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Electricity Consumption and Economic Growth: A Linear and Nonlinear Causality Investigation for Turkey

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ABSTRACT: This paper aims to explore the potential linear and nonlinear causal relationship between electricity consumption and economic growth in Turkey during the time period 1945-2006. The study employs the standard linear Granger causality test and the nonparametric Diks and Panchenko causality test. Electricity consumption is disaggregated into residential and commercial electricity consumption, government offices, street illumination, industrial and other activities electricity consumption, in order to determine the sources of both linearity and nonlinearity. The findings provide evidence for the existence of a unidirectional nonlinear causality between income and electricity consumption at the aggregate level. The results also support the presence of a unidirectional linear flow running from economic growth towards residential, commercial and street illumination electricity consumption as well as a unidirectional nonlinear flow running from the residential and commercial electricity consumption towards economic growth and from income to electricity consumption for street illumination. Policies should focus on promoting electricity consumption, especially in the residential and commercial sectors to drive economic growth.

Keywords: electricity consumption; economic growth; linear and nonlinear Granger causality
JEL Classifications: Q43; Q48

1. Introduction

Over the last two decades, the causal relationship between electricity consumption and economic growth has been the subject of extensive investigations among energy economists. The exploration of the linkage between these two variables is particularly attractive due to the potential effects that fluctuations in fuel prices, changes in consumption and production patterns and/or the commitments to international environmental agreements may have on electricity consumption. Additionally, the economic development shrinkage that appeared as a consequence of the global economic crisis and characterises a rising number of countries lately may adversely influence the level of electricity consumption. In this sense, the electricity consumption – economic growth causal nexus may reveal interesting policy implications.

The causal flow between electricity consumption and real income may take the following four forms (Ozturk, 2010) : a) the ‘neutrality hypothesis’, which refers to the absence of causality between the variables, b) the ‘growth hypothesis’, which refers to the uni-directional causality running from electricity consumption to economic growth, c) the ‘conservation hypothesis’, which refers to the uni-directional causality running from economic growth to electricity consumption and d) the ‘feedback hypothesis’, which refers to the bi-directional causality between the variables. The classification of the results in the above categories implies the adoption and implementation of different policies.

Electricity consumption contributes to the production process complementary to labour and capital and plays an important role in the economic development of Turkey. Since the 1980s, electricity consumption has been growing at an approximate average rate of 7.7% annually and the real GNP by 4.2%. Due to its development status, Turkey is -and will be- facing a continuing increase in electricity demand (ESMAP Report, 2000); the evidence indicates that, within the last 10 years, total electricity consumption has almost doubled. This trend is additionally enhanced by the fast growing population and the shift from the primary sector of the economy towards industry and services[1]. On the other hand, during the early 80s and 90s, Turkey experienced economic crises and shortages in electricity supply. The reforms that have taken place in the Turkish electricity sector with the Electricity Market Law no. 4628[2] passed in 2001 may help overcome these rigidities.

In the present study, a nonlinear causality technique has been applied in addition to the standard linear Granger causality test. Recent studies (Cheng-Lang, 2010; Dergiades et al., 2011, Chiou-Wei et al., 2008) have shown that the power of the linear causality tests is lower compared to the nonlinear ones and this type of tests fail to uncover nonlinear predictive power. As Baek and Brock (1992) have indicated forecasting performance of linear models decreases in the presence of nonlinearity and the forecasting performance of nonlinear models is better than that of linear models. The implementation of nonlinear techniques helps overcome limitations of the linear framework. The rationale behind the use of nonlinear testing in the electricity consumption – economic growth nexus rests on the fact that changes in the economic environment, such as financial crises and environmental policy reforms may induce changes in electricity consumption (Chiou-Wei, 2008; Cheng-Lang et al., 2010; Dergiades et al, 2011). On the other hand, modifications on the electricity consumption patterns – due to, for instance, fluctuations in fuel prices, changes in production processes - could affect economic development, in terms of production and income generation. Such changes are abrupt and unpredictable, implying the existence of a potential non-proportional link between electricity consumption and income. Besides, the implementation of nonlinear tests is considered to be crucial since, as Karanfil (2009) suggests, researchers should focus more on new approaches and perspectives rather than employing usual methods in their attempt to explore the electricity (energy) consumption - economic growth nexus. To our knowledge, among studies in the field of electricity and/or energy consumption and economic growth causality, this is the first to account for the potential nonlinearity that may exist between electricity consumption and national income in the case of Turkey. Nonlinear causal relations between variables have been detected, mainly, in the financial and public economics field (Kyrtsou and Labys, 2006; Karagianni et al, 2012).

The nonlinear causality technique that has been employed to explore the directions and causal flows between electricity consumption and economic growth, in the present paper, is the nonparametric causality test developed by Diks and Panchenko (2006). The present study is the first that applies the nonlinear Diks and Panchenko causality test to investigate the electricity consumption – economic growth relation in a nonlinear context. The nonlinear causality test by Hiemstra and Jones (1994) that has been used in previous studies (Chiou-Wei et al., 2008 and Cheng-Lang et al., 2010) has been criticized for inconsistency, since it tends to over-reject the null hypothesis (Bekiros and Diks, 2008). The Diks and Panchenko test statistic overcomes this bias and offers more reliable results. Moreover, the implementation of the Diks and Panchenko (2006) test is justified by the existence of high heteroskedasticity in most of the examined series (a more detailed analysis is included in the Data and Preliminary Analysis section). The findings provide evidence for the existence of nonlinear causality between electricity consumption and income at the aggregate level.

Another novelty is that the study goes further and makes an effort to determine the sources of linearity and nonlinearity by disaggregating electricity consumption data. Since our analysis focuses exclusively at the macroeconomic level, we are interested in exploring the relationship between electricity consumption -and its components- and total economic output ad hoc. The exploration of this relationship provides to policy makers the potential to implement the appropriate economic policies in order to enhance economic growth. The disaggregation of total electricity consumption into residential, commercial, government offices, street illumination, industrial and other activities electricity consumption serves many purposes. First of all, it enables us assess the magnitude of each sector as a determinant factor of economic growth. At the same time, this classification reveals the evolution of the electricity consumption patterns across time and sectors (Tsani, 2010; Abid and Sebri, 2012). Furthermore, the disaggregation helps define the extent to which each sector's electricity consumption interrelates with total output and determines whether electric policy in certain sectors

[1] The industrial sector holds the first place in electricity consumption in Turkey, while the residential and service sectors come at the second place. Transportation and agriculture are relatively small electricity consumers. (for details see Hamzaçebi, 2007).

[2] The law aimed at liberalising the electricity market in Turkey. The full text of the law is available in: http://www.epdk.gov.tr./

impacts on the economic system. The results indicate that researchers should consider nonlinear techniques to uncover potential nonlinear causal relations in the area of energy economics, both at the aggregate and the disaggregate levels.

The remainder of the paper is organized as follows. Section 2 provides a literature review on the electricity consumption – economic growth nexus. Section 3 discusses the econometric methodology, namely the linear Granger (1969) causality test and the Diks and Panchenko (2006) nonlinear causality test. Section 4 presents the data and the empirical findings and section 5 concludes and provides policy implications.

2. Literature Review

The literature dealing with the determination of the causal relationship between electricity consumption and economic growth provides controversial results, due to the different techniques, time periods and variables applied. An exhaustive survey of the studies that explore the electricity consumption – economic growth relationship is conducted by Ozturk (2010) and Payne (2010). Most of the studies have been employing the standard linear Granger causality tests. The first one to examine the relationship between electricity consumption and economic growth was Ramcharran (1990) -with the use of elasticities in Jamaica- who finds a significant impact of electricity on economic growth. Analogous results that hold for the 'growth hypothesis' appear in the studies of Acaravci and Ozturk (2012), Acaravci, (2010), Narayan and Singh (2007), Shiu and Lam (2004), Ho and Siu (2007), Georgantopoulos (2012), Solarin (2011), Aqeel and Butt (2008), Abosedra et al. (2009) and others. On the contrary, signs for the validity of the 'conservation hypothesis' are found in Adom (2011), Ghosh (2002), Narayan and Smyth (2005), Yoo and Kim (2006), Hu and Lin (2008), Joyeux and Ripple (2011) etc. The 'feedback hypothesis' is confirmed in Yang (2000), Jumbe (2004), Yoo (2005), Zachariadis and Pashouortidou (2007), Odhiambo (2009), Tang and Tan (2012) and others. The 'neutrality hypothesis' is supported for approximately 80% of the OECD countries, Turkey included, according to the Narayan and Prasad (2008) study. Specifically, in the case of Turkey, a large number of studies are concentrated on the causality between energy consumption and growth (Ozturk and Acaravci, 2010 and 2013, Kaplan et al., 2011, Lise and Van Montfort, 2007; Erdal et al., 2008; Karanfil, 2008; Halicioglu, 2009; Fuinhas and Marques, 2012 etc.). Yet, there are only two studies that focus on the electricity consumption – economic growth relationship in Turkey. Altinay and Karagol (2005) investigate the causal relationship between electricity consumption and real GDP for the time period 1950-2000 using the Dolado-Lütkepohl and the Granger causality tests that provide strong evidence for the 'growth hypothesis'. On the contrary, Halicioglu (2007) - employing augmented Granger causality tests over the period 1968–2005 - finds that the direction of causality runs from income to electricity consumption.

However, the traditional linear causality tests fail to uncover potential nonlinear linkages between economic variables. Recent studies have detected nonlinear patterns in the relationship between electricity consumption and economic growth. Cheng-Lang et al. (2010) investigate the linear and the nonlinear causality between electricity consumption, both at the aggregate and the sectoral level and real GDP employing quarterly data from 1982 to 2008 for Taiwan. The nonlinear testing has been conducted with the use of the nonlinear causality test proposed by Hiemstra and Jones (1994). With regard to the nonlinear causality, their findings indicate a bi-directional causality between total electricity consumption and real GDP and a unidirectional causality running from real GDP to the residential sector electricity consumption. The study of Cheng-Lang et al. (2010) is the only one that focuses on the electricity consumption - income nexus. There are a couple of studies (Chiou-Wei et al., 2008 and Dergiades et al., 2011) that deal with the energy consumption – economic growth relationship at the nonlinear level. The former uses the nonlinear causality test suggested by Hiemstra and Jones in a sample of Asian newly industrialized countries and the USA and offers mixed results. The latter investigates the causal linkage between total energy consumption and economic growth in the case of Greece using both the nonlinear test introduced by Brock et al. (1996) and the Diks and Panchenko (2006) nonparametric Granger causality test.

3. Methodology

3.1 The Linear Granger Causality Test

In 1969, Granger proposed a causality test to describe the relations between economic time series. According to this, a time series X_t causes another time series Y_t in the Granger sense if present Y can be predicted better by using past values of X than by not doing so, considering also other relevant information, including past values of Y. In mathematical terms, X is said to cause Y, provided some βj is nonzero in the full regression equation (1):

$$Y_t = \delta_0 + \sum_{i-1}^{r} a_i Y_{t-i} + \sum_{j-1}^{s} \beta_j X_{t-j} + \varepsilon_t \qquad (1)$$

The relevance of X is indicated when comparing the error in (1) to that of the reduced equation:

$$Y_t = \delta_0 + \sum_{i-1}^{r} a_i Y_{t-i} + \varepsilon \qquad (2)$$

The error terms are compared formally with the F-statistic.

3.2 The Nonparametric Diks-Panchenko Causality Test

The linear Granger causality test is inappropriate to detect the presence of a potential nonlinear causal relation between two variables. In 2006, Diks and Panchenko proposed a new nonparametric test for nonlinear causality. According to them, the null hypothesis is stated as:

$$q \equiv E\,[f_{X,Y,Z}(X,Y,Z) f_Y(Y) - f_{X,Y}(X,Y) f_{Y,Z}(Y,Z)] = 0 \qquad (3)$$

where $Z_t = Y_{t+1}$. If we ignore the time index and we assume that $l_X = l_Y = 1$, the distribution of Z - given that $(X, Y) = (x, y)$ - is the same as that of Z - given $Y = y$. The joint probability density function $f_{X,Y,Z}(x,y,z)$ and its marginals should satisfy the following relationship:

$$\frac{f_{X,Y,Z}(x,y,z)}{f_Y(y)} = \frac{f_{X,Y}(x,y)}{f_Y(y)} \cdot \frac{f_{X,Z}(y,z)}{f_Y(y)} \qquad (4)$$

In other words, equation (4) states that X and Z are independent, when $Y = y$ for each fixed value of y. Suppose $\hat{f}_W(W_i)$ is a local density estimator of a d_W-variate random vector $\mathbf{W}$ at W_i, defined by $\hat{f}_W(W_i) = (2\varepsilon_n)^{-d_W} (n-1)^{-1} \sum_{j,j \neq i} I_{ij}^W$, where $I_{ij}^W = I(\|W_i - W_j\| < \varepsilon_n)$, $I(\cdot)$ the indicator function and ε_n the bandwidth, which depends on the sample size n[3]. Then, the test statistic is a scaled sample version of q in equation (3):

$$T_n(\varepsilon_n) = \frac{n-1}{n(n-2)} \cdot \sum_i (\hat{f}_{X,Z,Y}(X_i, Z_i, Y_i) \hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i, Y_i) \hat{f}_{Y,Z}(Y_i, Z_i)) \qquad (5)$$

For $l_X = l_Y = 1$ and if $\varepsilon_n = Cn^{-\beta} (C > 0, \frac{1}{4} < \beta < \frac{1}{3})$, Diks and Panchenko (2006) prove that the test statistic in equation (5) satisfies the following:

$$\sqrt{n} \frac{(T_n(\varepsilon_n) - q)}{S_n} \xrightarrow{D} N(0,1) \qquad (6)$$

where $\xrightarrow{D}$ denotes convergence in distribution and S_n is an estimator of the asymptotic variance of $T_n(\cdot)$ (Diks and Panchenko, 2006; Bekiros and Diks, 2008). In this study, following the Diks and Panchenko's suggestion, we implement a one-tailed version of the test.

4. Data and Empirical Results

4.1. Data and Preliminary Analysis

The study uses annual data that cover the period from 1945 to 2006 for Turkey. RGNP stands for the real gross national product, TC for total electricity consumption, RC for residential and commercial electricity consumption, GO for government offices electricity consumption, SI for street illumination electricity consumption and IC for industrial and other activities electricity consumption.

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[3] The bandwidth ε_n values are set according to table 1, p. 1658, from the Diks and Panchenko (2006) paper. For $100 < n < 500 \Rightarrow \varepsilon_n = 1.5$

The disaggregation of the electric power consumption serves to determine the source of the likely linear and nonlinear causality flow. Real GNP is expressed in 1987 constant prices, whereas electricity consumption is measured in 10^6 kilo Watt hours (kWh). All data are obtained from the Turkish Statistical Institute's (2011) *Statistical Indicators 1923-2010* and they are expressed in natural logarithms.

In the present paper, Engle's (1982) ARCH-LM test has been applied to detect autoregressive conditional heteroscedasticity. Table 1a in the appendix displays the results of the ARCH-LM test. For all components of electricity consumption (namely, residential, commercial, industrial and other activities, government offices and street illumination electricity consumption), the *LM-stat* is bigger than the critical value, suggesting evidence of heteroskedasticity (Asteriou, 2006).

Before conducting the causality tests, unit roots need to be removed to obtain stationary series. The findings from the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979), employed in the present study, are reported on table 1 and they suggest that all variables are stationary in their first differences. As a second step, we carry out the linear Granger causality test. The results of the linear Granger causality test are used as inputs to the nonlinear test. In order to test for nonlinear causality, any linear dependence should be removed. For this purpose, in the case linear causality has been detected, we apply a Vector Autoregression (VAR) model and use the estimated residual series to test for nonlinear causality. The number of optimum lags is denoted in parentheses (table 1). In the absence of linear causality, the returns are used in the nonlinear testing.

Table 1. Tests of the unit root hypothesis (intercept and trend included)

Variables	**ADF unit root tests**	
	Level	**First difference**
RGNP (0)	-2.169877	-9.221754[a]
TC (1)	-0.546371	-5.607448[a]
RC (1)	-2.054899	-3.952031[b]
GO (1)	-1.684673	-7.280167[a]
IC (0)	0.478706	-7.190222[a]
SI (0)	-1.449006	-7.189695[a]

Notes: 1. [a] and [b] indicate significance at 1% and 5% level, respectively.
2. The numbers in parentheses refer to the lag order in the ADF tests. The selection of the lag parameters is based on the AIC criterion rule.

4.2 Empirical results

By applying the Granger causality test, the causal flow between electricity consumption and economic growth has been examined. In order to be able to assign whether linear Granger causality exists or not, we need to compare the probability that the null hypothesis exists with the critical value. The null hypothesis declares that no Granger causality exists; thus, no linear relationship between electricity consumption and economic growth is observed in Turkey from 1945 to 2006. In case that the probability is greater than the critical value, the null hypothesis is considered as significant and we accept it as the true case. On the other hand, if the critical value is greater than the probability, the null hypothesis is not considered to be significant and we accept the alternative hypothesis, which suggests that a linear Granger causality exists.

Table 2 provides a view of the linear Granger causality results. The empirical results indicate that there are signs of a linear unidirectional causal relationship running from economic growth towards residential and commercial electricity consumption as well as towards street illumination electricity consumption.

Table 2. Results from the linear Granger causality test

Causation	Null Hypothesis	Probability	Critical value	Comments
RGNP - TC	RGNP does not Granger Cause TC	0.4726	0.05	Linear Granger causality does not exist
TC - RGNP	TC does not Granger Cause RGNP	0.2801		Linear Granger causality does not exist
RGNP - RC	RGNP does not Granger Cause RC	0.0094	0.05	Linear Granger causality exists
RC - RGNP	RC does not Granger Cause RGNP	0.8342		Linear Granger causality does not exist
RGNP - GO	RGNP does not Granger Cause GO	0.9084	0.05	Linear Granger causality does not exist
GO - RGNP	GO does not Granger Cause RGNP	0.3686		Linear Granger causality does not exist
RGNP - IC	RGNP does not Granger Cause IC	0.5711	0.05	Linear Granger causality does not exist
IC - RGNP	RIC does not Granger Cause RGNP	0.4032		Linear Granger causality does not exist
RGNP -SI	RGNP does not Granger Cause SI	0.00001	0.05	Linear Granger causality exists
SI - RGNP	SI does not Granger Cause RGNP	0.7694		Linear Granger causality does not exist

In the light of the reported empirical results, one may tentatively suggest that, the growth of certain components of electricity consumption in Turkey (such as street illumination, residential and commercial electricity consumption) is dependent on and determined by economic growth. The findings indicate that fluctuations in the electricity consumption of these sectors will have limited effects on real GNP growth. In the rest of the cases, the absence of causality confirms the existence of the neutrality hypothesis, implying that electricity consumption policies will have no impact on economic growth. The results of our study are in line with Narayan and Prasad (2008) and in contrast to Altinay and Karagol (2005) and Halicioglu (2007); this inconsistency could be attributed to the utilization of different techniques and sample periods.

In order to avoid the estimation bias that might exist if the relation between electricity consumption and real GNP is nonlinear (Chiou-Wei et al., 2008), we apply the nonlinear causality test proposed by Diks and Panchenko. The nonparametric Diks and Panchenko test has been applied in both directions for $Lx=Ly=2, \ldots, 5$ and for bandwidth $\varepsilon_n=1.5$, which has been set according to the time series length n[4]. Table 3 reports the resulting T-statistics and p-values of the Diks-Panchenko testing.

[4] The lag lengths $Lx=Ly$ are ranged between 2 and 5. In that way, the rejection rate decreases with $Lx=Ly$, so that the risk of rejecting under the null becomes small. Besides, in the Diks and Panchenko test, ε_n depends on the sample of the data and it is equal to Max($C^{n-2/7}$, 1.5), where n is the number of observations and C an optimal constant. More details on the use of delays $Lx=Ly$ and the bandwidth ε_n can be found in Diks and Panchenko (2006).

Table 3. Results from the Diks and Panchenko nonlinear causality test

Lx=Ly	TC → RGNP		RGNP → TC		RC → RGNP		RGNP → RC		GO → RGNP	
	Cs	**T-Val**	**Cs**	**T-Val**	**Cs**	**T-Val**	**T-Val**	**T-Val**	**Cs**	**T-Val**
2	-0.973	0.165	-1.964	0.025[a]	-1.623	0.052[a]	0.603	0.273	0.474	0.318
3	-1.089	0.138	-0.703	0.241	-0.176	0.430	0.358	0.360	0.192	0.424
4	-1.195	0.116	-0.548	0.292	0.589	0.278	0.252	0.401	-0.169	0.433
5	-1.180	0.119	-0.485	0.314	1.226	0.110	-0.786	0.216	0.141	0.444
Lx=Ly	**RGNP → GO**		**IC → RGNP**		**RGNP → IC**		**SI → RGNP**		**RGNP → SI**	
	Cs	**T-Val**	**Cs**	**T-Val**	**Cs**	**T-Val**	**Cs**	**T-Val**	**Cs**	**T-Val**
2	0.605	0.272	-1.142	0.127	-1.596	0.055	0.740	0.230	1.311	0.095[a]
3	-0.271	0.393	-0.891	0.186	-0.211	0.417	-0.089	0.465	1.164	0.122
4	-0.256	0.399	-1.033	0.151	-0.188	0.426	0.358	0.360	1.114	0.133
5	-0.820	0.206	-1.149	0.125	-1.184	0.118	0.845	0.199	1.341	0.090[a]

Notes: 1. [a] indicates significance at 10% level.

The results obtained from the above test indicate evidence of a unidirectional nonlinear causality running from real GNP to total electricity consumption (with lag order 2). It is evident that the ‘conservation hypothesis’ applies to the aggregate level of electricity consumption and economic growth. This outcome suggests that, in Turkey, economic growth impacts total electricity consumption, implying that, as the economy grows, higher levels of electricity consumption are required. The presence of nonlinear causality at the aggregate level is inconsistent with the result from the linear causality test, denoting that the standard linear causality test has failed to detect the nonlinear causal relation between the variables.

At the disaggregated level, the findings provide support for the existence of a unidirectional nonlinear causality running from the residential and commercial electricity consumption to real GNP (with lag order 2) as well as from real GNP to electricity consumption for street illumination (with lag order of 2 and 5). the results reveal the absence of nonlinearity among real government offices as well as industrial and other activities electricity consumption and GNP. In other words, the ‘growth hypothesis’ seems to hold for the residential and commercial electricity consumption (a result in contradiction with the linear test), the ‘conservation hypothesis’ for street illumination (a result in accordance with the linear test) and the ‘neutrality hypothesis’ for government offices and industrial electricity consumption (a result in accordance with the linear test). Electricity consumption in the residential and commercial sector plays an important role to economic growth, rendering these variables significant determinants of GNP growth. Thus, to the extent that Turkey intends to influence its growth path through electric policy, it is suggested to expand electricity consumption in the aforementioned sectors of the economy. Restrictions in the electricity supply of these sectors may adversely affect economic growth. The nexus between electricity consumption for street illumination and income, which seems to be consistent with the ‘conservation hypothesis’, indicates that the overall amelioration of Turkey’s economic status may lead to higher electricity consumption for luxury and superfluous goods and services, such as street illumination. For instance, the massive increase in the number of motor vehicles or the intense demand for entertainment services, as a consequence of income improvements, may boost electricity demand for street illumination. Besides, the absence of nonlinearity between electricity consumption for government offices and economic growth denotes that fluctuations of electricity demand in public administration leaves the level of economic growth unaffected and vice versa. Hence, electricity consumption for government services is exogenously determined by factors other than income, i.e. organizational reforms and technological modernization of public administration, the establishment of new public structures, the enhancement of human capital resources in the public sector etc. The same applies to the industrial and other activities sector. The absence of nonlinear causality between industrial electricity consumption and real GNP suggests that the industrialisation progress is independent from the level of economic development and that the electricity use in industry does not impact the level of economic activity.

5. Conclusions

This study has investigated the existence of potential linear and nonlinear causal linkages between electricity consumption and economic growth, both at the aggregate and the sectoral level, for the time period 1945-2006 in Turkey. The innovative feature of the study regards the application of the Diks and Panchenko nonparametric test in addition to the standard linear Granger causality test. The adoption of nonlinear techniques is justified by the fact that developments in the economic environment and changes in the global energy scene may affect the level of electricity use in an unexpected and unpredictable way. Linear models cannot fully explore all information, whereas nonlinear methodologies provide more robust and proper results. The implementation of the newly proposed Diks and Panchenko test is grounded on the witnessed high heteroskedasticity in data sets as well as on the effort to overcome the bias that causes overestimation of nonlinear causality.

At the aggregate level, the empirical results uncover a unidirectional nonlinear causal relation between economic growth and electricity consumption in the case of Turkey. At the disaggregated level, signs of both linearity and nonlinearity are evident in some sectors of the economy, indicating that electric policy should be targeted at specific sectors in order to enhance economic growth. Specifically, the results support the presence of a unidirectional linear flow running from economic growth to the residential, commercial and street illumination electricity consumption as well as a unidirectional nonlinear causality running from the residential and commercial electricity consumption towards economic growth and from income to electricity consumption for street illumination. The neutrality hypothesis is supported in the rest of the cases.

The findings of the study indicate that policy makers should secure electricity supply at sufficient levels to avoid impeding economic growth. On the other hand, economic development raises the demand of durable goods, whose consumption entails increasing levels of electricity consumption. Policies should focus on promoting electricity consumption, especially in the residential and commercial sectors to drive economic growth. However, the presence of nonlinearity inhibits policy makers from assessing the exact impact of the projected policies. Government authorities should be cautious with the shocks they intend to raise in the energy sector, since they are unable to determine the potential effects on the economy. Although there are signs that electricity use has been assigned as a determinant factor of economic growth in Turkey, yet the magnitude of its effect remains unpredictable.

The empirical results of this study can serve as a useful guide for further research. Future research can be pursued by extending the sample size as well as by introducing new methodologies. Researchers could also focus on determining the causes that raise the differences in the electricity consumption influence on GNP growth.

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Appendix

Table 1a. Results of the ARCH-LM test

RGNP	*F*-statistic	0.1654	Probability	0.6857
	Obs*R-squared	**0.1706**	**Probability**	**0.6796**
TC	*F*-statistic	0.0843	Probability	0.7726
	Obs*R-squared	**0.0872**	**Probability**	**0.7678**
RC	*F*-statistic	1.3487	Probability	0.2682
	Obs*R-squared	**2.7118**	**Probability**	**0.2577**
GO	*F*-statistic	0.6827	Probability	0.4120
	Obs*R-squared	**0.6981**	**Probability**	**0.4034**
IC	*F*-statistic	0.6215	Probability	0.4338
	Obs*R-squared	**0.6364**	**Probability**	**0.4250**
SI	*F*-statistic	5.5666	Probability	0.0217
	Obs*R-squared	**5.2543**	**Probability**	**0.0219**