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How Costly is Energy Conservation? The Energy-GDP Relationship Re-examined for Turkey

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ABSTRACT

Economic structure, technology, consumption habits, cultural and similar values vary greatly between countries. Energy consumption included in this structure is theoretically thought to be related to growth output. Could slowing the growth be the cost of reducing energy consumption? In this study, using annual data between 1970 and 2019, it was investigated whether per capita energy consumption affects per capita income asymmetrically or not by using the NARDL model. The feature that makes this study different from similar studies is that it interprets the short and long-term asymmetric effects with the analysis model used and makes a unique contribution to the literature. The findings gave us the conclusion that income is affected in the same way by shocks experienced in energy consumption, and it has been observed that the effect of positive shocks is greater in the long run. However, we conclude that negative shocks are more effective than positive shocks in the short term. Thus, we see that the increase in energy consumption in the long term increases the per capita income, and the decrease in energy consumption has a high as well as negative impact on income per capita in the short term. Based on the fact that the conservation approach is managed in a balanced way, one of the reasons for the slowdown in the national income rates of the countries may be due to the decrease in energy consumption in the long term. Accepting that the conservation approach is managed in a balanced way, one of the reasons for the slowdown in the national income rates of the countries may be due to the decrease in energy consumption in the long term.

Keywords: Energy Consumption, Per Capita Income, Economic Growth, NARDL Asymmetric
JEL Classifications: Q43, P44, O47, C12

1. INTRODUCTION

All activities of people and especially those that contribute to economic and social development live in a life based on energy consumption. Currently, a significant part of the world's energy consumption is used through daily individual electronic consumption materials. In addition, all transportation services (air, sea, road, rail) increase the dependency on energy with the goods and services sector along with the use of oil. Service providers (hotels, offices, shops, shops, etc.) use energy to meet multiple needs (lighting, cooking, hot water, heating, air conditioning, audio-visual, cooling and other devices). In addition, the industry and transportation sector, which constitute the indicators of economic growth parameters, continues its activities with a significant amount of energy use. Due to the intensive use of technology, especially in developed countries, we can think that growth may change depending on commercial energy consumption. However, it is inevitable to increase and develop the diversity of sources in energy consumption with a sustainable growth. In response to the question of what should be done in this regard, policies should be created with an understanding of consumption for efficient growth and efficiency.

Therefore, one of the most important questions that societies should think about on energy is to focus on the quality of growth based on energy use. We can look at per capita energy consumption as one of the indicators that economic growth is accelerating in developing countries. Therefore, despite the intensive use of labor in developing countries, the increase in energy consumption due to the use of technology may have a positive effect on growth in the long term, if not in the short term.

Understanding long-term "energy transitions" and "development trajectories" is a major challenge in moving towards sustainable development in a globalizing world. Energy transitions are defined as changing and expanding the depreciable capital stock to meet the growing energy demand, investing in cleaner technologies. Also, when considered over a longer period of time, significant changes in energy technologies and consumption can be observed across countries as well. Energy intensity-technological change roles affect labor-energy-capital (Moroney, 1992). Development trajectories can characterize by sectoral changes in the economy that transform society from traditional (agriculture/industrial sector) to modern (service/ITC sector) (Lise and Van Montfort, 2007). For this reason, energy consumption, energy problems, and its relationship with economic variables should be investigated closely. Figure 1 depicts per capita energy consumption (in kilowatt-hours equivalent) vs. per capita GDP (in current foreign dollars). The scale of the bubbles represents each country's total population. Both figures are based on the year 2011. Increases in per capita energy usage indicates potential changes in the economy's structure, such as shifts to more energy-intensive sectors, as well as shifts in service demand, such as rising demand for air conditioning and appliances.

When we look at developed and developing countries, especially after the 1980s, the rapidly increasing world population has accelerated both labor and technology-oriented production in these economies. As one of the components that create this value, we can say that energy use is partially balanced with per capita income among these countries. In addition, if we consider that domestic energy is an important consumption area in developing countries; It is much more common to use biomass, especially as a fuel for humans to make basic food, and this non-commercial energy is actually used at low efficiency. Of course, the effect of the population in rural areas should not be ignored. However, in developed economies, electricity efficiency other than biomass is higher due to the prevalence of urban areas. Therefore, in countries like Turkey and Brazil, although per capita national income is less than per capita national income of the developed countries, per capita energy consumption is closer to the level of developed countries. In fact, this is an indication that the desired results in efficient energy consumption have not yet been achieved on behalf of developing countries. Therefore, lower urban energy consumption for a given income level, higher productivity for urban households and a better quality of life are required.

In the field of energy economics, a subject that remains empirically difficult to understand and controversial is the causal relationship with variables based on energy consumption. At the center of this problem arises the question of which variable takes precedence over another. Different evidence can have important aspects of policy (Masih and Masih, 1996). This brings this question: does energy consumption lead to economic growth or does economic growth cause energy consumption? Discussions can be done either way, but experimental studies have been inconclusive. Because, countries show great differences in economic development, culture, technology, consumption habits and similar stages. For this reason, let's first consider the relationship between energy economy and growth from a theoretical framework.

2. THEORETICAL FRAMEWORK

2.1. Concept of Energy and Properties of Energy Sources

Energy, as one of the most important economic arguments for individuals and societies all over the world, has continued to protect its value from past to present. Affecting factors can be list as follows:

- Energy is a finite source in the world
- It is the fact that Energy is not distributed equally in every region in the world which is causing disparity. Therefore, energy is an important element in the power balance for countries
- Energy can be transformed, and this affects the wealth of individuals. Despite of all these positive aspects, energy has negative effects which is increasing the possibility of environmental pollution due to energy transformations and encourages the major depletion of natural resources (Bilginoğlu, 1991. p. 123).

Energy resources are divided into two main groups as commercial and non-commercial. It is accepted that oil, natural gas, waterpower and nuclear energy are commercial energy sources, while wood, agricultural residues and animal residues are among the non-commercial energy sources. Commercial energy sources are more subjected to scientific studies. Because this kind of resources have the power of a greater impact on increasing living comfort of individuals. These are more valuable trade objects, and these may cause political and military crises between countries. Therefore, politicians use this subject as propaganda in order to be more powerful in politics and to be elected again (Bilginoğlu, 1991. p. 123).

Within the economic development in countries, the demand for commercial energy resources increases day by day, however, the demand for non-commercial energy resources shows a decreasing trend. Individuals' increasing incomes due to industrialization and urbanization and preferring more luxurious living conditions cause this situation. However, changes and innovations in technology lead to a reduction in energy demand. The decrease in energy demand will result in a decrease in the foreign dependency levels of the countries. Thus, the reduction in energy costs will enable the public benefit from services that require high energy in more appropriate way and the level of social welfare will increase accordingly. Another factor to be taken into account in energy is the time factor. Despite technological advances, making Energy available to use is still a time-consuming process. Therefore, it also takes time to measure the impact of energy on economies and the sociocultural change on society. In addition, the dynamic course of technological innovations has significant effects on the rate of usage of new energy resources together with technological innovations. High demand for technological innovations by individuals will also attract new investments, but this process will take time as the realization of this situation depends on the capital stock (Hansen, 1990. p. 633).

2.2. Factors of Determining the Energy Supply and Demand

Energy supply can be expressed as making it available to use and increasing production capacity. Factors which are needed in order to produce the energy supply with minimum cost and quality will be explained further. It is possible to increase the energy supply to a higher level with the effective use of energy production and natural resources available. There are basically two factors that determine the energy supply. One of these is the accessibility and availability of resources; another is the cost of production prices. Making natural resources available is directly related to the climate, geopolitical location and geographical conditions of the countries. If the geographical conditions of a country are suitable for the formation of renewable energy resources and are supportive in replacing the depleted resources, the possibility of an expected increase in production volume increases depending on the investments made for production. For example, if the climatic conditions are suitable for the use of wind energy, the solution of resource scarcity can be eliminated by converting wind energy to other forms of energy (Yüksel, 2010. p. 3215).

In order to provide a sufficient level of energy and increase the energy supply, the amount of investment allocated to energy should be higher and the energy should be provided in financially the most efficient way. It is possible for countries which increase their energy investments and to spend most of their available resources in the field of energy. In case of insufficient investments, closing the energy deficit by importing energy from outside offers a short-term solution to the energy supply deficiency (Bilginoğluand Yılmaz, 1986. p. 360-361).

Energy production requires both high costs and requires accurate planning. For this reason, many companies act hesitant and hold back on the provision of many energy services that have the nature of a natural monopoly. Therefore, for such services, the state is expected to provide these services at a less cost in terms of economies of scale. In addition, it is necessary to regulate the state in preventing externalities that will arise due to environmental pollution as a result of energy production (Dumrul, 2011. p. 9-16).

Energy demand is related to household rights and consumption patterns of businesses in the short term. Therefore, the factors that determine energy demand are individuals' incomes, interest rates and energy prices. Individuals are unwilling to buy comfort at a high price. Therefore, increasing energy investments will not only make prices cheaper as it will increase energy supply, but also will reflect positively on their income due to reasons such as the employment of individuals due to increased investments. With the increase in employment as well as investments, economic growth will be positively affected by the multiplier effect, so it will be possible to obtain the necessary resources for energy investments more easily (Ersoy, 2010. p. 6).

2.3. The Concept of Economic Growth and Economic Growth Models

Economic growth means that there is an increase in the amount of goods and services in a country at a certain time. In short, economic growth can be expressed as the real increase in national income compared to the previous year. Economic development includes economic growth as well as some social, cultural and technological innovations. Countries did not want economic growth to become a problem, as economic growth is seen as a cake that individuals benefit from in order to have more resources and redistribute wealth. Therefore, some theories of economic ideas about how to achieve economic growth in a country have emerged. It is possible to briefly list these views, which are called economic growth theories and based on a model, as follows: They are exogenous growth models and endogenous growth models such as classical growth model, Keynes' growth model, Harrod Domar growth model, Neoclassical growth model (Özel, 2012. p. 64-67).

Since the classical growth model is supply-side, it argues that growth can only be achieved by increasing the production capacity of investments. The Keynesian growth theory, on the other hand, is demand-side contrary to the classics and argues that investments contribute to economic growth by generating income, thus Keynes neglected the aspect of investments that increase production capacity. The Harrod-domar growth model, on the other hand, explained growth with capital accumulation and argued that there is a significant relationship between capital stock and output in the economy. Again, according to this model, if the marginal saving rate is high and the capital/output coefficient is low, economic growth will increase. (Özel, 2012. p. 64-67).

"As for the neo-classical growth model, it is also called as the Solow growth model, since it is pioneered by Solow. According to this model, the growth rate is affected by technological innovations. Therefore, it believes that it is necessary to invest in technology to ensure growth. Because according to this view, productivity will reflect positively on growth as technology will increase the productivity of labor and capital. The pioneers of the endogenous growth model are Lucas, Romer and Barro. In endogenous growth models, Lucas drew attention to the importance of capital investments, Barro and Rand investments, and Romer to the importance of capital investments and technical knowledge. Growth in this idea changes depending on technological development stimulated by human investment. (Özel, 2012. p. 64-67; Öğretir, 2020. p. 403-404).

2.4. Factors Affecting Economic Growth

Since economic growth exhibits a multidimensional and dynamic structure, factors affecting growth may also differ over time. However, today, it is possible to list some of the important factors that affect growth as follows:

- Technological development and innovations
- High level of savings and investment opportunities
- Human capital accumulation
- Qualified workforce and educational opportunities of the country
- Presence of natural resources
- Climate Conditions suitability for growth.

2.5. The Relationship between Economic Growth and Energy

Increasing investments in energy will make the country's economic conditions grow in its favor. As energy, especially renewable energy, is a popular resource all over the world, the foreign trade volume of the country will expand as a result of energy exports to foreign countries. Thanks to the investments made in energy, new employment opportunities and, demands for goods and services will be brought along with the increased investments that are demanded from outside the country. This will contribute to the growth of the countries' economy in the long run. Here, the important issue in terms of energy supply is to accurately determine the production scale of energy supply and to reach the optimal production scale. Determining the demand correctly is one of the most important issues in reaching the optimal scale in terms of production. As a matter of fact, determining the demand lower than it should be, it is not possible for countries to benefit from energy in a homogeneous way as it will cause production shortage, while determining the demand above expected means the provision of production in an expensive way. In this case, a situation arises where the available resources are not used optimally (Costantini and Martini, 2010. p. 595-596).

As the increase in energy consumption will increase the demand for investments, it can be said that it will affect the economic growth positively. But the externality dimension of energy should not be neglected. As a matter of fact, the state will apply taxation in order to prevent or reduce the environmental pollution caused by the increase in energy supply. At this point, it is important how the state will allow production at an optimal level.

If the reason for economic growth in a country is due to the increase in energy investments, tax revenues will increase accordingly. Because the increased income of companies that allocate resources to energy investments and gain profits will also have a positive impact on the tax they will pay. Increase in energy investments will contribute to tax revenues by providing income source to the unemployed, as well as causing an increase in the purchase of goods and services depending on the nature of the investment and may cause an increase in sales revenue and tax revenues due to the increase in demand in certain sectors (Arslan et al., 2020. p. 337).

3. LITERATURE REVIEW

There are many studies in the literature such as energy consumption-income-prices, energy consumption-economic growth, energy consumption-employment (Eden and Jin, 1992; Hondroyiannis et al., 2002; Masih and Masih, 1997; Sari and Soytas, 2004). However, these studies focused on the relationship between energy consumption and gross domestic product.

Hwang and Gum examined the causality between energy consumption and GDP for Taiwan Province of China, and a two-way causality was found in Taiwan during the period 1955-1993. Another study by Cheng and Lai in 1997 showed that in Taiwan, where Hsiao's version of the Granger causality methodology was applied to investigate the causality between energy consumption and GDP in Taiwan for the period 1955-1993, causality goes from GDP to energy consumption without feedback. In another study based on the same sample by Yang (2000), he re-investigated the causality between energy consumption and GDP for Taiwan using updated data for the period 1954-1997. He observed that there are different causal aspects between GDP and various types of energy consumption. Based on these mixed results, it is wrong to make any generalizations about the potential relationship between GDP and energy consumption. Therefore, when designing an improvement policy aimed at facilitating energy consumption and promoting economic growth, it is necessary to consider the situation of each developing country individually. For example, as in most of the other oil-importing countries, Turkey's energy demand is met by imports in large quantities. Therefore, Turkey's economy is faced with constraints arising from energy supply and demand management policies to meet growing energy needs. However, for this kind of policy making, it is important to determine the causal relationship between GDP and energy consumption (Altinay and Karagol, 2004).

Lise and Van Montfort (2007) stated that, the energy situation in Turkey has indicated that it needs to examine from many different angles. Turkey is a candidate to become an EU member in the near future and membership in the preparatory process for the Turkish economy may be stabilizing. The presence of oil and gas transport routes in Turkey, is an advantage in energy efficiency due to important strategic location.

In another study, it has been investigated the integration between GDP and energy consumption and partners and causality in Turkey by using Granger Representation Theorem. 5.9% annual increase of GDP and 7% annual increase in energy consumption was expected in Turkey by 2025. By using annual data of Turkey's 1970-2003 period, it is tried to explain the link between GDP and energy consumption. The analysis shows that energy consumption and GDP are integrated together. This means that there is a (possibly bidirectional) causal relationship between the two. It has been found that there is a one-sided causality, from GDP to Energy Consumption, indicates that energy savings will not harm economic growth in Turkey. It was also observed that as the economy grows, it also increases in energy consumption in Turkey (Lise and Van Montfort, 2007).

Energy consumption is a well-studied topic in energy economy. In the study examining the time series properties of energy consumption and GDP and investigating the causality relationship between the two series in the top 10 developing markets except China due to the lack of data, and the causality relationship between the G-7 countries; two-way causality from GDP to energy consumption from Argentina to Italy and Korea and causality from energy consumption to the GDP in Turkey, France Germany and Japan has been found. Thus, it has been concluded that energy savings can harm economic growth in the last four countries. This suggests that energy savings in the long run can hurt economic growth in these countries (Soytas and Sari, 2003).

Panel unit root, recently developed tests for heterogeneous panel cointegration, and panel-based error correction models are used in the study, which re-investigates the joint movement and causality relationship between energy consumption and GDP in 18 developing countries using data from 1975-2001. Empirical results provide a clear support for a long-term cointegration relationship after allowing for heterogeneous country impact. The long-term relationship is estimated using a fully modified OLS. Evidence suggests that long-term and short-term causations are moving from energy consumption to GDP, but not the other way around. This result shows that energy savings can harm economic growth in developing countries, regardless of whether they are temporary or permanent (Lee, 2005).

In another study, the causal relationship between energy consumption and economic growth was examined by applying a multivariate capital, labor, energy and GDP model. Four variables (energy, GDP, capital stock and labor) were used in the multivariate Granger causality analysis and for Korea, the empirical results for the period 1970-1999 show that there is a long-run bidirectional causal relationship between energy and GDP and a short-run unidirectional causality from energy to GDP. It has been found that the source of causality in the long run is error correction terms in both directions (Oh and Lee, 2004).

Another study used energy consumption and GDP panel data for 82 countries from 1972 to 2002. Based on the income levels defined by the World Bank, the data are divided into four categories: low-income group, lower middle-income group, upper middle-income group and high-income group. The GMM-SYS approach was used to estimate the panel VAR model in each of the four groups. Then, the causal relationship between energy consumption and economic growth was determined. (a) in the low-income group, there is no causal relationship between energy consumption and economic growth; (b) economic growth in middle income groups (lower and upper middle-income groups) positively affects energy consumption; (c) Economic growth in high-income countries has been found to negatively affect energy consumption. However, energy efficiency decreases and CO2 emission increases after the energy crisis in upper middle-income countries. Since there is no evidence that energy consumption leads to economic growth in any of the four income groups, it was stated that a stronger energy saving policy should be followed in all countries (Huang et al., 2008).

Belloumi (2009) examined the causal relationship between energy consumption per capita (PCEC) and per capita gross domestic product (PCGDP) for Tunisia in the period 1971-2004 with the Johansen cointegration technique. In order to test Granger causality in the presence of cointegration between variables, the vector error correction model (VECM) was used instead of the vector autoregressive model (VAR) to reach the estimation results. They found that for Tunisia, PCGDP and PCEC are associated with a cointegration vector and there is a long-run bidirectional causal relationship between the two series and a short-run one-way causality from energy to gross domestic product (GDP). It has been found that the source of causality in the long run is error-correction terms in both directions. Therefore, an important policy implication that emerges from this analysis is that energy can be considered as a factor limiting GDP growth in Tunisia. The consequences for Tunisia may apply to a few countries that have to go through a similar development pathway that increases the pressure on already scarce energy resources.

The USA is a diverse country with some states producing and consuming fossil fuel energy to feed their industries, with other states being prominent in renewable energy production and consumption. Some parts of the country are driven by agricultural products, others by manufacturing. For example, the US Energy Information Administration 1 (EIA) reported that Texas consumed 13% of total US energy consumption in 2012, and California ranks second in energy use. While Texas consumes 14.2 quadrillion Btu, the California consumer is only about 8 trillion Btu. The EIA also reports that "the top 10 states exceed the combined energy use of the other 41 states (including DC)". The aim of the study is to show energy consumption and real GDP by states and reveal that there are significant differences in energy consumption between US states. Louisiana has the highest per capita energy consumption, while New York ranks the lowest. It is important to understand and address these differences so that the policies implemented do not hinder economic growth and the overall development of the country (Mahalingam and Orman, 2018).

Another study aims to explore the economic growth-energy consumption link in Algeria between 1980 and 2012. Cointegration tests show that there is a long-term link between real gross domestic product, real capital and two energy consumption categories, namely renewable energy. Long-term and short-run autoregressive distributed lag (ARDL) estimates show that only non-renewable energy type and capital can contribute to increased economic growth, but renewable energy does not show a significant impact. The result of causality tests proves that there is a feedback link between non-renewable energy consumption and gross domestic product, capital and gross domestic product, and between non-renewable energy and capital, both in the short and long term. Moreover, the results reveal a one-way link from renewable energy to economic growth, capital and non-renewable energy, respectively, in the long run (Amri, 2017).

Another study, taking the Italian sample, aims to examine the relationship between energy consumption, real income, financial development and oil prices in Italy in the period 1960-2014. Toda-Yamamoto causality tests and Granger causality tests were applied with the data. The ARDL cut-off F test provides evidence of a long-term relationship between four variables at the 1% significance level. In addition, the increase in real GDP and oil prices had a significant effect on energy consumption in the long term, with the findings showing that energy consumption is affected by real GDP (Magazzino, 2018).

Studies can differ in many econometric and statistical methods. Rodríguez-Caballero (2021) proposed a fractionally integrated panel data model with cross-sectional dependency. This type of dependency is driven by a factor structure that captures interpretations made by higher-order factors among blocks of variables and by factors uncommon within those blocks. The model can include both fixed and non-stationary variables, making it flexible enough to analyze the relevant dynamics often found in macroeconomic and financial panels. The estimation methodology is based on fractionally differentiated block-to-block section averages. Monte Carlo simulations suggest that the procedure performs well with typical sample sizes.

Lu (2018) aimed to examine the effects of information and communication technology (ICT), energy consumption, economic growth and financial development on carbon dioxide emissions using 1993-2013 panel data from 12 Asian countries. Both energy consumption and GDP have significant positive effects on carbon dioxide emissions; has seen that energy consumption and GDP have an impact on the growth of carbon dioxide emissions. ICT has a significant negative impact on carbon dioxide emissions. Energy consumption, GDP, and carbon dioxide emissions cause ICT. While GDP causes financial development, energy consumption and GDP are determined by each other.

4. DATA AND METHODOLOGY

4.1. Data

In this study, an annual frequency dataset covering the years 1970-2019 is used to examine the relationship between per capita income (USD) and per capita energy consumption (kilograms of oil). The time-series data consist of per capita income (Percap), per capita energy consumption (EC). We obtained the time series data on PERCAP and EC from the World Bank website. Until analysis, all variables were translated to logarithms. Statistics are presented in a summary format.

4.2. Methodology

To examine the long-run and short-run effect of energy consumption (EC), the per cap income (percap) in Turkey country, we specify the relationship between variables asymmetrically, we used the NARDL model and Shin et al. (2014), we made use of the error correction model in equation 1.

$$\Delta Y_t = \alpha_0 + \alpha_1 T + \rho Y_{t-1} + \varphi^+ X_{t-1}^+ + \varphi^- X_{t-1}^- + \sum_{k=1}^{p-1} \delta_k \Delta Y_{t-k} + \sum_{k=0}^{q-1} \left(\alpha_k^+ \Delta X_{t-k}^+ + \alpha_k^- \Delta X_{t-k}^-\right) + \varepsilon_t \quad (1)$$

Long term coefficients established as $\partial^+ = -\varphi_1^+/\rho$ and $\partial^- = -\varphi_1^-/\rho$.

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_{j,} 0)$$

$$x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \max(\Delta x_{j,} 0)$$

To check if an asymmetric long-run cointegration exists, we used a proposed bound test by to perform a combined test for all lagged levels of regressors. In this section of the paper, we used F-statistics to test the null hypothesis of θ = 0 against the alternative hypothesis of Y θ < 0 and T-statistics In this case, the null hypothesis is tested at = 0 against the alternative hypothesis of 0. We used $Lmi^+ = \theta^+/\rho$ and $Lmi^- = \theta^-/p$ to estimate long-run asymmetric coefficients, where these long-term coefficients expose the positive and negative charges of the exogenous variables and display the long-run relationship between the (Chukwunonso Bosah et al., 2020).

Here, the independent variables are the partial sum of positive and negative changes. The error terms of the model should be homoscedastic, normally distributed and not autocorrelated. The existence of co-integration in this model is tested by the following hypotheses with the F test proposed by Pesaran et al. (2001) and Banerjee et al. (1998) and the t-test proposed by Banerjee et al. (1998).

H_0:$\rho=\varphi_1^+=\varphi_2^-=0$
H_0:$\rho=0$

For the significance of the asymmetric relationship, the Wald test's null hypotheses are established as;

For the long term: H_0:$\varphi_1^+=\varphi_2^-$

For the short term: H_0: $\alpha_k^+=\alpha_k^-$, j=0, 1, 2, 3…q–1

Long term asymmetry coefficients, long term parameters $\partial^+ = -\frac{\varphi_1^+}{\rho}$ ve $\partial^- = -\frac{\varphi_2^-}{\rho}$ for its significance:

H_0:$\partial^+=0$
H_0:$\partial^-=0$

Hypotheses are being tested.

$h \to \infty$, $mh^+ \to Lm^+$ and $mh^- \to Lm^-$ shows the dependent variable's asymmetric responses to positive and negative variance in the independent variables. Following the variance that affects the system, we find a constant shift in the changes from the original to the new equilibrium between system variables based on calculated multipliers. To determine the asymmetric causal relationship between the variables, the asymmetric causality test, as suggested by is used. He goes on to say that integrated variables can be given in a random walk phase in the following generalized form. Also, granger proposed a causality test in 1969 to explain the interdependence of economic time series. If two variables Xt, Yt, t 1 are purely stationary, Yt Granger induces Xt if past and/or current values of X provide additional details on potential values of Y, according to this. (Chukwunonso Bosah et al., 2020):

5. EMPIRICAL RESULTS

To test the propensity of a unit root test over a time series, we used both the Augmented Dickey–Fuller (ADF) test proposed by and the Phillips and Perron (PP) test proposed by without the structural split. In addition, the appropriate model was chosen if the integration instructions of the selected variables were known. Under the alternative hypothesis, the presence of the unit root is the null hypothesis of stationarity in both experiments. This provided the variables following I(0) or I(1) processes by checking the stationarity of all selected variables (CE, EC, and EG) with intercept or along intercepts and trends. The unit root test for stationarity is shown in Table 1 to decide whether variables are incorporated of order one. In the diagram above, C and T represent the ADF and PP options for "Constant" and "Constant + Trend," respectively.

According to the unit root results, both variables contain unit root at the level. But when their first difference is taken, they become stationary. The variables provide the assumption of NARDL since they are integrated at most first order.

5.1. NARDL Estimated Result

We then used important statistic values to see whether variables are influenced by each other in the long run at various significant levels, in order to see whether cointegration exists. The tBDM-statistics developed by and the F-test proposed by were used to test

Table 1: Unit ROOT results

Level (PP)	PERCAP	EC
Constant		
t-Statistic	3.3158	1.1067
Prob.	1	0.997
Constant and Trend		
t-Statistic	–0.1045	–2.2728
Prob.	0.9933	0.4395
Level (ADF)	**PERCAP**	**EC**
Constant		
t-Statistic	2.2279	0.2884
Prob.	0.9999	0.9751
Constant and Trend		
t-Statistic	–0.1283	–2.1858
Prob.	0.9928	0.4856
First Diff.(PP)	**d(PERCAP)**	**d(EC)**
Constant		
t-Statistic	–5.5483	–6.9045
Prob.	0	0
Constant and Trend		
t-Statistic	–6.1743	–8.0298
Prob.	0	0
First Diff.(ADF)	**d(PERCAP)**	**d(EC)**
Constant		
t-Statistic	–5.5528	–6.601
Prob.	0	0
Constant and Trend		
t-Statistic	–6.1757	–6.5988
Prob.	0	0

a nonlinear long-run relationship between electric consumption, economic growth, and carbon emissions. The outcomes are shown in Table 2.

The results of the diagnostic checking in terms of Serial correlation (SC), Heteroscedasticity (HT), Functional Form (FF), and Jarque–Bera (JB) developed by estimating the cointegration relationship are shown in Table 2. All of the variables meet the statistical criteria for serial correlation (SC) and White heteroscedasticity (HT), and the Ramsey test (FF) reveals that the model has no misspecification at the 5% level of statistical significance.

$$\Delta PERCAP_t = \alpha_0 + \sum_{k=1}^{p-1} \delta_k \Delta PERCAP_{t-k} + \sum_{k=0}^{q-1} \left(\alpha_k^+ \Delta EC_{t-k}^+ + \alpha_k^- \Delta EC_{t-k}^-\right) + \rho PERCAP_{t-1} + \varphi_1^+ EC_{t-1}^+ + \varphi_2^- EC_{t-1}^- + \mu_t \quad (2)$$

The appropriate lag length is determined as p =3, q =3, which gives the highest corrected R value by making a step-by-step trial, and the diagnostic tests and estimation results are given in Table 2.

When the diagnostic tests are examined, it is concluded that the model provides all the assumptions. Since the calculated F statistics and t statistics for cointegration exceed the upper critical values, it is concluded that there is cointegration between series.

Table 3 clearly shows the distribution of asymmetric relationships between energy consumption and per capita income based on the

Table 2: Model prediction and diagnostic tests

NARDL (3,3)	Coeff.	Std.Err.	t-stat	Prob.
$PERCAP_{t-1}$	–0.60501	0.2022065	–2.99	0.005
EC_{t-1}^{+}	6.614688	2.2332	2.96	0.006
EC_{t-1}^{-}	0.645235	1.935444	0.33	0.741
$\Delta PERCAP_{t-1}$	0.257049	0.2231471	1.15	0.258
$\Delta PERCAP_{t-2}$	0.33202	0.2148708	1.55	0.133
ΔEC_{t}^{+}	4.320917	1.841209	2.35	0.026
ΔEC_{t-1}^{+}	–2.84582	2.132394	–1.33	0.192
ΔEC_{t-2}^{+}	–4.57066	2.299448	–1.99	0.056
ΔEC_{t}^{-}	7.029489	2.403698	2.92	0.007
ΔEC_{t-1}^{-}	3.083398	2.800749	1.1	0.28
ΔEC_{t-2}^{-}	1.642705	2.705913	0.61	0.548
TREND	–89.1323	30.42432	–2.93	0.006
C	2717.118	861.7161	3.15	0.004
Diagnostic tests		**Test stat.**		**Prob.**
Breusch-Pagan-Godfrey Het. Test		0.4028		0.5256
Breusch-Godfrey AC LM Test		19.06		0.4532
Jarque-Bera Normality		1.684		0.4308
RAMSEY RESET test		1.436		0.2542
Cointegration test		**Test stat.**		**Critical value**
t_BDM		–4.39		–3.69
F_PSS		9.87		7.3

Model prediction and Diagnostic tests presented in Table 2 above. From the table, it can be seen that for Turkey, an asymmetric relationship between energy consumption and per capita income, can be identified.

When the asymmetry tests are examined, the dependent variable is income per person for both the long term and the short term; independent variable reacts differently according to the direction of the shock in energy consumption per capita. In the long run, a 1-unit increase in energy consumption increases the income by 10.93 units, while the decrease in consumption does not affect the income statistically. In the short term, shocks in consumption affect income in the same period and in the same direction, and the effect of negative shock is higher.

6. DISCUSSION

The asymmetric causality test, introduced by, was used to evaluate the causal relationship between the variables and their cumulative coefficient (Hatemi-J, 2012). In a positive shock of energy consumption and economic growth, the asymmetric nexus running from energy consumption to economic growth is noted (Shahbaz et al., 2017). For positive shocks, asymmetric causality between energy consumption and economic growth was also discovered. Simultaneously, a natural impact for the negative shock in energy consumption and economic growth was observed in the short term. To accelerate energy production and ensure an energy supply for industries, policymakers should encourage new investors to construct more energy ınvestment in a region. The positive effects that will occur in the economic conjuncture can accelerate from investment to growth. In order to increase this effect, indirect employment can be improved by providing incentive financial supports to the investor when necessary.

Figure 1: GDP per capita with energy use

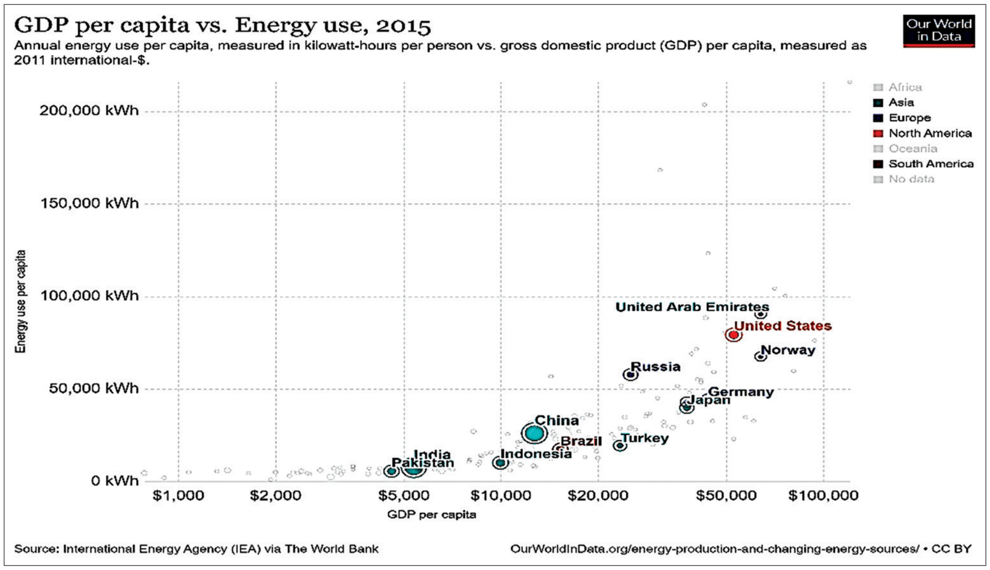

Table 3: Distribution of asymmetric relationships

Asymmetry tests	F-stat		Prob.
EC (long term)	13.63		0.001
EC (short term)	4.742		0.037
Long term	**Coeff.**	**F-stat**	**Prob.**
EC(+)	10.933	74.39	0.000
EC(–)	–1.066	0.1231	0.728

Undoubtedly, reducing the growth trend by reducing energy consumption has high opportunity cost for the economies of the country (Alola et al., 2019). Because the main carriers of growth are energy-dependent production sectors. Especially for Turkey, the most significant energy consuming sectors are industry-manufacturing, transportation, residences and energy production-distribution systems. When viewed from the perspective of the energy intensity of the sector in Turkey, manufacturing industry has higher intense than the services, transportation and agricultural sectors. The industrial sector and buildings are the areas that offer the greatest opportunity in terms of energy efficiency. Although there are differences in potential energy efficiency gains between sub-sectors, high energy consumption in the industrial sector makes this sector a target sector for promoting energy efficiency investments. Thanks to this projects and supportive actions may causes serious improvements in Turkey. It is possible to assume that most of the developments in the manufacturing industry are due to process and equipment upgrades. With modern technologies, including electric motors and other equipment, production has become more efficient than before.

7. CONCLUSION AND POLICY IMPLICATIONS

The COVID-19 pandemic is shaking all countries of the world, regardless of the developed or developing economy. Globally, it is aimed to stimulate economic commercial activities with financial support programs of institutions such as the US Federal Reserve (Fed), European Central Bank (ECB) and IMF. The losses in exports and the contraction of international trade volume are the result of the disruptions in the provision of intermediate goods inputs required for the production of the manufacturing industry in the global economy and the bottlenecks in the global value chains. Therefore, there has been a significant decrease in electricity demand in the last 1 year in Turkey. It has been observed that the increased consumption of houses due to the restrictions could not compensate the decline in the industry, services and trade sectors due to the slowdown in economic activities. The dramatic decline in electricity demand has led to a decrease in electricity sales prices as there is already a surplus in the market. With the effect of the pandemic in electricity generation, the decline from January to May 2020, and then an increase again with the effect of the recovery of economic activities with the normalization process in Turkey. The production decline in the relevant period occurred in thermal power plants.

As a result, more investments should be made for sustainable economic growth, increase in per capita national income and construction of alternative energy sources. Government officials and politicians should attract more investors to boost the country's economy. Otherwise, increases in exchange rates and an increase in import-dependent energy demand are faced with a suppression in personal income. We know that the energy sector alone is not enough to increase per capita national income in the country. However, we should not forget that it is a fundamental issue that should not be neglected.

We investigate the nexus between economic development, energy use, agriculture, and capital for time-series data from 1970 to 2019 in Turkey using the output function as a Non-linear Auto-Regressive Distributed Lag (NARDL). We investigate the long-term and short-term equilibrium relationship using a non-linear ECM under the NARDL defined by (Shin et al., 2014). Our findings show that the variables have a good asymmetric co-integration relationship. Furthermore, from the viewpoint of the economic growth effect, asymmetric causality is explored for energy consumption and per capita income.

The findings gave us the conclusion that per capita income is affected in the same way by shocks experienced in energy consumption, and it has been observed that the effect of positive shocks is greater in the long run. However, we conclude that negative shocks are more effective than positive shocks in the short term. In other words, we realized that the policy of increasing growth by decreasing energy consumption would be wrong. We conclude that it is necessary to carry out various activities in order to meet energy demand in the country of Turkey's energy sector, establishing an energy efficiency culture in the society for efficient energy consumption policy and to change consumption habits positively by increasing awareness on efficiency and environmental issues. In addition, it is considered that it will be more sustainable to carry out studies on the trend of consumption increase considering the sensitivities in energy efficiency, sustainability and climate change, and in case of a decrease in energy consumption-income relationship.

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