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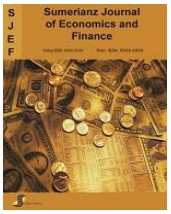

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Testing the Relationships Among Environmental Pollution, Electricity Consumption, Economic Growth: The Empirical Evidence from Turkey

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Abstract

This study examines the long-term cointegration and causality relationships between economic growth, carbon emission (CO_2), electricity consumption, and the industrial production index for the period from 1980 to 2011 in Turkey. Accordingly, the Johansen Cointegration Test and VECM Granger Causality Test have been used. Empirical analysis shows a long-term cointegration relationship between all variables. According to the findings of Granger Causality Analysis, there is unidirectional the Granger Causality relationship from economic growth to electricity consumption. Furthermore, the findings show unidirectional causality from CO_2 emissions, electricity consumption, and economic growth to the industrial production index.

Keywords: VECM granger causality; Johansen cointegration test; Electricity consumption; CO_2 emission; Economic growth.

1. Introduction

Energy, an indispensable building block of economic development, is an important factor that influences countries' economies and policies. After two major oil crises in the 1970s, energy increased in importance in parallel with globalization. In this context, countries' energy demands and their increasing energy dependence have brought the search for alternative and renewable energy sources into the agenda (Karagol *et al.*, 2007).

Among energy components, electrical energy has the highest quality and the widest usage area. Electricity consumption is one of the most important indicators of the numerical, industrial, and economic development of a country. Per-capita electricity consumption is higher in developed and industrialized countries compared with that in developing countries. Most of the energy needed globally is supplied by fossil fuels (coal, oil, natural gas). However, after the world oil crisis (1973), countries have turned to new energy sources because of the lack of confidence in those energy sources and environmental pollution they cause. The EU, which is not particularly rich in fossil energy resources, industrialized Far East countries, and the USA—which has a very large energy consumption—have pioneered the development of alternative renewable energy sources (Yilmaz, 2012).

Among the Organization for Economic Cooperation and Development (OECD) countries, Turkey has had the most rapid increase in energy demand in the last ten years. After China, Turkey has become the second-largest economy in the world with the highest rate of increase in demand for electricity and natural gas since 2002. In parallel with increasing population, economic development, and rising living standards, the demand for energy is increasing daily (Akova, 2008; EUAS., 2012). Turkey's dependency on energy imports, especially oil and natural gas, is increasing due to the rapidly increasing energy demand. Whereas approximately 25% of Turkey's total energy demand is supplied by indigenous sources, the remaining 75% is supplied by various import sources (MFA).

In parallel with developments in infrastructure investments in Turkey as a developing country, significant increases in the level of economic development have also been observed in electricity consumption over the years. The provision of energy demands from fossil fuels to assure economic growth is accompanied by an increase in CO_2 emissions, and particularly in greenhouse gas emissions. Importantly, because most of the energy needs of these countries are still fulfilled by fossil fuels and that this demand will continue to increase, also brings with it regulation of environmental policies (Kar and Kinik, 2008).

Countries need energy input for production and continuation of production, therefore countries with more abundant energy sources are in a more advantageous position than those without. Countries, both those with energy sources and those without energy sources, increase the use of energy depending on the rate of growth of the economy. The increase in energy consumption has also become one of the indicators of the level of development of a country. The relationship between energy consumption, economic growth, and CO_2 emissions has been one of the important issues discussed in the literature. Different results have been achieved for different groups of countries during different periods. What follows is a list of important studies that analyze these variables:

In their study, Soytas and Sari (2003) examined the causal relationships between energy consumption and income for some of the G-7 countries. Their results showed a bidirectional relationship between GDP and energy consumption in Argentina, a bidirectional causal relationship for Italy and Korea from GDP to energy consumption, and a unidirectional causality relationship for Turkey, France, Germany, and Japan from energy consumption to GDP.

Ang (2007) examined the dynamic causal relationships between pollution emissions, energy consumption, and output growth in France for the period 1960–2000. His results showed that economic growth has a causal impact on

long-term energy use and pollution increase. In the short term, that researcher found a unidirectional causality from growth in energy use to increases in output.

Wietze and Montfort (2007) discussed a cointegration analysis for Turkey in relation to energy consumption and GDP for the years 1970–2003. Their findings showed that energy consumption and GDP were coordinated, and that energy consumption affected economic growth in Turkey over the long term. In his 2008 study, Ang examined the long-term relationship between output, pollution emissions and energy consumption in Malaysia for 1971–1999. His results showed that pollution and energy use are positively associated with output in the long term and that economic growth has a causal relationship with energy consumption.

Narayan *et al.* (2008) examined the effect of electricity consumption shocks on the real GDP for the G7 countries. The results showed that electricity consumption outside the USA has a statistically significant positive effect on GDP.

sssssAkbostanci *et al.* (2009) examined the relationship between income and environmental quality at two levels in Turkey for 1968–2003. First, those researchers assessed the relationship between cointegration techniques and CO_2 emissions, and second, the relationship between income and air pollution. The results of the time series and panel data analysis in the study showed that the environmental Kuznets curve hypothesis was not supported.

Halicioglu (2009) studied the dynamic causal relationships between carbon emissions, energy consumption, income, and foreign trade for Turkey using time-series data for 1960–2005. The study results support that income is the most important variable describing carbon emissions in Turkey, followed in turn by foreign consumption and energy consumption.

Odhiambo (2009) studied the causal relationships between energy consumption and economic growth in Tanzania for 1971–2006. Causality analysis showed a unidirectional relationship from total energy consumption to economic growth. In addition, the study confirmed that energy consumption in Tanzania encouraged economic growth.

Zhang and Cheng (2009) studied the direction and presence of Granger causality between economic growth, energy consumption, and carbon emissions in China. The researchers found that carbon emissions and energy consumption were not a factor in economic growth.

Ozturk and Acaravci (2010) examined the long-term and causal relationships between carbon emissions, energy consumption, and employment rate in Turkey for 1968–2005 using the autoregressive distributed lag test and the cointegration approach. The study results show that the employment rate was related to GDP per capita in the short term.

Yildirim *et al.* (2014) examined the relationships between energy consumption per capita and real GDP per capita for Malaysia, Philippines, Indonesia, Singapure and Thailand for the period 1971-2009 by using time series causality and panel data causality tests. They found that conservation hypothesis is supported.

Wang *et al.* (2016) evaluated the cointegration and causality relationships between economic growth, energy consumption and CO_2 emissions in China for 1990–2012. Based on their findings, the cointegration test results showed the existence of a long-term cointegration relation between variables. Moreover, based on that study, there is a bidirectional causal relationship between economic growth and energy consumption. The results showed a unidirectional causality from energy consumption to CO_2 emissions.

Dogan and Aslan (2017) examined the relationship between carbon emissions, real incomes, energy consumption and tourism for European Union member countries and candidate countries in 1995 to 2011 using panel estimation methods. The CADF and CIPS panel unit root tests found that the analyzed variables were stationary in their first differences. In addition, findings showed a bidirectional causality relationship between CO_2 emissions and energy consumption and between real income and CO_2 emissions.

The literature cited above displays that the relationship between CO_2 emissions and economic variables such as energy consumption and economic growth for different countries yielded different results. The present study examines the causality between CO_2 emissions (as indicators of environmental pollution), electricity consumption, economic growth, and industrial production index in Turkey. It consists of three parts: the Introduction, the Analysis of Results—which summarizes the findings of cointegration and causality tests in which the data are introduced and unit root test results are presented—and finally, Conclusions.

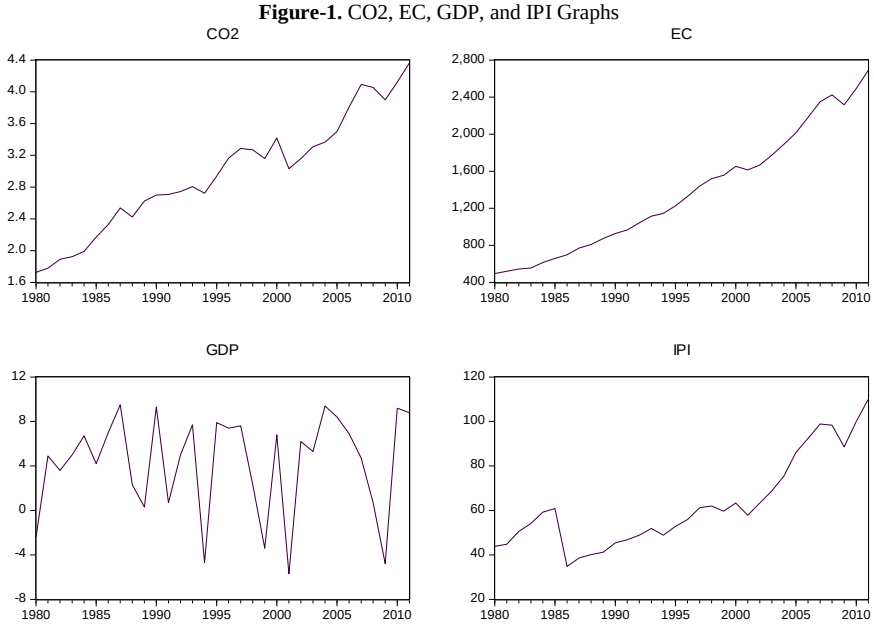
2. Analysis Results

In the study; yearly data includes Turkey's carbon dioxide emissions (CO_2) (as Metric Tons Per Capita), electricity consumption (as kwh per capita), economic growth rates (GDP-Growth%) and industrial production indices for the period from 1980 to 2011.

Electricity consumption data were obtained from the Turkish electricity distribution and consumption statistics (TEDAS) database, industrial production indices from the data of the Central Bank of the Republic of Turkey, and other data from the World Bank Economic Indicators (http://data.worldbank.org).

Figure 1 shows the changes in CO_2 Emissions (CO_2), Electricity Consumption (EC), GDP-growth (GDP) and Industrial Production Index (IPI).

Figure-1. CO2, EC, GDP, and IPI Graphs



For the period 1980–2011; CO_2, EC, and IPI have an increasing trend and show similar trends. Figure 2 shows graphs of logarithmically transformed variables (LCO2, LEC, and LIPI) and GDP used in analysis.

Figure- 2. LCO2, LEC, GDP, and LIPI Graphs

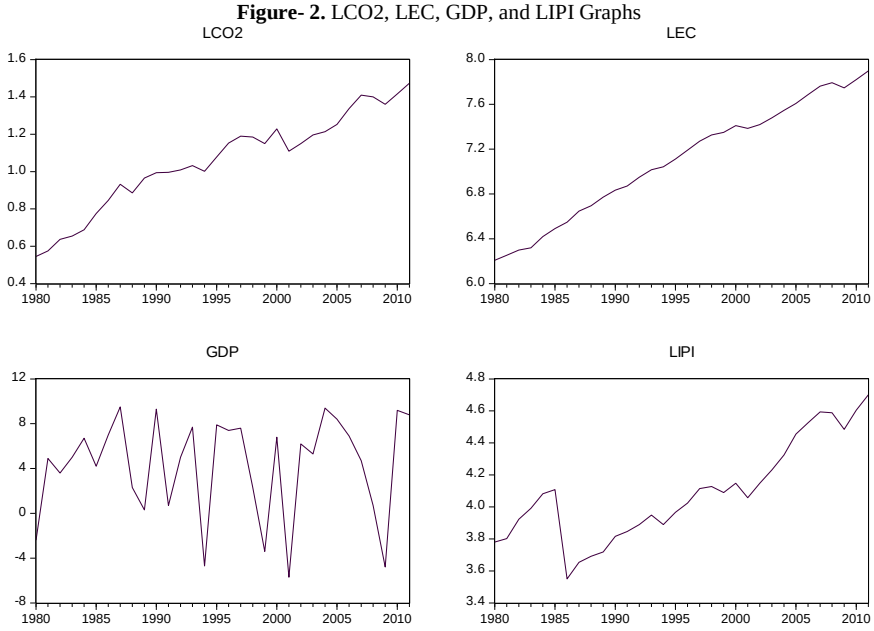


Table 1 summarizes the ADF, PP, and KPSS Unit Root Test results for LCO2, LEC, LGDP, and LIPI.

Table-1. Unit Root Test Results

Variable	ADF	PP	KPSS
LCO2	-2.584601	-2.527417	0.134246
LEC	-1.566020	-1.625355	0.177881
GDP	-3.018357	-3.089823	0.084884**
LIPI	-2.095685	-2.124482	0.153850
D(LCO2)	-6.147812**	-6.183650**	0.146961**
D(LEC)	-4.936676**	-4.907421**	0.164762**
D(GDP)	-5.975672**	-7.169672**	0.142779**
D(LIPI)	-5.700240**	-5.816724**	0.170798**

** denotes rejection of hypothesis at the 0.05 level (H_0: unit root), and D (.) denotes first differences variable

The results of the ADF, PP, and KPSS Unit Root Tests in Table 1 show that the series are not stationary at the level but they are I(1). The Johansen Cointegration Test was used to determine whether the series were co-integrated; these results are shown in Table 2.

Table-2. Johansen Cointegration Test Results

Hypothesized No. of CE(s)	**Maximum Eigenvalue Statistics**	**5% Critical Value**	**Prob.**
r=0*	51.11331	27.58434	0.0000
r≤1*	42.61014	21.13162	0.0000
r≤2*	15.84147	14.26460	0.0279
r≤3	0.184573	3.841466	0.6675
Hypothesized No. of CE(s)	Trace Statistics	5% Critical Value	Prob.
r=0*	109.7495	47.85613	0.0000
r≤1*	58.63618	29.79707	0.0000
r≤2*	16.02604	15.49471	0.0416
r≤3	0.184573	3.841466	0.6675

* denotes rejection of hypothesis at the 0.05 level (H_0: No Cointegration)

According to the Maximum Eigenvalue and Trace statistics in Table 2, there are three cointegration relations between the four variables in study.

Accordingly, the Johansen Cointegration Test indicates evidence of the existence of long-term co-change among all variables. Examining the causality relations between LCO2, LEC, GDP, and LIPI generated the data in Table 3.

Table-3. VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: D(LIPI)

Excluded	**Chi-sq**	**df**	**Prob.**
D(LCO2)	2.936654	2	0.0303
D(LEC)	20.37975	2	0.0000
D(GDP)	11.21557	2	0.0037
All	26.37412	6	0.0002
Dependent variable: D(LCO2)			
Excluded	Chi-sq	df	Prob.
D(LIPI)	3.850473	2	0.1458
D(LEC)	2.023371	2	0.3636
D(GDP)	0.978838	2	0.6130
All	5.120807	6	0.5284
Dependent variable: D(LEC)			
Excluded	Chi-sq	df	Prob.
D(LIPI)	4.279868	2	0.1177
D(LCO2)	0.500192	2	0.7787
D(GDP)	8.782581	2	0.0124
All	11.94629	6	0.0632
Dependent variable: D(GDP)			
Excluded	Chi-sq	df	Prob.
D(LIPI)	2.146614	2	0.3419
D(LCO2)	0.840403	2	0.6569
D(LEC)	3.606896	2	0.1647
All	9.097198	6	0.1682

The results in Table 3 show a long-term unidirectional Granger causality relationship from economic growth to electricity consumption. If the direction of causality is from economic growth to energy consumption, it can be said that in this case, an economy with less energy dependence and energy politics can be constructed without harming economic growth (Jumbe, 2004).

It appears that electricity consumption is based on economic growth. Also, based on the findings, unidirectional causality relationship from CO_2 emission, electricity consumption, and economic growth to industrial production index can be asserted. Despite the slow acceleration of positive growth in manufacturing in recent years, the increase in electricity consumption is limited. Factors such as the increasing share of the service sector in electricity consumption, the decrease in production of iron and steel plants—an important share of electricity consumption—and the increase of energy efficiency investments in energy-intensive sectors limit the increase in electricity consumption. Such situations weaken the relationship between electricity consumption and industrial production (TSKB, 2015).

In the early 2000s, increase in the importance of sectors such as automotive, chemical, and machinery with high added value but relatively low energy intensity caused a further increase in GDP than in energy consumption. In addition to consumption in industry, the heating and cooling demand from service sectors and from residents affect the sensitivity of the consumption of electricity to the industrial production index, because the demand for electricity increases steadily.

The findings of the causality analysis for the examined period show that CO_2 emissions is the Granger cause of industrial production growth in the long term. Environmental risk, which prevents economic growth, paves the way for the implementation of new environmental regulations on industrial pollution.

3. Conclusions

The relationship between environmental consciousness and economy has been one of the most heavily researched topics in recent years. Accordingly, long term relationships between CO_2 emission, electricity consumption, economic growth, and industrial production index in Turkey for 1980–2011 were examined in the present study.

The Johansen Cointegration test showed the existence of a long-term equilibrium relationship between all series and experimental results: CO_2 emission, electricity consumption, economic growth, and industrial production index variables are cointegrated. The development of the economy has a great influence on the environment; therefore, any long-term environmental change has a great impact on the country's economy.

From this point of view, it is very important to take the environmental degradation problem and the long term growth effects into account while maintaining economic growth and ensuring efficient use of energy within industry.

Countries' financial regulatory agencies, policy makers, and investors should develop practical solutions and practices that provide economic growth in an environmentally friendly and sustainable system that supports renewable energy sources.

Future studies should focus on the long-term relationships between the environment and different macroeconomic variables and the studies of causality by using different econometric approaches, to provide important implications in this area for future researches.

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