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Analyzing the Causality Relationship Between Economic Growth Information and Communication Technologies Energy Consumption and Ecological Footprint: The Case of Türkiye (1975-2018)

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Abstract

This study aims to examine the causal relationship between economic growth, information and communication technologies, energy consumption, and ecological footprint in Türkiye between 1975 and 2018. The Toda-Yamamoto causality test, which is one of the time series analysis methods, was used in this study. Descriptive statistics of the variables were first created in the study. Then, the stationary structures of the variables were checked through unit root tests and it was understood that the variables were stationary at different levels. In the last stage, the analysis was completed by applying the Toda-Yamamoto causality test to the variables. In the analysis, a one-way causality relationship was found from information and communication technologies, energy consumption, and ecological footprint to economic growth. In addition, a one-way causality relationship was found from information and communication technologies to energy consumption and ecological footprint, while a one-way causality relationship was found from energy consumption to ecological footprint.

Keywords: economic growth, ecological footprint, energy consumption, information and communication technologies, Türkiye
Jel codes: C32, O47, P18, Q57

1. Introduction

The increases in production and consumption with the industrial revolution have increased the need for energy, technology, and other production factors. This has led to the unconscious and uncontrolled consumption of resources, especially natural resources. In addition to increasing developments such as production and consumption as a result of these developments, the use of energy, technology, and other production factors in an unconscious and uncontrolled way causes nature to be destroyed and depleted (Aytekin, 2022).

The purpose of this study is to examine the causality relationship between economic growth, information and communication technologies, energy consumption, and ecological footprint between 1975 and 2018 in Türkiye. In the study, as a method of econometric time series analysis methods; Phillips-Perron's (1988) unit root test, Lee-Strazicich's (2003) unit root test with two structural breaks, and Toda-Yamamoto (1995) causality test were used.

The most important feature that distinguishes this study from the literature is the use of energy consumption as an energy variable as a wider area of energy variables in most of the previous studies, while the use of electrical energy consumption as an energy variable with economic growth, ecological footprint, information and communication technologies variables. In addition, the fact that the studies used in this study together with the analysis period and analysis country used in economic growth, information and communication technologies, ecological footprint, and electricity consumption variables together are other important features that distinguish this study from the studies in the literature.

The first chapter of the study is the introduction. After the introduction chapter, the literature review chapter of similar studies carried out for the subject of this study is given. After the literature examination, the third chapter of the methods and data sets used in the analysis of the study is included. In the fourth chapter, the empirical results section of the unit root tests and the results of the Toda-Yamamoto causality test results are given. In the last stage, the result and discussion chapter of the empirical findings were included.

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2. Literature Review

In the literature, economic growth, information and communication technologies, and ecological footprint are generally examined with energy consumption, which is a wider area. In this study, economic growth, information, and communication technologies, and ecological footprint are handled with electrical energy consumption.

In the literature, similar to the subject of this study and close studies; Collarda et al. (2005), Yoo (2006), Wolde-Rafael (2006), Squalli (2007), Yuan et al. (2007), Narayan & Singh (2007), Narayan & Prasad (2008), Acaravcı & Öztürk (2010), Ciarreta & Zarraga (2010), Bildirici & Kayıkçı (2012), Sadorsky (2012), Akpan & Akpan (2012), Farhani & Rejeb (2012), Azal & Gow (2016), Chen et al. (2016), Salahuddin & Alam (2016), Lu (2018), Chimbo (2020), Kutlar et al. (2022), Satrovic & Adedoyin (2022) and Aytekin (2022) it is possible to sort. The findings and results achieved in the literature examination for these studies are given in detail below.

Collarda et al. (2005), France's services sector through computers and software increased as the production of electricity consumption increased and communication devices spread with the spread of electricity consumption decreased. Yoo (2006), 4 Southeastern Asian Countries (ASEAN) member states of Malaysia and Singapore in the two-way causality relationship between electricity consumption and economic growth; in Indonesia and Thailand, there is a unidirectional causality relationship from economic growth towards electricity consumption. Wolde-Rufael (2006), in the 9 African countries, it has been found that there is a long-term relationship between electricity consumption per capita and GDP per capita, and in 12 African countries, there is a causality relationship between these variables. Squalli (2007) has observed to have a long-term relationship between electricity consumption and economic growth for all OPEC members. Yuan et al. (2007) İt has been observed that there is a cointegration relationship between economic growth and electricity consumption in China and a causal relationship from electricity consumption to economic growth. Narayan & Singh (2007) observed that in Fiji, the direction of electricity consumption and the direction of the labor force is towards economic growth.

Narayan & Prasad (2008), in the 30 OECD countries, electricity consumption in Australia, Iceland, Italy, Slovakia, Czech Republic, Korea, Portugal, and the United Kingdom is the reason for economic growth; in the remaining 22 countries, it was concluded that electricity consumption is not the cause of economic growth. Acaravcı & Öztürk (2010) did not have a long-term relationship between electricity consumption and economic growth in 15 transitional countries. In addition, a clear conclusion between these variables on the causality relationship could not be reached. Ciarreta & Zarraga (2010) in Spain, there is causality from economic growth towards electricity consumption. Bildirici & Kayıkçı (2012), 11 in the Independent State of Nations (CIS), it has been concluded that there is a causality relationship from long-term electricity consumption to economic growth. Sadorsky (2012) has been found to have a positive and statistically significant relationship between ICT and electricity consumption in developing countries. Akpan & Akpan (2012) has been observed that in Nigeria, economic growth and electricity consumption caused an increase in carbon emissions. Farhani & Rejeb (2012), in the 15 MENA countries here was no causal relationship between economic growth, energy consumption, and CO_2 emissions in the short term. In the long term, -a way causality relationship has been encountered from economic growth and CO_2 emissions to energy consumption.

Azal & Gow (2016) has a positive and statistically significant relationship between ICT and electricity consumption in 11 developing countries (N-11). Chen et al. (2016) show that there are long-term relationships between economic growth, energy consumption, and carbon dioxide emissions in 188 countries. On the other hand, energy consumption in developing countries harms economic growth, while a causality relationship has been found from energy consumption to carbon dioxide emissions in all countries. Salahuddin & Alam (2016) has been concluded that with the use of ICT in OECD countries, economic growth increases electricity consumption in the short and long term. In addition, electricity consumption causes economic growth, while the use of the telephone and internet is the reason for economic growth with electricity consumption. Lu (2018), in 12 Asian countries; energy consumption, GDP, and financial development have been found to cause causality towards CO_2. In addition, from CO_2, energy consumption, and GDP to the ICT causality relationship was found.

Chimbo (2020) it was found that the impact of ICT on electricity consumption in developing countries was negative and insignificant according to the results of dynamic GMM and pool. According to the results of the fixed and random effects model, it has been concluded that ICT has a positive effect on electricity consumption. Kutlar et al. (2022), in the countries of MINT (Mexico, Indonesia, Nigeria, and Türkiye), there was no causality relationship between energy consumption, per capita income, and ecological footprint variables in the short term.

However, there was a causality relationship between these variables in the long term. Satrovic & Adedoyin (2022), for the 10 most complex countries in the world (Japan, Switzerland, South Korea, Germany, Singapore, Austria, Czech Republic, Sweden, Hungary, and Slovenia), there was a one-way causality relationship between electricity consumption and ecological footprint. However, a bidirectional causality relationship between economic growth and the ecological footprint was found. Aytekin (2022), in Türkiye, there was a negative and statistically meaningless relationship between economic growth and ecological footprint in the short term. However, a positive and statistically significant relationship was found between economic growth and ecological footprint in the long term.

3. Data Set and Method

In this section, brief information about the data sets and study methodology used in the study is given. The analysis data used in the study are discussed in detail in Table 1 given below. These data cover Türkiye's 1975-2018 period. The reason why the analysis period started in 1975 is due to limited reason for electrical energy consumption data. The reason why the analysis period ended in 2018 is due to limited ecological footprint data. Data were obtained from the data.footprintnetwork.org database with the Türkiye Statistical Institute.

Table 1. Variables and description

Variables	Variable Short Name	Variable Description
Ecological Footprint	LNEFP	Ecological footprint per person (global average hectare).
Electric Energy Consumption	LNEEC	Annual electrical energy consumption (megawatt)
Economic Growth	LNGDP	Annual gross domestic product (US $).
Information and Communication Technologies	LNICT	Number of fixed telephone, mobile telephone and internet subscribers.

In the study, as a method of econometric time series analysis methods; Phillips-Perron's (1988) unit root test, Lee-Strazicich's (2003) unit root test with two structural breaks, and Toda-Yamamoto's (1995) causality test were used.

4. Empirical Findings

In this study, the first findings of the empirical analysis are defined as descriptive statistics. The descriptive statistics created in this direction are given in Table 2 shown below.

Table 2. Descriptive statistics

Variable	Observation	Min. Val.	Max. Val.	Mean	Std. Dev.	Skewness	Kurtosis
LNEFP	44	0.703	1.261	0.958	0.172	0.047	1.652
LNEEC	44	9.509	12.461	11.140	0.886	-0.204	1.759
LNGDP	44	24.558	27.483	26.069	0.990	0.103	1.567
LNICT	44	13.430	18.929	16.490	1.810	-0.256	1.652

When the descriptive statistics of the variables given in Table 2 are examined, it is understood that the variables are suitable for the analysis. After the descriptive statistics, the unit root conditions of the variables were examined and the results of the first PP unit root test are given in Table 3 shown below.

Table 3. PP unit root test result

Level	Variables	PP	
		Constant	Constant & Linear Trend
		t-stat. (Prob.)	t-stat. (Prob.)
At Level	LNEFP	-0.906 (0.776)	-5.426 (0.000)*
	LNEEC	-2.788 (0.068)***	-1.3458 (0.862)
	LNGDP	-0.769 (0.818)	-2.486 (0.333)
	LNICT	-1.799 (0.376)	-0.068(0.9959)
At First Difference	ΔLNEFP	-12.471 (0.000)*	-12.419 (0.000)*

	ΔLNEEC	-6.041 (0.000)*	-6.319 (0.000)*
	ΔLNGDP	-6.925 (0.000)*	-6.845 (0.000)*
	ΔLNICT	-2.453 (0.134)	-2.705(0.241)
At Second Difference	**ΔLNICT**	-7.408(0.000)*	-10.492(0.000)*

Notes : * and *** denote statistical significance at 1% and 10% significance levels, respectively, while Δ denotes difference operator.

When the PP unit root test results given in Table 3 are examined, the ecological footprint (LNEFP); I(0) according to the constant & trend model and I(1) according to the constant model; it is understood that electrical energy consumption (LNEEC) is I(0) according to the constant model and I(1) according to the constant & trend model. In addition, according to Table 3, economic growth (LNGDP) is I(1) according to both models; it was understood that information and communication technologies were I(2) according to both models. As a result, according to the results of the PP unit root test, it was found that the variables are stationary at different levels. After the PP unit root test, the Lee-Strazicich (2003) unit root test with two structural breaks was applied to variables and the results are given in Table 4 shown below.

Table 4. Lee-Strazicich unit root test with two structural breaks result

Variables	**LNEFP**	**LNEEC**	**LNGDP**	**LNICT**
Model	**Break C**	**Break C**	**Break C**	**Break C**
t-stat.	-6.571781	-5.884612	-4.548518	-4.899
%1	-6.750	-6.821	-6.691000	-7.004000
%5	-6.108**	-6.166	-6.152000	-6.185000
%10	-5.779***	-5.832*	-5.798000	-5.828000
TB_1	1981	1999	1985	1986
TB_2	1984	2008	2005	2004

Notes: *, ** and *** refers to 1%, 5%, and 10% significance. **TB:** Refers to breakage time.

When Table 4 was examined, it was understood that there were structural breaks in 1981 and 1984 in the ecological footprint (LNEFP) and that these breaks were statistically significant. It was found that structural breaks in 1999 and 2008 in the consumption of electrical energy (LNEEC), another variable in Table 4, were statistically significant in these breaks. In Table 4, the structural breakdowns in the variable of economic growth (LNGDP) were experienced in 1985 and 2005, while these structural breaks were found to be statistically meaningless. Finally, in Table 4, structural breaks were found in 1986 and 2004 in the information and communication technologies (LNICT) variable, while these breaks were found to be statistically meaningless.

The structural break periods in the ecological footprint indicate the effects of liberalization policies in Türkiye as well as political, military, and economic developments. The structural refraction in the consumption of electrical energy in 1999 pointed out the Marmara Earthquake in Türkiye and the economic crisis experienced at the end of 1999; The structural breakage in 2008 points to the global financial crisis in 2008.

In the final stage of this study, the Toda-Yamamoto causality test was applied to variables. Thus, the results of the predictions created and the causality results are given below (Toda & Yamamoto, 19951):

$$LNEFP_t=\mu+\sum_{i=1}^{k+dmax} a_1\, LNEFP_{t-i}+\sum_{i=1}^{k+dmax} a_2\, LNEEC_{t-i}+\sum_{i=1}^{k+dmax} a_3\, LNGDP_{t-i}+\sum_{i=1}^{k+dmax} a_4\, LNICT_{t-i}+\varepsilon_t \quad (1)$$

$$LNEEC_t=\mu+\sum_{i=1}^{k+dmax} a_1\, LNEEC_{t-i}+\sum_{i=1}^{k+dmax} a_2\, LNEFP_{t-i}+\sum_{i=1}^{k+dmax} a_3\, LNGDP_{t-i}+\sum_{i=1}^{k+dmax} a_4\, LNICT_{t-i}+\varepsilon_t \quad (2)$$

$$LNGDP_t=\mu+\sum_{i=1}^{k+dmax} a_1\, LNGDP_{t-i}+\sum_{i=1}^{k+dmax} a_2\, LNEFP_{t-i}+\sum_{i=1}^{k+dmax} a_3\, LNEEC_{t-i}+\sum_{i=1}^{k+dmax} a_4\, LNICT_{t-i}+\varepsilon_t \quad (3)$$

$$LNICT_t=\mu+\sum_{i=1}^{k+dmax} a_1\, LNICT_{t-i}+\sum_{i=1}^{k+dmax} a_2\, LNEFP_{t-i}+\sum_{i=1}^{k+dmax} a_3\, LNEEC_{t-i}+\sum_{i=1}^{k+dmax} a_4\, LNGDP_{t-i}+\varepsilon_t \quad (4)$$

Table 5. Toda-Yamamoto causality test results

Independent Variables	**Dependent Variable: LNEFP**				
	d_{max}+k=3	**χ^2**	***P***	**Decision**	**Conclusion**
LNEEC	3	8.7469	0.003*	H_0: Rejection	LNEEC => LNEFP
LNGDP	3	0.999	0.317	H_0: Acceptance	LNGDP ≠>LNEFP
LNICT	3	10.307	0.001*	H_0: Rejection	LNICT => LNEFP
ALL	3	14.010	0.003*	H_0: Rejection	ALL => LNEFP
Independent Variables	**Dependent Variable: LNEEC**				
	d_{max}+k=3	**χ^2**	***P***	**Decision**	**Conclusion**
LNEFP	3	0.091	0.763	H_0: Acceptance	LNEFP ≠> LNEEC
LNGDP	3	1.639	0.200	H_0: Acceptance	LNGDP ≠> LNEEC
LNICT	3	2.845	0.092***	H_0: Rejection	LNICT => LNEEC
ALL	3	4.832	0.184	H_0: Acceptance	ALL ≠> LNEEC
Independent Variables	**Dependent Variable: LNGDP**				
	d_{max}+k=3	**χ^2**	***P***	**Decision**	**Conclusion**
LNEFP	3	4.955	0.026**	H_0: Rejection	LNEFP => LNGDP
LNEEC	3	4.672	0.031**	H_0: Rejection	LNEEC => LNGDP
LNICT	3	3.494	0.062***	H_0: Rejection	LNICT => LNGDP
ALL	3	6.664	0.083***	H_0: Rejection	ALL => LNGDP
Inependent Variables	**Dependent Variable: LNICT**				
	d_{max}+k=3	**χ^2**	***P***	**Decision**	**Conclusion**
LNEFP	3	0.225152	0.6351	H_0: Acceptance	LNEFP ≠> LNICT
LNEEC	3	0.154932	0.6939	H_0: Acceptance	LNEEC ≠> LNICT
LNGDP	3	0.022502	0.8808	H_0: Acceptance	LNGDP ≠> LNICT
ALL	3	2.182855	0.5353	H_0: Acceptance	ALL ≠> LNICT

Notes: χ^2 : Chi-sqki value, **P:** Probability value, *, ** and *** refers to 1%, 5% and 10% significance, =>: Granger is the causality. ≠> : Granger isn't the causality.

The first part of Table 5 shows the result of Model 1's Toda-Yamamoto causality test. These results show that there is a causality relationship from electrical energy consumption and information and communication technologies to ecological footprint, but there is no causality relationship from economic growth to ecological footprint.

The second part of Table 5 shows the result of Model 2's Toda-Yamamoto causality test. The results show that there is a causality relationship from information and communication technologies to electrical energy consumption in Türkiye. There was no causality relationship from economic growth and ecological footprint to electrical energy consumption.

The third part of Table 5 shows the result of Model 3's Toda-Yamamoto causality test. Results show that there is a causality relationship from information and communication technologies, ecological footprint, and electrical energy consumption to economic growth.

The last part of Table 5 shows the result of Model 4's Toda-Yamamoto causality test. Results show that there is no causality for ecological footprint, electrical energy consumption, and economic growth to information and communication technologies.

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The schematic impression, which is a summary of the results of the Toda-Yamamoto causality test given above, is as in Figure 1 below.

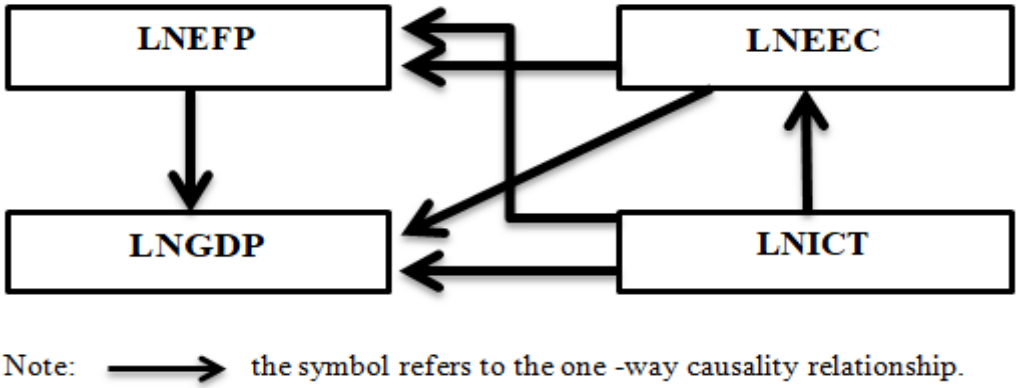

Figure 1. Schematic representation of causality results

5. Conclusion and Discussion

In this study; in Türkiye, it has been found that there is a one-way causality relationship from information and communication technologies, energy consumption, and ecological footprint to economic growth. In addition, a one-way causality relationship from information and communication technologies to energy consumption and the ecological footprint was found. Finally, a one-way causality relationship from energy consumption to ecological footprint was determined.

On the other hand, in the ecological footprint of Türkiye (LNEFP) in 1981 and 1984 structural breaks occurred, while these breaks were found to be statistically significant. These structural breakdown periods, which are seen in the ecological footprint, indicate the liberalization policies in Türkiye as well as political, military, and economic developments. In Türkiye's electricity consumption (LNEEC), structural breaks occurred in 1999 and 2008, while these breaks were also statistically significant. The breakage of electrical energy consumption in 1999 points to the economic crisis with the Marmara earthquake in Türkiye in 1999, while the breakage in 2008 points to the global financial crisis in 2008.

The empirical results achieved in the study show that the policies supporting electrical energy savings in Türkiye and the decrease in the use of information and communication technologies will adversely affect economic growth. In addition, it is possible to say that the use of information and communication technologies and the increases in the use of electrical energy damage the environment. Finally, the results of the two-breaking unit root test show that shocks in Türkiye temporarily affect the ecological footprint and electrical energy consumption.

The results achieved in this study; Collarda et al. (2005), Yoo (2006), Squalli (2007), Naradayan & Singh (2007), Yuan et al. (2007), Bildirici & Kayikci (2012), Sadorsky (2012), Azal & Gow (2016), Salahuddin & Alam (2016), Satrovic & Adedoyin (2022) and Aytekin (2022) support the results of the studies. However, Acaravcı & Öztürk (2010) does not support the results of the study.

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