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Which Type of Energy Consumption is Effective on Economic Growth? Industry or Residential? The Case of Nuts-2 Regions in Turkiye

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ABSTRACT

This study aims to determine the causal relationship between energy consumption and growth at the regional level, considering energy use's production and consumption purpose. In this direction, the relationship between industrial and residential electricity consumption and economic growth in Turkey has been tested for 26 regions and the period 2007-2020 by the Kónya Bootstrap Panel Causality Approach. According to the analysis results, while 11 areas support the growth hypothesis in terms of industrial electricity consumption, only one shows a bidirectional relationship; that is, it gives results by the feedback hypothesis. Five regions support the growth hypothesis regarding residential electricity consumption, and only two show a bidirectional relationship. In addition, four areas that do not offer a bidirectional relationship have findings that support the conservation hypothesis. According to the results, using energy as an input in final consumption or production may cause different regional effects on growth. Considering these relations, especially when choosing regional development and energy policies, will bring the right results specific to the regions. In addition, the absence of a causal relationship between electricity consumption and growth in many of the 26 areas examined indicates regional problems in the efficient use of resources.

Keywords: Regional Economic Growth, Energy Consumption, Panel Causality
JEL Classifications: R11, C23, O47, Q32

1. INTRODUCTION

In most growth models, aggregate supply and aggregate demand are considered important in measuring the short-run performance of the economy. However, when it comes to long-term growth, the structure that includes aggregate demand is often ignored (Dutt, 2006, p. 319). Classical and Neo-Classical growth theories clearly advocate supply-side growth and show various distinctions in terms of the source and limits of growth (Bingöl et al., 2022, pp. 30-311). Endogenous growth theories mostly neglect the demand factor and create long-term supply-side growth models by internalising the variables that were previously considered external. These theories accept that the growth rate of per capita income in long-run equilibrium depends on supply-side factors (Dutt, 2006, p. 321). Especially since the growth theories based on Classical Economics adopt the view that the economy is always at full employment, they agree that changes in demand will have short-term effects and will not be included in the long-term growth structure. Harrod (1939) revealed a demand-centred growth model with research that can be regarded as a pioneer in incorporating aggregate demand into growth. Harrod (1939) constructed a demand-side growth model by starting with an unstable steady-state equilibrium and accepting random full employment. Kahn (1959) and Robinson (1962) were among the first economists to adopt Harrod's idea and his results on growth. A group classified as Post-Keynesian or Heterodox-Keynesian studies follow this path opened by Harrod, and while investigating the phenomenon of demand-driven long-term growth, they are also looking for solutions to the knife-edge imbalance phenomenon (Skott, 1989; Palley, 1996; Blecker, 2002; Setterfield, 2010. etc). These economists mainly focus on studies that evaluate the effects of demand-increasing factors, such as fiscal policies, on growth and neglect the effect of aggregate supply on growth.

Both demand-side and supply-side growth models differ in the source of economic growth. However, researchers' main goal is to determine the factors affecting growth and develop theories on the effectiveness of these factors. Despite its controversial nature, growth in this direction maintains its currency as a constantly researched phenomenon in different geographies in different periods, with other structures including supply and demand.

Another critical issue, considered as old as growth theories and identified with growth for many years, is the development phenomenon. The growth phenomenon, which is examined through quantitative variables, differs from the development concept. "Development," a concept that concerns especially developing countries and expresses the change in more qualitative variables, draws attention as an essential subject examined by many disciplines (Kaynak, 2011, p. 83-85). The development phenomenon, which attracted great attention in political and academic literature after the Second World War, does not lose its currency with relatively new additions such as sustainability. Although the concepts of growth and development are separated from each other both theoretically and structurally, they can be expressed with identical variables due to the difficulties in accessing data on empirical studies.

Energy, one of the basic needs for social development, is also accepted as the driving force of economic growth. The use of energy and how it is obtained cause significant changes in society's demand and supply conditions, which can often even cause social development differences. The relationship between energy, which directly affects both production and consumption, with economic growth and development is also frequently the subject of research.

While analysing the relationship between energy and economic growth, two main aspects draw attention. Birincisi, ekonomik büyümenin enerjiye bağlı olduğu ve ondan ayrılamayacağı görüşüdür. İkincisi, enerji kullanımının derecesi ve ölçeğinin belirli ekonomik kalkınma koşullarına bağlı olmasıdır. Therefore, from a secondary point of view, the economic development level directly affects energy use (Dai et al., 2022, pp. 1-2). From both perspectives, energy policies' importance in economic growth or development should be known.

The question of how and in which direction energy policies affect the economy is at the centre of both growth/development and global environmental policies. Although empirical studies investigating the causal relationship between energy consumption and economic growth are extensive, there is not a common consensus on the energy consumption-growth link. However, knowing the direction of causality is of great importance for policy makers. Because in an economy where energy consumption is the cause of growth, energy saving policies may negatively affect growth (Belke et al., 2011, p. 783).

Studies in the literature show that there are four possible outcomes of causality that can be tested (Apergis and Payne, 2009, pp. 642-643):

- The growth hypothesis accepts that energy consumption is both an indirect compliment to the factors of production and a direct input to the production process. Thus, changes in energy consumption reveal a causal effect on real GDP
- The conservation hypothesis arises when policies for lower energy consumption are ineffective on real GDP. Even if there is no direct relationship between energy consumption and GDP, this hypothesis has an inverse relationship. In other words, it expresses a unidirectional causal relationship in which GDP changes affect energy consumption
- The feedback hypothesis states that there is a bidirectional relationship between energy consumption and real GDP and that these two variables can affect each other simultaneously
- The neutrality hypothesis expresses a situation where energy consumption does not affect real GDP and vice versa. Therefore, there is no causal relationship between these two variables.

Although the findings of the studies are united around four possibilities, it is noteworthy that a causal relationship distinction based on the source of energy consumption is not theoretically made. Namely, there is a possibility that the electricity consumption variable can be used separately in both production and consumptionFor example, while energy consumption in the industry plays a vital role in the production process as an input, it is seen that residential energy consumption emerges as a consumption-oriented variable related to economic development rather than the production process. In this respect, the nature of electricity consumption data both directly affects the causality relationship and can guide energy and growth policies in terms of supply and demand. This issue, which is mostly neglected in the literature, is taken into account in this study and the existence of a causal relationship between industrial and residential electricity consumption and economic growth of 26 sub-regions of Turkey according to the statistical region classification is investigated. In Turkey, three types of classification have been made by the regional development policies in the EU harmonisation process. The Classification of Statistical Regional Units (NUTS) was adopted by a law that came into force in 2002 and was formed as Level 3, which includes 81 provinces, Level 2, which includes 26 regions, and Level 1, which includes 12 regions (Kalkınma Ajansları Genel Müdürlüğü). In the creation of Level 2 regions; The philosophy of "provinces with common problems, socio-economic and cultural close to each other and geographically similar" was adopted (Şengül et al., 2013, p. 77). In this respect, it is vital to know the relationship between energy consumption and growth in Level 2 regional units where regional differences are essential and regional development and energy policies will differ. Heterogeneous Panel Bootstrap Causality tests, which allow the identification of this relationship specific to each region, were therefore determined as the primary method in the research.

The electricity consumption data used in the research to express energy consumption will be handled separately as industry and residential types. In this direction, it will also be examined whether supply-side or demand-side growth theories are in question in a regional sense.

In the following parts of the research, firstly, the literature investigating the causal relationship between energy consumption and growth/development will be mentioned. In line with the research question, the materials and method of the analysis to be applied will be mentioned, and the findings obtained as a result of the investigation will be included. As a result of the findings, necessary political suggestions will be mentioned in the conclusion section.

2. EMPIRICAL STUDIES EXAMINING THE RELATIONSHIP BETWEEN ENERGY CONSUMPTION AND GROWTH

As mentioned in the introduction, empirical studies focus on four main topics. Studies in which causality is unidirectional and from energy consumption to growth, unidirectional and from growth to energy consumption, bidirectional causality and no causality. The literature has been diversified to include all possibilities in this direction. The main studies in the literature are summarized in Table 1. Due to the fact that the literature is quite dense on this subject, especially the studies after 2000 and studies conducted in Turkey in accordance with the research sample have been emphasized.

Considering the literature summarised in Table 1, it is observed that the relationship between economic growth and causality includes four different theoretically expected possibilities. The method used, time difference and regional differences cause the causal relationship between these two variables to differ. It is noteworthy that different country groups and countries have different results. Moreover, it is not overlooked that there are other results even for the same country. Bu çalışmanın örneklemini oluşturan Türkiye örneğinin sonuçları incelendiğinde, Türkiye için ilişkinin nasıl olduğu sonucuna varmanın mümkün olmadığı açıkça görülmektedir. For example, Altınay and Karagöl (2005) obtained a result that supports the growth hypothesis for the 1950-2000 period; Aydin (2020) tested a shorter time period with more up-to-date methods and reached the same result. On the other hand, Topallı and Alagöz (2014) and Yıldırım (2019) mentioned a finding that supports the conservation hypothesis with the same method for different periods. Erdal et al. (2008) and Kaplan et al. (2011) obtained findings on the feedback hypothesis for the same period with the same method, while Araç and Hasanov (2014) changed both the period and the method and still found similar results. In addition, Öztürk and Acaravcı (2010), Nazlıoğlu et al. (2014) and Kızılkaya (2018), on the other hand, used different causality tests for close periods and obtained the conclusion that there is no relationship between growth and energy consumption for Turkey, in other words, the findings regarding the neutrality hypothesis. Here, the differences regarding the proxy energy consumption variable should not be overlooked.

Studies investigating causality based on regions of different development levels of a country, the central motif of this research, are in the minority in the literature. There are studies specific to the provinces of China (Wei et al., 2020; Shuyun and Donghua, 2011). However, these studies use panel methodology and do not yield region-specific results. On the other hand, studies investigating the relationship between growth and energy consumption with regional data specific to Turkey are also available in the literature (Usta, 2016; Akyol, 2020; Recepoğlu et al., 2020; Doru and Atay Polat, 2022). Only Doru and Atay Polat’s (2022) study included findings on causality based on regional units. However, electricity consumption, the proxy variable of energy consumption used in this research, is taken at the total level and not divided into residential or industrial.

3. DATA, METHODOLOGY, AND RESULTS

3.1. Data

The paper’s data set covers 26 sub-regions in the Turkish Statistical Regional Units Classification Level-2 between 2007 and 2020. Information on the variable definitions used in the study is shown in Table 2.

3.2. Cross Section Dependency Test

If the panel data set consists of units in a similar category, it is essential to evaluate the cross-sectional dependence between the panel units. Inevitably, a sudden shock occurring in one region within the same country will also impact other areas (Nazlioglu et al., 2011, pp. 6617-668). For this reason, investigating the existence of cross-section dependence by using three types of tests in the horizontal study constitutes the first stage of the study. The Lagrange multiplier (LM) test, developed by Breusch and Pagan (1980), is suitable when N is more minor than T. If N is greater than T, there is significant size distortion in the LM test. Therefore, Pesaran (2004) recommended using the following CD test, which is appropriate in these situations.

$$CD_{LM} = \sqrt{\frac{2T}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij} \tag{1}$$

The CD test asymptotically has a standard normal distribution under the null cross-section independence hypothesis. The null hypothesis in the CD test is that the residuals between units are equal to zero; that is, there is no cross-sectional dependence. Pesaran et al. (2008) have proposed the Lagrange multiplier test statistic (NLM), a scaled version of the LM test statistic, which can be used when N is greater than T. T→∞ and N→∞, CD_{LM} test statistic follows an asymptotic standard normal distribution (Ozcan and Ozturk, 2019, p. 34).

$$NLM = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T\rho_{ij}^{\ 2}-1) \tag{2}$$

Findings related to CD and NLM tests regarding cross-section dependency are given in Table 3. According to the cross-section dependency test results shown in Table 3, the null hypothesis suggesting no correlation between the units was rejected in

Table 1: Summary of the literature on studies investigating the causal relationship between energy and growth/development

Author (s)	Research period	Sample	Method	Result
Wolde-Rufael (2009)	2004-2007	17 African Countries	Granger Causality Test-VECM, Toda-Yamamoto	1
Yıldırım et al. (2012)	1960-2010	USA	Toda-Yamamoto and Bootstrap Causality	1
Lean and Smyth (2010a)	1980-2006	ASEAN-5	Granger causality test	1
Altınay and Karagöl (2005)	1950-2000	Türkiye	Granger Causality Test	1
Aydin (2020)	1965-2017	Türkiye	Toda and Yamamoto, Breitung AND Candelon Causality Tests	1
Usta (2016)	2004-2011	Türkiye level 2 regions	Panel Regression	1
Akyol (2020)	2005-2018	Türkiye level 2 regions	Gengenbach, Urbain and Westerlund Panel Cointegration Test	1
Yenilmez and Erdem (2018)	1986-2016	Türkiye and EU	Toda-Yamamoto Causality Test	1
Wei vd (2020)	2002-2007 and 2012	30 regions of China	Tapio Separation Model	1
Mehrara (2007)	1971-2002	11 Petroleum Exporting Countries	Granger Causality Test	2
Wolde-Rufael (2009)	2004-2007	17 African Countries	Granger Causality Test-VECM, Toda–Yamamoto	2
Yoo (2006)	1971-2002	Indonesia, Thailand	Granger Causality Test; Hsiao's Causality-VAR	2
Topallı and Alagöz (2014)	1970-2009	Türkiye	Granger Causality Test	2
Yıldırım (2019)	1961-2014	Türkiye	Granger Causality Test	2
Binh (2011)	1976-2010	Vietnam	Granger Causality Test-VECM	2
Belke et al. (2011)	1981-2007	25 OECD countries	Granger Causality Test-VECM	3
Shuyun and Donghua (2011)	1985-2007	Regions of China	Granger Causality Test	3
Lean and Smyth (2010b)	1971-2006	Malaysia	ARDL; Johansen-Juselius; MWALD	3
Yoo (2006)	1971-2002	Malaysia, Singapore	Granger Causality Test; Hsiao's Causality-VAR	3
Siddique et al. (2016)	1982-2015	Pakistan	Granger Causality Test	3
Fuinhas and Marques (2012)	1965-2009	Portugal, Italy, Greece, Spain and Türkiye	ARDL; Short and Long Term Elasticities	3
Erdal et al. (2008)	1970-2006	Türkiye	Granger Causality Test	3
Kaplan et al. (2011)	1971-2006	Türkiye	Granger Causality Test	3
Araç and Hasanov (2014)	1960-2010	Türkiye	Generalized Impact Response Function	3
Recepoğlu et al. (2020)	2004-2014	Türkiye at provincial level	Granger Causality Test	3
Usta and Berber (2017)	1970-2012	Türkiye, Sectoral	Toda-Yamamoto Causality Test	3
Pirlogea and Cicea (2012)	1990-2010	Spain, Romania and EU	Granger Causality Test	4
Öztürk and Acaravcı (2010)	1968-2005	Türkiye	Granger Causality Test-VECM	4
Nazlıoğlu et al. (2014)	1967-2007	Türkiye	Nonlinear Grenger Causality Test	4
Kızılkaya (2018)	1960-2015	Türkiye	Hacker and Hatemi-J Bootstrap Causality Test	4
Wolde-Rufael (2014)	1975-2010	15 Transition Economy	Kónya Panel Granger Causality Test	Miscellaneous results
Doru and Atay Polat (2022)	2004-2018	Türkiye Level 2 Regions	Emirmahmutoğlu and Köse Causality Test	Miscellaneous results

The numbers in the concluding part of the table are classified according to the theoretical distinction. 1: Growth hypothesis, 2: Conservation hypothesis, 3: Feedback hypothesis, 4: Neutrality hypothesis. In addition, if there is more than one result in the studies, they are either divided in the table according to the results of the study or placed in the table according to the nature of the general result obtained from the study

Table 2: Variable definitions

Variable	Definition	Source
SELK	Electricity consumption by place of use: Logarithm of industrial electricity consumption (KWh) per capita	TurkStat
MELK	Electricity consumption by place of use: Logarithm of residential electricity consumption (KWh) per capita	TurkStat
KBGDP	Gross domestic product per capita (2009 base): Logarithm of GDP ($) per capita	TurkStat

all tests. In the NLM test, which gives more effective results, especially in the case of N>T, the null hypothesis was rejected at the 5% significance level, and the existence of a cross-sectional dependence from per capita income to industrial electricity consumption per capita and from per capita income to residential electricity consumption was determined.

Table 3: Cross-section dependency results

Model	Test	Statistics	Probability
KBGDP-SELK	CD	254.6***	0.000
	NLM	59.68***	0.000
KBGDP-MELK	CD	274.7***	0.000
	NLM	62.33***	0.000

H_0: There is no cross-sectional dependency. H_1: There is a cross-section dependency. *** denotes statistical significance at the 1% level

3.3. Testing the Homogeneity

While there is likely to be a strong dependency between regions, testing for slope heterogeneity is essential as the level of development differs, particularly in areas of developing countries such as Turkey (Wolde-Rufael, 2014, pp. 326-327). The second step in the study is to test the homogeneity of the slope coefficients. The Swamy S test has been used to test homogeneity. Swamy (1971) expressed this test statistic, which is a Hausman type test, as

$$\hat{S} = \chi^2_{k(N-1)} = \sum_{i=1}^{N} \left(\hat{\beta}_i - \bar{\beta}^*\right)' \hat{V}_i^{-1} \left(\hat{\beta}_i - \bar{\beta}^*\right) \quad (3)$$

Where, $\hat{\beta}_i$ the OLS estimators obtained from the regression by b units, $\bar{\beta}^*$ weighted within-group estimator and $\hat{V}_i$ is the difference between the variances of the two estimators. In the Swamy S test, the null hypothesis states that the parameters are homogeneous. The homogeneity of the model was tested using the Swamy (1971) S Test. The findings regarding the Swamy S test are given in Table 4.

The S statistical value was found to be 2546.70 in the KBGDP-SELK model, and the probability value of this statistic was found to be statistically significant at the 5% significance level (P = 0.000 < 0.05). It has been found to be 1670.59 in the KBGDP- MELK model, and this statistic's probability value was found statistically significant at the 5% significance level (P = 0.000 < 0.05). According to the test result, the null hypothesis claiming that the parameters are constant, that is, homogeneous, was rejected in both models. It has determined that the parameters are not homogeneous, that is, heterogeneous.

3.4. Kónya Bootstrap Panel Causality Approach

Considering the variables examined in the study, it was determined that they had cross-sectional dependence and region-specific heterogeneity. The bootstrap panel causality approach proposed by Kónya (2006) explains both cross-sectional dependence and country-specific heterogeneity. In the study, a panel causality test developed by Kónya (2006) using seemingly unrelated regression (SUR) systems and reporting together the Wald test statistics and critical values specific to each unit were used. Using Kónya's (2006) panel causality approach, the following systems of equations for industrial electricity consumption and real national income per capita were estimated primarily by the SUR method.

$$\ln KBGDP_{1,t} = \alpha_{1,1} + \sum_{l=1}^{mly_1} \beta_{1,1,l}$$
$$\ln KBGDP_{1,t-1} + \sum_{l=1}^{mly_1} \theta_{1,1,l} \ln SELK_{1,t-1} + \varepsilon_{1,t,t}$$

$$\ln KBGDP_{2,t} = \alpha_{1,2} + \sum_{l=1}^{mly_1} \beta_{1,2,l} \ln KBGDP_{2,t-1}$$
$$+ \sum_{l=1}^{mlx_1} \theta_{1,2,l} \ln SELK_{2,t-1} + \varepsilon_{1,2,t}$$

$$\vdots$$

$$\ln KBGDP_{N,t} = \alpha_{1,N} + \sum_{l=1}^{mly_1} \beta_{1,N,l} \ln KBGDP_{N,t-1}$$
$$+ \sum_{l=1}^{mlx_1} \theta_{1,N,l} \ln SELK_{N,t-1} + \varepsilon_{1,N,t}$$

And

$$\ln SELK_{1,t} = \alpha_{1,1} + \sum_{l=1}^{mly_1} \beta_{1,1,l} \ln SELK_{1,t-1}$$
$$+ \sum_{l=1}^{mlx_1} \theta_{1,1,l} \ln KBGDP_{1,t-1} + \varepsilon_{1,t,t} \quad (4)$$

$$\ln SELK_{2,t} = \alpha_{1,2} + \sum_{l=1}^{mly_1} \beta_{1,2,l} \ln SELK_{2,t-1}$$
$$+ \sum_{l=1}^{mlx_1} \theta_{1,2,l} \ln KBGDP_{2,t-1} + \varepsilon_{1,2,t}$$

$$\vdots$$

$$\ln SELK_{N,t} = \alpha_{1,N} + \sum_{l=1}^{mly_1} \beta_{1,N,l} \ln SELK_{N,t-1}$$
$$+ \sum_{l=1}^{mlx_1} \theta_{1,N,l} \ln KBGDP_{N,t-1} + \varepsilon_{1,N,t}$$

Secondly, the following SUR models were estimated for residential electricity consumption and real national income per capita.

$$\ln KBGDP_{1,t} = \alpha_{1,1} + \sum_{l=1}^{mly_1} \beta_{1,1,l} \ln KBGDP_{1,t-1}$$
$$+ \sum_{l=1}^{mlx_1} \theta_{1,1,l} \ln MELK_{1,t-1} + \varepsilon_{1,t,t}$$

$$\ln KBGDP_{2,t} = \alpha_{1,2} + \sum_{l=1}^{mly_1} \beta_{1,2,l} \ln KBGDP_{2,t-1}$$
$$+ \sum_{l=1}^{mlx_1} \theta_{1,2,l} \ln MELK_{2,t-1} + \varepsilon_{1,2,t}$$

$$\vdots$$

$$\ln KBGDP_{N,t} = \alpha_{1,N} + \sum_{l=1}^{mly_1} \beta_{1,N,l} \ln KBGDP_{N,t-1}$$
$$+ \sum_{l=1}^{mlx_1} \theta_{1,N,l} \ln MELK_{N,t-1} + \varepsilon_{1,N,t} \quad (5)$$

And

$$\ln MELK_{1,t} = \alpha_{1,1} + \sum_{l=1}^{mly_1} \beta_{1,1,l} \ln MELK_{1,t-1}$$
$$+ \sum_{l=1}^{mlx_1} \theta_{1,1,l} \ln KBGDP_{1,t-1} + \varepsilon_{1,t,t}$$

Table 4: Slope parameter homogeneity test (Swamy S test)

Model	Statistics	Probability
KBGDP-SELK	2546.70***	0.000
KBGDP-MELK	1670.59***	0.000

H_0: The parameters are homogeneous. H_1: Parameters are not homogeneous. *** denotes statistical significance at the 1% level

$$\ln MELK_{2,t} = \alpha_{1,2} + \sum_{l=1}^{mly_1} \beta_{1,2,l} \ln MELK_{2,t-1} + \sum_{l=1}^{mlx_1} \theta_{1,2,l} \ln KBGDP_{2,t-1} + \varepsilon_{1,2,t}$$

$$\vdots$$

$$\ln MELK_{N,t} = \alpha_{1,N} + \sum_{l=1}^{mly_1} \beta_{1,N,l} \ln MELK_{N,t-1} + \sum_{l=1}^{mlx_1} \theta_{1,N,l} \ln KBGDP_{N,t-1} + \varepsilon_{1,N,t}$$

In these systems of equations, lnKBGDP 2009 shows the logarithm of the per capita gross national product value, lnSELK the logarithm of per capita industrial electricity consumption (KWh), and lnMELK the logarithm of per capita residential electricity consumption (KWh). N represents the number of regions (i = 1,2,…, 26), t represents the time period (t = 2007, 2008,…, 2020) and l represents the number of lags.

The above systems of equations have two different properties. First, each equation consists of other predetermined variables. The system has a cross-correlation, which is the only possible link between individual regressions. Therefore, this system of equations needs to be estimated using the SUR method instead of VAR. OLS is not an efficient estimator due to simultaneous correlations between regions. The individual estimations of the equations were performed using the SUR estimator proposed by Zellner (1962). Second, the variables of interest do not have to be stationary because of specific bootstrap critical values. That is, there is no need to test the unit root analyses of the variables of interest (Ozcan and Ozturk, 2019, p. 325).

Since the causality test results are sensitive to the number of lags, optimal lag numbers should be defined before applying the causality test. Too much delay can cause specification errors due to extra loss of observation. In this case, the standard errors of the estimated coefficients will increase, and a statistically significant causality relationship may be insignificant. In the study, the systems mentioned above of equations were estimated for each possible lag pair ranging from 1 to 4, the combinations that minimised the Akaike and Schwarz Information Criteria were selected, and the optimal lag length was determined to be 1.

According to the Kónya Bootstrap Panel Granger Causality test results given in Table 5, the null hypothesis suggesting that there is no Granger causality from industrial electricity consumption to per capita national income is rejected for TRC2, TR31, TR32, TR41, TR51, TR52, TR62, TR71, TR82, TR83 and TR90 regions. The null hypothesis is rejected, which suggests that there is no Granger causality from per capita income to industrial electricity consumption in the TR51 region. As seen in Table 6, a two-way Granger causality relationship between per capita national income and industrial electricity consumption in the Ankara region has been determined.

In Table 6, the null hypothesis suggesting no Granger causality from residential electricity consumption to per capita national income is rejected for TRB1, TRC2, TR22, TR82 and TR83 regions. The null hypothesis is rejected, which suggests that there is no Granger causality from per capita income to residential

Table 5: Results of Kónya Panel bootstrap causality analysis

Region	SELK-KBGDP		KBGDP-SELK		MELK-KBGDP		KBGDP-MELK	
	Wald	P	Wald	P	Wald	P	Wald	P
TRA1	0.601	0.460	0.990	0.353	1.170	0.322	5.748**	0.043
TRA2	0.326	0.582	0.595	0.487	0.183	0.663	0.002	0.959
TRB1	0.204	0.676	0.257	0.628	3.554*	0.091	0.933	0.363
TRB2	0.096	0.774	0.024	0.866	1.254	0.310	0.459	0.518
TRC1	0.415	0.541	2.319	0.163	0.414	0.551	0.192	0.674
TRC2	5.824**	0.031	0.165	0.686	14.359***	0.004	1.896	0.220
TRC3	0.045	0.824	0.443	0.500	1.675	0.231	0.144	0.778
TR10	0.001	0.979	0.266	0.634	0.982	0.352	8.725**	0.013
TR21	1.268	0.286	0.915	0.330	0.530	0.475	16.559***	0.005
TR22	0.045	0.820	0.014	0.897	4.888*	0.054	3.921*	0.070
TR31	4.660**	0.045	0.206	0.657	2.238	0.184	0.342	0.582
TR32	3.640*	0.082	0.647	0.443	2.935	0.129	0.673	0.454
TR33	1.895	0.207	0.542	0.487	2.085	0.185	0.370	0.580
TR41	3.871*	0.085	0.113	0.729	0.965	0.356	2.068	0.183
TR42	0.812	0.403	0.998	0.354	2.009	0.184	0.960	0.371
TR51	3.979*	0.081	3.656*	0.084	2.519	0.124	4.066*	0.080
TR52	3.569*	0.094	0.008	0.937	1.354	0.270	1.145	0.322
TR61	0.167	0.711	0.065	0.792	3.242	0.106	0.045	0.854
TR62	3.399*	0.096	0.009	0.935	1.712	0.234	0.003	0.970
TR63	0.512	0.496	0.579	0.471	1.583	0.249	0.419	0.540
TR71	5.451**	0.040	0.344	0.572	1.745	0.198	0.360	0.584
TR72	1.395	0.292	0.019	0.892	2.213	0.172	1.749	0.238
TR81	1.089	0.319	1.193	0.303	3.274	0.113	0.222	0.671
TR82	3.287*	0.097	1.378	0.262	5.754**	0.033	2.736	0.136
TR83	4.852*	0.051	0.876	0.375	3.760*	0.094	3.621*	0.081
TR90	3.479*	0.093	0.084	0.785	2.504	0.156	1.055	0.343

*, **, *** indicate 10%, 5% and 1% statistical significance levels.

Table 6: Granger causality direction

Causality direction	SELK→KBGDP	KBGDP→SELK	KBGDP↔SEL	KBGDP×SELK	
Regions	TRC2	TR51	TR51	TRA1	TR22
	TR31			TRA2	TR33
	TR32			TRB1	TR42
	TR41			TRB2	TR61
	TR51			TRC1	TR63
	TR52			TRC3	TR72
	TR62			TR10	TR81
	TR71			TR21	
	TR82				
	TR83				
	TR90				
Causality direction	**MELK→KBGDP**	**KBGDP→MELK**	**KBGDP↔MELK**	**KBGDP×MELK**	
Regions	TRB1	TRA1	TR22	TRA2	TR52
	TRC2	TR10	TR83	TRB2	TR61
	TR22	TR21		TRC1	TR62
	TR82	TR22		TRC3	TR63
	TR83	TR51		TR31	TR71
		TR83		TR32	TR72
				TR33	TR81
				TR41	TR90
				TR42	

electricity consumption in TRA1, TR10, TR21, TR22, TR51 and TR83 regions. It has been determined that there is a bidirectional causality relationship between residential electricity consumption and per capita gross national product in the TR22 and TR83 regions.

4. CONCLUSION

Energy is a necessary phenomenon for the existence of all life. When we consider economies as living organisms, they need energy like other living things. Therefore, energy consumption is an indispensable resource for economies both to maintain their existence and to grow. There is a vast amount of literature on the effects of energy consumption on the growth of economies. The presence of four possible outcomes in line with these literature findings is available for both the same and different samples. On the other hand, in addition to these four possible outcomes, the use of energy consumption for input or final consumption in production is likely to reveal different political consequences in terms of growth. In this direction, the study's research question is to determine what results this difference will show in IBBS level 2 regions in the example of Turkey. The development levels and internal dynamics of these regions are different from each other. In addition, knowing the regional differences in energy consumption can directly affect the differentiating energy and development policies in these regions. For this purpose, the existence and direction of the causal relationship between energy consumption and growth were investigated by the Kónya Bootstrap Panel Granger Causality test in 26 regions in Turkey. Changes in technology in today's world, especially in terms of zero emission efforts, and the increasing demand for rapidly developing electric vehicle technology shows that fossil fuels will be replaced by electricity in the near future. In this sense, electricity consumption data is a proxy variable for energy consumption. If the results obtained are evaluated:

- First of all, when we evaluate the regions where the causality relationship is from electricity consumption to growth at the point of determining whether the source of growth, which is the main question of the research, is demand-side or supply-side; 11 out of 26 regions [TRC2 (Şanlıurfa-Diyarbakır), TR31 (İzmir), TR32 (Aydın, Denizli, Muğla), TR41 (Bursa, Eskişehir, and Bilecik), TR51 (Ankara), TR52 (Konya, Karaman), TR62 (Adana, Mersin), TR71 (Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir), TR82 (Kastamonu, Çankırı, Sinop), TR83 (Samsun, Tokat, Çorum, Amasya) and TR90 (Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane)] a supply-side growth causality; In 5 of them [TRB1 (Malatya, Elazığ, Bingöl, Tunceli), TRC2 (Şanlıurfa-Diyarbakır), TR22 (Balıkesir, Çanakkale), TR82 (Kastamonu, Çankırı, Sinop) and TR83 (Samsun, Tokat, Çorum, Amasya)] demand-side growth causality is observed. In this direction, when choosing pro-growth energy policies in these regions, it is necessary to distinguish between policies that increase or decrease industrial energy consumption that will encourage production, or those that are planned for residential consumption. It should be taken into account that policies that save industrial energy consumption in eleven supply-side regions will have a negative effect on growth. In comparison, policies that save on residential electricity consumption in five demand-side regions will have such an effect. In addition, according to the findings, both industrial and residential energy consumption in TRC2, TR22, TR82 and TR83 regions show a granger causality relationship with growth. Besides that, it has been determined that there is a bidirectional causal relationship between industrial energy consumption and growth in TR51 (Ankara). Therefore, considering that energy consumption in this region may have a multiplier effect in terms of growth, it has emerged that energy-saving policies for this region may severely affect growth. Similarly, the bidirectional causal relationship between residential electricity consumption and growth in TR22 (Balıkesir, Çanakkale) and TR82 (Kastamonu, Çankırı, Sinop) regions states that the multiplier mechanism can also operate in this structure. The growth hypothesis that the literature draws attention to is that energy consumption is adequate for growth and valid for only 13 of the 26 regions when industry and residence are evaluated together. In the study of Doru and Atay Polat (2022), which investigated the causality between total electricity consumption and growth in 26 regions of Turkey, developed and developing regions were analysed separately and stated that the growth hypothesis was valid in TR22 and TR71 regions. This result, which includes two regions, is in line with the findings of this study. On the other hand, in this study, which takes into account the production and consumption purposes of energy consumption, it is seen that more regions support the growth hypothesis.

- When the results obtained in the context of the conservation hypothesis are evaluated-excluding those showing a bidirectional relationship-it is seen that there is a causal relationship between growth and residential electricity consumption in 3 regions out of 26 [TR10 (Istanbul), TR21 (Tekirdağ, Edirne, Kırklareli) and TR51 (Ankara)]. The causality relationship, which emerged in the TR10 and TR21 regions, draws attention to whether the growth is directed towards luxury consumption, which deepens the electricity need. In Doru and Atay Polat's (2022) study, findings supporting the conservation hypothesis were obtained for two regions, TR33 and TR61, regarding total electricity consumption. The results of the two studies differ in this sense.
- In the context of the neutrality hypothesis, there are regions where no causal relationship exists. It has been determined that fifteen regions in industrial electricity consumption and seventeen regions in residential electricity consumption do not show any causal relationship with growth. Catch-up hypotheses within development theories see the backwardness of lagging countries or regions as a potential. It should also be investigated that this potential, which can be used in line with various conditions, is adaptable to electricity consumption that does not cause growth in a country's economy. However, the fact that energy consumption does not cause causality in most of the 26 regions in the Turkish economy clearly shows that this issue should also be considered in the development plans programmed for these regions. Considering that one of the main problems examined by economics is the efficient and correct use of resources, the inefficiency of energy resources in growth should be considered a significant problem. In addition, policies to be made on two sensitive issues, such as energy consumption and regional development, must be considered in future studies that will investigate the reasons for the relationship between these two variables.

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