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Level of Urbanization and Renewable Energy Consumption: The Case of Azerbaijan and Türkiye

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ABSTRACT

Conventional energy consumption requires serious costs, especially for countries that import this type of energy. In this study, one of the countries included in the analysis is considered as energy exporting countries and the other as energy importing countries. The study attempted to measure the relationship between urbanization levels and renewable energy consumption in Türkiye and Azerbaijan for the period 2000-2020. Granger causality test was applied to measure the effect of the relationship between variables in these countries. After the necessary assumption tests were applied, the analysis was started. According to the Granger test results, no causal relationship was found between the variables in both countries.

Keywords: Level of Urbanization, Renewable Energy, Granger Casuality, Azerbaijan, Türkiye
JEL Classifications: P25, Q42, O13

1. INTRODUCTION

As a result of the activities carried out with the increase in people's demands and needs along with the globalization process, nature is damaged and negative residues are left on the quality of life of future generations. There are increases in energy demand in the world due to reasons such as increasing population, increasing industrialization activities, developments in technology, improvements in living standards, and increase in consumption expenditures. Non-renewable energy sources are preferred to meet the increasing demand. The reason for this preference is that access to these resources is less costly and more easily accessible (Çınar and Yılmazer, 2015).

The use of renewable energy such as wind, solar, geothermal and hydroelectricity has been encouraged more in recent years than before. Investing in renewable energy resources by governments has begun to become government policies. Energy resources are divided into two groups according to their usability and convertibility. While they are divided into two as renewable and non-renewable energy sources according to their availability; they are divided into two as primary energy and secondary energy sources according to their convertibility (Erdem and Şenel, 2013).

There is no denying the significance of energy in the modern world. Energy is not only one of the fundamental elements that contribute to industrialization, but it is also an essential component of human lifestyle. According to Sarkhanov (2022), the significance of oil has risen as a result of the fast growth in oil consumption that has occurred alongside the process of industrialization. On the other hand, there is no other energy source aside from oil. Renewable sources of energy are absolutely necessary for the continued existence of the earth. According to Huseynli (2023), the act of forecasting the production of renewable energy sources has a considerable influence on the decisions that are made about the operation and administration of power systems.

Renewable energy resources, which are the subject of the study, are energy resources that do not run out when used once, can be used

again and again and do not run out. Examples of these resources are solar energy, wind energy, geothermal energy, hydrogen energy, hydroelectric energy, biomass energy and marine-based energy resources (Bilginoğlu, 1991). Renewable energy has many advantages and disadvantages. Chiras (2001) lists these advantages as follows:

- Renewable energy is an energy source that does not run out once used and can be used over and over again
- Renewable energy is much cleaner than non-renewable energy sources
- Since it is not subject to the control of multinational companies, it can be said that renewable energy is free, with some exceptions
- With the development of technology, energy can be obtained from renewable sources. For this, when the necessary investments are made in some areas, costs will decrease and thus energy production from renewable sources will occur more quickly and easily
- Since renewable energy resources are mostly controlled through small energy companies, the possibility of sabotage is low. Considering the disadvantages
- The high costs of investments made to meet large amounts of demand can be seen as the biggest disadvantage
- Full specialization cannot be achieved as a result of not having sufficient knowledge in the use of resources. Lack of specialization at a sufficient level brings with it many problems such as feasibility and durability within the framework of technical innovations
- Some energy sources, such as solar and wind, need storage because they are not available every day, every hour. Storage of renewable resources is expensive and has many difficulties.

With population growth and urbanization, energy needs arise for both industrial production and daily life. Energy use resulting from the process of economic growth and urbanization is vital for societies to raise their living standards and ensure economic development. Along with globalization, the rapid development of technology and the increase in industrialization activities cause a serious increase in the energy consumption of countries. On the other hand, limited energy resources encourage countries to reorganize their energy policies and seek alternative and renewable energy sources to meet their energy needs (Karagöl et al., 2007).

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The aim of the study is to suggest appropriate policies to policy decision makers in order to achieve economic growth by using energy effectively, which is seen as an indispensable element for economic expansion. For this purpose, Granger causality test was conducted with annual data taken from the World Bank Economic Indicators database for the period 2000-2020 for Türkiye and Azerbaijan, which experienced significant increases in terms of population, geographical area, and economic growth rates.

2. LITERATURE REVIEW ON URBANIZATION AND RENEWABLE ENERGY CONSUMPTION

Energy is an indispensable element for meeting basic needs and sustaining life. For this reason, the fact that energy has a very important place in social life, the diversity of energy sources and the fact that it includes many economic activities from production to consumption have created energy economy, which is a sub-branch of the economy. The field that analyzes people's use of energy resources and energy goods and the result of this use is called energy economics. Issues such as the increase in the amount of goods and services consumed globalization and urbanization also change depending on the increase in energy consumption. In this context, there are a number of studies in the literature within the framework of renewable energy and urbanization.

The term "renewable energy" refers to fuels that do not contribute to environmental pollution. There are a number of factors that influence the use of renewable energy sources, including environmental contamination and the risk of sustainable development for existing energy sources. The term "renewable energy" refers to the energy that is obtained from renewable sources such as the sun, the wind, and biogas (Huseynli, 2022).

Looking at the studies examining the relationship between urbanization and economic growth, Liu (2009) examined the relationship between energy use, population growth, economic growth, and urbanization for China in the period between 1978 and 2008. ARDL bounds test and factor decomposition model were used in the study. As a result of the study, it was determined that there was a unidirectional causality from urbanization to total energy use in both the short and long term. Al-mulali and Ozturk (2015) investigated the causes of environmental degradation based on the panel cointegration test for 14 Middle East and North Africa (MENA) countries during the period between 1996 and 2012. As a result of the cointegration test, they determined that there is a long-term relationship between ecological footprint, energy use, urbanization, trade openness, industrial development, and political stability.

Shahbaz et al. (2014) examined the relationship between economic growth, electricity consumption, urbanization, and environmental degradation for the United Arab Emirates during the period between 1975 and 2011. As a result of the study, they determined that there was a long-term relationship between the variables and

an inverted-U-shaped relationship between economic growth and CO_2 emissions. Additionally, electricity consumption reduces CO_2 emissions and urbanization increases CO_2 emissions. As a result of Granger causality, they mentioned the existence of a bidirectional causality relationship between CO_2 emissions and electricity consumption, economic growth, and urbanization. Hossain (2012) analyzed the causality relationship between CO_2 emissions, energy consumption, economic growth, foreign trade, and urbanization for Japan in the period covering the years 1960-2009. The analysis reveals that more energy consumption increases environmental pollution, but economic growth, trade openness and urbanization do not affect environmental quality in the long term.

Al-mulali and Lee (2013) investigated the relationship between energy use, financial development, economic growth, urbanization, and total trade for the Gulf Cooperation Council (GCC) countries in the period covering 1980-2009. As a result of the study conducted using panel cointegration and Dynamic OLS (DOLS) tests, they found that financial development, economic growth, urbanization, and total trade have a positive effect on energy use in the long term. Additionally, while there is a bidirectional causality relationship between energy use and economic growth; they concluded that there is a one-way causality relationship from financial development to energy use and from urbanization to energy use.

In the studies of Zhao and Wang (2015), a unidirectional causality relationship was detected between energy and urbanization, from renewable energy consumption to urbanization. A unidirectional relationship was found between oil and urbanization, from oil prices to urbanization. Other studies conducted; Topalli (2016), Ergün and Polat (2015), Jalil and Mahmud (2009), Apergis and Payne (2010), Saboori et al. (2012), Hamit-Haggar (2012) can be given as examples. They found a one-way causality relationship between carbon and urbanization, from CO_2 emissions to urbanization.

Halicioglu (2007) stated that the Granger causality relationship between urbanization and energy consumption is inclusive in the long term, but inconclusive in the short term. Other researchers have determined that as the urbanization process develops, the structure of energy consumption rapidly develops within a year and eventually where oil can be found (Sathaye and Meyers, 1985, Jones, 1991).

Wang and Wan (2014) researched and revealed through a time series analysis available on residential energy consumption (REC) and energy production consumption (PEC) of urbanization produced; It was observed that the REC per capita could be reduced due to the size economies of urbanization. Poumanyvong et al. (2012) studied the charges on transportation and highway energy use of urbanization, which offers low, medium, and high-income product options, between 1975 and 2005. As a result of the research, it can be seen that the change in the level of urbanization is that high-income groups have a greater activity on transportation and road energy use with other groups, and the urbanization of middle-income groups on transportation and road energy operation is smaller.

Poumanyvong and Kaneko (2010) suggested that the impact of urbanization on emissions is positive for all income groups, but middle-income groups are more pronounced than other groups. Martínez-Zarzoso and Maruotti (2011) found that the relationship between urbanization and carbohydrates (CO_2) emissions showed an inverted U shape, and the emission-urbanization ratio was determined to be positive for low levels of urbanization.

3. RESEARCH METHODOLOGY

3.1. Data Set

The data set used in the study consists of an annual data set covering the years 2000-2020. Logarithmic values of urbanization levels at both country levels were taken and included in the analysis. The necessary statistical data was obtained from the world bank platform.

3.2. Analysis Method and Results

In addition to economic theories when explaining the relationship between economic variables, econometric methods such as the Granger model are used to analyze the dynamic relationship between economic indicators. The Granger model tests whether there is any causality between variables.

In Granger analysis, the model must be stationary for the results to be reliable. The fact that all inverse roots of the characteristic polynomial obtained from the model are located within the unit circle indicates that the model is stationary as a whole (Banerjee et al., 1993). There are a number of stationarity tests in the literature. According to the results of the extended Dickey Fuller test, Phillips test, Levin Lin and Chu Test and Im, Pesaran, Shin stationarity tests, all variables should be stationary at the $\alpha = 0.05$ significance level when the first order difference of the series is taken.

One of the assumed tests before measuring causality in the data set is to determine the appropriate lag length. Determining the lag length in Granger models is one of the important problems. To find the appropriate lag length, criteria such as the Sequential modified Likelihood Ratio (LR) test statistic, Last Prediction Error Criterion (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC) and Hannan-Quin Information Criterion (HQ) are used. After the appropriate lag length is determined, the results of the Granger model estimated using the lag length in question are interpreted. Granger developed it to determine the direction of the relationship between the variables in question (Granger, 1969).

Dumitrescu and Hurlin (2012) developed Granger causality analysis and created a new causality analysis for heterogeneous panel data sets. Today, this causality test, developed in studies

requiring causality testing, is widely used. The Dumitrescu and Hurlin test are like a combination of homogeneous non-causal and heterogeneous non-causal tests. Dumitrescu and Hurlin define two standardized test statistics: the test statistic based on exact asymptotic movements of individual Wald statistics and the test statistic based on converged movements for a finite T sample (Dumitrescu and Hurlin, 2012).

Before applying the analysis, the necessary data for the model was determined. As stated in the literature section, the changes included in the analysis were chosen as the urbanization rate and renewable energy consumption for both countries. Information about the variables used in the analysis is given as in Equation 1.

$$Y = f(\textit{urbanization level, Renewable energy consumption}) \quad (1)$$

To measure the relationship between the variables included in the analysis, each variable was replaced as a dependent variable once. In this way, it was tried to reveal whether the variables affect each other or not. The established models for the variables are included in Equation 2 and Equation 3.

$$\textit{Urbanization level} = \beta 0 + \beta 1\ \textit{Renewable energy consumption} \quad (2)$$

$$\textit{Renewable energy consumption} = \beta 0 + \beta 1\ \textit{Urbanization level} \quad (3)$$

Before proceeding with the analysis, a series of assumption tests required for causality tests must be carried out. The first of these tests is to observe whether the variables are stationary or not. If the variables have level stability, the transition to other stages is made. If the stationarity level is not obtained, the necessary tests are carried out. The level-order stationarity results for both countries are given in Table 1.

According to the applied ADF test results, surface degree stationarity could not be achieved for both countries. For this reason, stationarity was achieved by applying the ADF test again. As can be seen from Table 2, stationarity levels on the basis of variables were obtained only in the second order. Data regarding the stationarity results are given in Table 2:

After completing the stationarity assumption test for the data set, the VAR model was established and the appropriate lag length for the data was determined. The appropriate delay length was examined in six steps within the framework of both countries. Information about appropriate lag lengths in the data set is given in Table 3.

After the assumption tests required for the Granger causality test were performed, the analysis was started. Two hypotheses were determined for each country and an attempt was made to measure whether the variables affected each other. Information about Granger results is given in Table 4.

Table 1: Level values of series

Türkiye				
ADF test resault	**Level of urbanization**		**Renewable energy consumption**	
	t-statistics	**Possibility**	**t-statistics**	**Possibility**
ADF testing statistics	−3.049897	0.1454	−2.419637	0.1492
Test critical values				
%1	−4.532598		−3.808546	
%5	−3.673616		−3.020686	
%10	−3.277364		−2.650413	
Azerbaijan				
ADF test resault	**Level of urbanization**		**Renewable energy consumption**	
	t-statistics	**Possibility**	**t-statistics**	**Possibility**
ADF testing statistics	−2.027419	0.2737	−1.147098	0.6755
Test critical values				
%1	−3.808546		−3.808546	
%5	−3.020686		−3.020686	
%10	−2.650413		−2.650413	

Table 2: Stationarity level of second order series

Türkiye				
ADF test resault	**Level of urbanization**		**Renewable energy consumption**	
	t-statistics	**Possibility**	**t-statistics**	**Possibility**
ADF testing statistics	−3.843612	0.0229	−5.572878	0.0003
Test critical values				
%1	−3.457386		−3.831511	
%5	−3.040391		−3.029970	
%10	−2.660551		−2.655194	
Azerbaijan				
ADF test resault	**Level of urbanization**		**Renewable energy consumption**	
	t-statistics	**Possibility**	**t-statistics**	**Possibility**
ADF testing statistics	−4.422443	0.0032	−4.890968	0.0011
Test critical values				
%1	−3.857386		−3.831511	
%5	−3.040391		−3.029970	
%10	−2.660551		−2.655194	

As can be seen from Table 4, H_1 hypothesis is rejected in both countries. In other words, no relationship has been determined between the variables in this country. Within the framework of Azerbaijan and Türkiye, the level of urbanization in both countries does not cause renewable energy consumption in these countries. Likewise, renewable energy consumption does not affect urbanization levels. As a result of the analysis, no causality was found between the variables in both countries.

Table 3: Appropriate delay length

Türkiye						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	−27.99720	NA	0.187171	3.999626	4.094033	3.998620
1	−18.00189	15.99248	0.085045	3.200253	3.483473	3.197236
2	−4.124739	18.50287*	0.023766*	1.883299	2.355332*	1.878270
3	−2.275956	1.972035	0.035116	2.170127	2.830974	2.163088
4	0.250878	2.021467	0.053045	2.366550	3.216210	2.357499
5	5.876045	3.000089	0.066164	2.149861	3.188334	2.138799
6	17.29115	3.044028	0.066996	1.161180*	2.388467	1.148107*
Azerbaijan						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	−22.22411	NA	0.086685	3.229881	3.324288	3.228876
1	−8.974182	21.19989	0.025521	1.996558	2.279778	1.993541
2	−4.991830	5.309803	0.026679	1.998911	2.470944	1.993883
3	7.295602	13.10659*	0.009801	0.893920	1.554767	0.886880
4	13.45257	4.925572	0.009124	0.606324	1.455985	0.597274
5	25.36256	6.351994	0.004923*	−0.448341	0.590133	−0.459403
6	36.61712	3.001217	0.005093	−1.415616*	−0.188329*	−1.428689*

*Indicates the appropriate lag length for the relevant test

Table 4: Granger causality test

Türkiye			
Hypotheses	**F-value**	**Probability value (p)**	**Decision at 1% significance level**
The level of urbanization is the reason for renewable energy consumption	1.312136	0.5189	Rejected
Renewable energy consumption is the reason for urbanization in this country	2.291675	0.3180	Rejected
Azerbaijan			
Hypotheses	**F-value**	**Probability value (p)**	**Decision at 1% significance level**
The level of urbanization is the reason for renewable energy consumption	1.057817	0.5892	Rejected
Renewable energy consumption is the reason for urbanization in this country	5.935854	0.0514	Rejected

4. DISCUSSION AND CONCLUSION

The concept of energy has a very important place in terms of enabling people to live their lives in a healthier and more prosperous way and ensuring economic growth. The environmental friendliness of renewable energy sources consisting of solar, wind, hydro, geothermal and sea-based energies provides significant socio-economic contributions. In addition to the contribution they provide, some renewable energy sources have higher costs than traditional energy sources. However, today's rapidly increasing technology is gradually reducing these costs. This makes renewable energy sources more attractive and increases investments in this field.

As a result of the Granger causality test applied to the variables in the study, an analysis of renewable energy consumption and urbanization in Türkiye and Azerbaijan was made. According to the analysis results, the urbanization level in both countries does not cause renewable energy consumption in these countries. Likewise, renewable energy consumption does not affect urbanization levels. As a result of the analysis, no causality was found between the variables in both countries.

If we discuss the importance that this study adds to the literature, it focuses on renewable energy and urbanization studies, albeit limited, in the Turkish context. The fact that such a study is not included in the literature within the framework of Azerbaijan shows the originality of this study. In future studies, a more comprehensive study can be conducted by increasing the number of variables and the number of countries.

Several sectors are impacted by urbanization and energy. The tourism industry is one among them. In the tourism industry, energy use is crucial. Energy utilization is one of the most crucial components of a nation's essential operations and economic dynamics. One unit of economic growth requires the usage of energy (Sarkhanov and Muradzada, 2023).

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