnEI	-0.418* (0.237)	-0.194*** (0.069)	-0.010 (0.007)	0.177 (0.066)

Note: ∗(10%) and ∗∗∗(1%) are levels of significance. Values in parentheses are standard error values.

The Error Correction Coefficient (ECT), which expresses the long-term relationship between errors, was found to be appropriate according to the theoretical expectation, and was negative and statistically significant. Therefore, this confirms a long-run relationship between energy intensity and explanatory variables. The error correction term (ECT) indicates the correction rate and shows how quickly the variables return to equilibrium in the long run. Thus, the coefficient of the ECT term was found to be 0.418, indicating that approximately 0.42% of a variant in the t-1 period will be corrected in the t period (within a period or year).

4. Conclusion and Policy Implications

To increase the level of socioeconomic development in the country's economies, both economic growth and development must take place. Today, besides the development indicators such as the rule of law and the human development index, the use of clean energy is considered important in terms of economic development. The energy intensity indicator, which decreases with the effective use of energy and is generally positively affected by technological developments, is also among the important development indicators in national economies. Low energy density leads to a cleaner environment, and a cleaner environment leads to healthier economic decision-making units. Especially in the economies of energy importing countries such as Turkey, the low level of energy intensity is considered important. Realizing a significant portion of its energy imports in the non-renewable energy type, Turkey is among the countries that stand out with its high energy density. Structural break unit root and cointegration tests were used in the study, which investigated the relationship between GDP per capita, industrialization and energy prices, and energy intensity in the 1968-2019 sample period. FMOLS estimator findings revealed that increases in per capita GDP and energy prices decrease energy intensity, while industrialization increases energy intensity. These results show that economic growth is important for reducing energy intensity in Turkey. The finding of the increase in energy density with the increase in the level of industrialization reveals that the industrial sector in Turkey does not sufficiently benefit from technological developments. Turkey, which is in the process of industrialization, needs to invest in sectors where technology is leading to reduce its energy intensity. On the other hand, it is considered that increasing renewable energy investments will have important results in reducing energy density and creating a cleaner environment.

As a result, while economic growth and energy prices decrease energy intensity, industrialization increases energy intensity. The findings obtained in this study; In the study by Ma and Stern (2008) and Akal (2015) for China, in the study by Akal (2016a) for the world, is consistent with the conclusion that the increase in efficient technology as a result of economic growth reduces energy intensity. Also, Fisher-Vanden et al. (2006) for China and the study by Akal (2016b) support the conclusion that the change in energy prices reduces energy intensity for Turkey. The study by Galli (1998), on the other hand, is consistent with the results that industrialization has increased the energy intensity in developing Asian economies.

In the light of the results obtained in the study, important duties fall on policymakers for the Turkish economy. First of all, increasing economic growth's reduction in energy intensity indicates the use of efficient technologies. Therefore, the increase in efficient technologies reduces the energy demand. In addition, the use of efficient technologies increases the efficient use of energy and is important for sustainable development. On the other hand, the decrease in energy density due to the increase in energy prices shows that the energy used is used efficiently and thrifty. However, this situation is not sustainable. The reason for this is that the increased energy prices for the energy importer Turkish economy are expected to reduce production and negatively affect economic growth and energy density. Therefore, it will be effective for Turkey to increase the use of renewable energy, which will reduce its dependence on foreign energy. On the other hand, the increase in the energy intensity of industrialization can be explained by the fact that Turkey's share of fossil fuel use in the industrial sector is 61.92% as of 2019. In addition, the increase in the use of fossil fuels by 123.36% in 2019 compared to 1990 in the industrial sector is also supported. Therefore, increasing industrialization causes more fossil fuel demand for the highly fossil fuel-dependent industrial sector. This situation has an increasing effect on energy imports. Therefore, while the use of renewable energy is important in reducing the general energy intensity, the use of renewable energy becomes important in reducing the sectoral energy intensity.

Intensity is only investigated with economic variables and only at the general economic level. For the researches following this study, it will be important to investigate energy density with social, political, structural, demographic, and political variables. In addition, researching energy density by sector will contain more detailed information. In addition, the use of current econometric methods with current period data will make important contributions to the literature.

Ethics Statement: The authors declare that ethical rules are followed in all preparation processes of this study. In case of detection of a contrary situation, BİİBFAD Journal does not have any responsibility and all responsibility belongs to the authors of the study.

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