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The Relationship Between CO2 Emissions and Health Indicators: The Case of Turkey

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Abstract

The aim of this study is to analyze the impact of carbon emissions on health indicators over the period 1971-2016 in Turkey. Infant mortality rate and life expectancy at birth which are frequently used in the international comparisons have been used as health indicators. According to the empirical results, there is a co-integration relationship between carbon emissions and health indicators in the long run. Increased carbon emissions reduce life expectancy at birth and increase infant mortality rate. According to these results, it is necessary to take measures to reduce carbon dioxide emissions and to increase the use of renewable energy investments.

Keywords: CO2 Emissions, Health Indicators, Turkey, Johansen Cointegration model

JEL Codes: C22 ; Q35 ; I1.

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1. Introduction

The relationship between energy consumption and environmental quality is evaluated from two different perspectives. From the first point of view, energy resources have a number of macroeconomic positive effects such as having economic growth, lowering production costs, increasing supply and demand for goods and services, the development of free trade and expansion of employment. The second perspective emphasizes the importance of environmental costs. According to this perspective, the use of resources such as oil, coal and natural gas increases waste production and causes environmental degradation (Munir and Riaz, 2019).

One of the most important causes of environmental degradation or the deterioration in the environmental quality is the increase in carbon dioxide emissions. The main reason for the increase in carbon dioxide emissions is the increase in the use of pollutant energy sources (Soytaş, Sarı and Ewing, 2007; Ahmad et al., 2016). Increasing carbon dioxide emissions by the consumption of pollutant energy sources adversely affects many health indicators. Negative effects of health indicators lead to a decrease in human capital power and thus a decline in economic growth performance. Variables such as life expectancy at birth and infant mortality rate are among the main health indicators. Life expectancy, which is defined as "the expectation of how long a newborn person can live on average, assuming that current mortality rates remain unchanged"; infant mortality rate; on the other hand, which is defined as "the number of children who die under the age of one for every 1000 live births in a year, are taken as data (OECD, 2011: 24 and 36).

Scientists aiming to contribute to the literature on energy economics and health economics mostly investigate the relationship between carbon dioxide emissions and health indicators using data from single countries or groups of countries. Determining the relationship between carbon dioxide emissions and these indicators is important in terms of revealing the negative effects of environmental damage. On the other hand, the findings of these researches are the data source that can be used by policy makers both in terms of health policies and environmental policies.

The aim of this study is to investigate the relationship between carbon dioxide emissions and health indicators for the period between 1971 and 2016 in Turkey. Infant mortality rate and life expectancy at birth variables which are frequently used in international comparisons were used as health indicators. The basic motive to include Turkey in the scope of the research is that despite favorable developments in terms of life expectancy, Turkey could not attain reasonable levels of infant mortality. Along with Korea and Chile, Turkey is among the OECD countries that had the most positive performance in terms of average life expectancy improvement in the period of 1970-2015. The increase in life expectancy since 1970 is 17 years (OECD, 2017: 48). As far as infant mortality rate is concerned, Turkey and Mexico seem to have a negative outlook. In 2015, while the average of OECD regarding the number of deaths per 1000 live births was below 4; it is more than 10 in these countries (OECD, 2017: 58).

Based on OECD data, despite a relative increase in life expectancy, the infant mortality rate is above the OECD average. In this study, we tried to answer whether there is a negative impact of

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carbon dioxide emissions despite the positive improvement in life expectancy and to what extent the infant mortality rate is affected by the increase in carbon dioxide emissions.

Carbon dioxide emissions were chosen as one of the main variables as it is one of the main causes of environmental degradation. The increase in carbon dioxide emissions is one of the main causes of global warming. Because of global warming, number of natural disasters like drought and flood increase along with sea level rises (Abokyi et al. 2019; Hosseini et al. 2019). The increase in carbon dioxide emissions is also one of the main causes of many health problems that directly affect the quality of life. It has been determined that carbon dioxide emissions have negative health consequences with the findings of numerous studies contributing to the literature.

Since carbon dioxide emissions have been rising with a significant trend in Turkey for a long time, it is critical to investigate its effects on health issues in Turkish case. As of 2016, carbon dioxide emissions increased by 135.4% since 1990. Carbon dioxide emissions per capita increased from 3.8 tons in 1990 to 6.3 tons in 2016 (TÜİK, 2018).

The contribution of this study to the relevant literature is investigating the relationship between carbon dioxide emissions and health indicators in the case of Turkey. The study consists of two main parts. Literature review is presented in the first part of the study. In the second part of the study, the econometric analysis is explained.

1. Literature Review

The findings of the studies investigating the relationship between health indicators and the carbon dioxide emissions are summarized as follows. There are many studies that have pointed the negative effects of carbon dioxide emissions on health indicators.

Sinha (2014) investigated the causal relationship between carbon dioxide emissions and infant mortality using India's data for the period of 1971-2010. He found a two-way causal relationship between the change in infant mortality and growth in carbon dioxide emissions. Onanuga and Onanuga (2014) investigated the impact of carbon dioxide emissions on infant mortality using the data from Sub-Saharan Africa for the period between 1990 and 2012. According to the test results, there is a positive relationship between carbon dioxide emissions and infant mortality rate. The increase in carbon dioxide emissions leads to an increase in infant mortality.

Jerumeh, Ogunnubi and Yusuf (2015) investigated the relationship between carbon dioxide emissions and life expectancy using the data of Nigeria for the period of 1971-2011. According to the results, there is a negative relationship between life expectancy and carbon dioxide emissions. Fotourehchi (2016) investigated the effects of PM10 and carbon dioxide emissions on infant mortality and life expectancy at birth using the data from 60 developing countries for the period between 1990 and 2010. According to the findings, the positive effects of the improvement in socioeconomic conditions on health are eliminated due to pollutants such as PM10 and carbon dioxide emission. Per capita GDP, education level and health expenditures were selected as variables related to socioeconomic conditions. In the study, it was stated that socioeconomic variables have more powerful effects on health than pollutants such as PM10 and carbon dioxide emissions. However, the gains from the high socio-economic level in the context of health cannot be realized at the desired level if the effects of pollutants are ignored while the

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health policies are implemented.

Jebli (2016) investigated the relationship between one health indicator and carbon dioxide emissions using the data for Tunisia for the period of 1990 - 2011. In the study, the number of doctors was chosen for the health indicator. According to the results, carbon dioxide emissions lead to a decrease in the number of doctors. Aliyu and Ismail (2016) investigated the impact of PM10 and carbon dioxide emissions on human death using the data from 35 African countries for the 1995-2011 period. According to the empirical results, the increase in PM10 and carbon dioxide levels has a significant effect on the increase in infant, children under-five years old and adult mortality rates.

Yang and Liu (2018) studied the implications of environmental pollution in terms of health effects and health inequality. The data from the study were obtained from the 2014 national survey of China Family Panel Studies. The 2014 survey covers 25 regions and approximately 16000 households. According to the results, the increase in pollution has a significant negative effect on health and air pollution triggers the increase in health inequality. On the other hand, health inequality was concentrated in poor regions. Ahmad et al. (2018) investigated the relationship between environmental quality, socioeconomic variables, and human health, using data of China for the 1960–2014 period. According to the results obtained, carbon emissions from coal, natural gas and oil selected as environmental quality indicators. The authors concluded that these pollutants have a long-term negative impact on human health. The authors also highlighted the role of reducing carbon dioxide emissions to improve quality of life. Asongu (2018) investigated the impact of the increase in carbon dioxide emissions on human development using the data from 44 Sub-Saharan countries for the period between 2000 and 2012. When the thresholds are taken into consideration, it has been found that carbon dioxide emissions have a negative effect on human development.

Matthew et al. (2018) investigated the effects of greenhouse gas emissions on health indicators using Nigeria's data for the period of 1985-2016. It was concluded that a 1% increase in greenhouse gas emissions leads to a 0.0422% decrease in life expectancy. The authors stated that carbon dioxide emissions are the main component of greenhouse gas emissions, and that health indicators would improve if strategies to reduce carbon dioxide emissions were implemented. Using the data of the 10 leading countries in terms of carbon dioxide emissions (China, USA, India, Russia, Japan, Germany, South Korea, Iran, Canada and Saudi Arabia) for the period between 1991 and 2014, Mohammed et al. (2019) investigated the causal relationship between carbon dioxide emissions and human development and the effect of carbon dioxide emissions on healthy life expectancy. According to the obtained results, there is a strong relationship between human development index, healthy life expectancy and carbon dioxide emissions in most of the countries included in the analysis.

Utilizing the data of 30 Chinese provinces for the period of 1996 – 2015, Farooq et al. (2019) analyzed the role of afforestation in the reduction of carbon dioxide emissions in different regions of China. In this study, health problems were expressed with the number of visits to health institutions. According to the results, the increase in carbon emissions leads to an increase in health problems. However, it was suggested that increasing afforestation could improve environmental quality and be used as a useful instrument for controlling health problems. The authors concluded that carbon dioxide emissions have additive effects on health problems;

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contrary, afforestation has reducing effects on health problems.

Using the data of the US for the period of 2000-2010, Hill et al. (2019) investigated the harmful impact of air pollution on health in the regions included in the analysis by taking income inequality into account. According to the results, the negative impact of air pollution on life expectancy is higher in the regions where income inequality is high. Dhrifi (2019) investigated the impact of environmental degradation, institutional quality, and selected macroeconomic variables on health using the data from 45 African countries for the period between 1995 and 2015. In this study, carbon dioxide emissions per capita were also used for life expectancy at birth, health indicator and environmental indicator. Some important results are as follows:

- There is a negative correlation between environmental degradation and health but a positive correlation between institutional quality and health.

- In addition to institutional quality, macroeconomic variables such as economic growth, financial system and direct investments reduce the negative effects of environmental degradation.

There are also studies in the literature that do not detect a significant relationship between carbon dioxide emissions and health indicators. Bayati, Akbarian and Kavosi (2013) studied the social, economic and environmental factors affecting life expectancy at birth using the data of the 1995-2007 period of 21 countries in the Eastern Mediterranean Region. Some important findings are as follows:

- Per capita income has a positive impact on health. A high-income level enables individuals to consume high quality goods and services, living in a better house and accessing health services easily. These advantages positively affect their health status.

- As the level of education increases, individuals' awareness to improve their health increases.

- No significant relationship was found between carbon dioxide emissions and life expectancy.

3. Econometric Analysis

In this study, the effects of carbon emissions on health indicators are analyzed in Turkey between the years 1971-2016. Infant mortality rate (death) and life expectancy at birth (life) series, which are frequently used in international comparisons, are used as health indicators. The estimation models to be used in the analysis are shown in Equation (1) and Equation (2).

$$DEATH=\beta_0+\beta_1 CO2+\varepsilon_t \quad (1)$$

$$LIFE=\beta_0+\beta_1 CO2+\varepsilon_t \quad (2)$$

DEATH and LIFE series are used as an indicator of health quality in the equations and CO2 represents environmental pollution. DEATH in Eq. (1): It is the infant mortality rate series. The

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infant mortality series refers to the number of infants who die before reaching the age of one in 1,000 live births in a given year. LIFE in Equation (2): Life expectancy at birth. Life expectancy at birth indicates the number of years a newborn will live if the death models at the time of birth remain the same throughout their lives. CO2: Calculated by the fuel-based carbon emission figures divided by population (metric tons of carbon emissions per capita). Data are compiled annually from the World Bank and the International Energy Agency. Natural logarithms of death and life series were used in the analysis. Descriptive statistics related to the series are shown in Table 1.

Table 1. Descriptive Statistics

	CO_2	LIFE	DEATH
Average	2.574	65.771	53.980
Medium	2.430	66.096	46.400
Maximum	4.330	75.755	122.900
Minimum	1.150	52.887	10.800
Std. Error	0.901	7.094	34.605

When the descriptive statistics of the series are examined in Table 1, it can be seen that the mean value of the carbon emission series is 2,574 metric tons and the mean life expectancy series is 65.7 and the infant mortality rate is 53.9 per 1000 babies.

In order to investigate the relationship between carbon emissions and the health indicators, the degree of integration of the series should be known. Therefore, it is important to examine the stationarity of the series in model selection. In our study, we used PP unit root tests, which are more frequently used in the literature, and give stronger results in case of heteroscedasticity and autocorrelation problems in order to investigate the stationary state of the series. The test results are shown in Table 2.

Table 2. ADF and PP Test Results

		ADF TEST			**PP TEST**		
		LNLIFE	LNDEATH	CO_2	LNLIFE	LNDEATH	CO_2
Constant	t-stat.	-1.263	-0.018	2.285	-7.457	12.648	1.348
	Prob.	0.638	0.952	1.000	0.000	1.000	0.999
Cons.&Trend	t-stat.	2.523	-1.303	-2.975	0.891	-2.855	-2.911
	Prob.	1.000	0.874	0.151	1.000	0.186	0.169
		UNIT ROOT RESULTS FOR FIRST DIFFERENCE					
		d(LNLIFE)	d(LNDEATH)	d(CO_2)	d(LNLIFE)	d(LNDEATH)	d(CO_2)
Constant	t-stat.	0.986	-2.710	-6.078	-0.101	-1.517	-9.431
	Prob.	0.996	0.081	0.000	0.943	0.516	0.000
Cons.&Trend	t-stat.	-3.098	-0.924	-4.297	-2.071	-3.716	-12.492
	Prob.	0.120	0.944	0.008	0.547	0.032	0.000
Cons.&Trend	t-stat.	-2.872	3.623	-6.099	-2.108	3.306	-6.100
	Prob.	0.005	0.999	0.000	0.035	0.999	0.000

Note: The selection of delay length is based on the Schwarz information criterion. The maximum delay length is 9.

Table 2 shows that the series are stationary at difference according to the ADF test results. On the

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other hand, when the PP test results are examined, it is seen that the LIFE series is stationary according to the model with constant, but the difference stationary according to the model with constant and trend. The unit root results of the LIFE series are complex. When the LIFE series is examined, it is seen that the series has a trend effect. Therefore, considering the results of constant and trendy models, it was decided that the series was stationary at difference. On the other hand, the DEATH and CO2 series are stationary for both unit root tests. In order to determine the degree of integration of the series, the first differences were taken and ADF and PP tests were applied again. According to the test results, the series were found to be stationary at first difference.

After examining the stationarity of the series, the co-integration relationship between the series can be investigated. The co-integration analysis is based on the assumption that a long-term relationship may exist between the series even if the series are not stationary and that the relationship can be stationary. In other words, when each series is I (1), the combination of the series can be I (0) (Hamilton, 1994: 571). In other words, although the variables are non-stationary, if a certain linear combination of these variables is stationary, it can be said that these variables are co-integrated (Chatfield, 1996: 223). In this case, it can be stated that the series are under the influence of a common stochastic trend instead of their own external and permanent shocks. Thus, the estimation model will not be spurious regression.

Johansen (1988) co-integration test is a test methodology based on VAR analysis. In the estimation equation, the level and lagged values of the series of the same order are taken together. The system of equations is defined as follows.

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \cdots + \Gamma_{k-1} \Delta X_{t-k} + \Pi \Delta X_{t-k} + \varepsilon_t \qquad (3)$$

$$\Gamma_i = -I + \Pi_1 + \cdots + \Pi_i, \qquad i = 1, \dots, k$$

In Equation 3, Π: represents the matrix of coefficients X: the variable vector. The rank of the Π matrix gives the number of cointegrations between the series. When Rank is equal to 0 and there is no cointegration relationship between the series, if there exists one or more co-integrated vectors, then it is concluded that one or more co-integrated vectors exist.

In Johansen Cointegration Test, the existence of a cointegrated relationship between the series is investigated by using trace and maximum eigenvalue statistics. For the research, firstly the null hypothesis that states that rank is less than or equal to r is compared with the alternative hypothesis. In the second step, the null hypothesis which states that rank equal to r and the alternative hypothesis which states that rank is r + 1 are compared. Critical values compared in the tests are indicated by Johansen and Juselius (1990), (Johansen, 1988: 251-254; Johansen and Juselius, 1990). Johansen cointegration analysis results are shown in Table 3.

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Table 3. Johansen Cointegration Analysis Results

Models	Hypothesis	Johansen Eigenvalue Stat.	Johansen Trace Stat.	Critical Values (%5)	Probality
LNLIFE CO_2	r=0	0.291	15.832	15.494	0.044
	r ≥ 1	0.032	1.374	3.841	0.241
LNDEATH CO_2	r=0	0.319	21.198	15.494	0.006
	r ≥ 1	0.092	4.293	3.841	0.038

Note: The selection of delay length is based on the Schwarz information criterion. The maximum delay length is 8. The delay length for the model with LNLIFE series is 3 and the delay length for the model with LNDEATH series is 1.

When the analysis results obtained from Table 3 are examined, it is seen that there is at least one co-integrated vector in the long-run between carbon emissions and life expectancy at birth series. On the other hand, there are at least two co-integrated vectors in the long run between carbon emissions and infant mortality rates. Long-term coefficients can be obtained since there is a long-term cointegration relationship between the series.

Pedroni (2000, 2001) stated that if there is a long-term cointegration relationship between the series, the predicted coefficients would be inconsistent and biased, and suggested a dynamic least squares method in the presence of cointegration relationship. In this study, dynamic OLS method (DOLS) was preferred. DOLS will provide an additional analysis result for the accuracy of our findings of the results obtained from the Johansen cointegration estimation method. Particularly preferred for the analysis of relatively small samples and in the case of endogenity problem it is a powerful method. Table 4 shows the long-term coefficients obtained from Johansen cointegration analysis and DOLS model results.

Table 4. Cointegration Equations

	JOHANSEN CO-INTEGRATION MODEL		Dynamic OLS MODEL	
	LNLIFE CO_2	**LNDEATH CO_2**	**LNLIFE CO_2**	**LNDEATH CO_2**
CO_2	-0.735	0.708	-0.148	0.192
Std.Error	0.168	0.071	0.003	0.008
t-stat.	-4.369	9.850	-46.423	23.989

According to the results obtained from Johansen co-integration analysis in Table 4, 1 unit increase in carbon emission decreases life expectancy at birth by -0.73 and increases infant mortality rate by 0.70. On the other hand, according to the results of Dynamic OLS analysis, an increase in carbon emissions by 1 unit reduces life expectancy at birth by -0.14 and increases infant mortality by 0.19 percent. The results obtained from dynamic OLS analysis and the results of Johansen co-integration analysis carbon emissions have a weaker effect on the health quality.

4. Conclusion

In this study, the impact of carbon dioxide emissions on health indicators for the 1971-2016 periods in Turkey was investigated. According to the empirical results, there is a co-integration

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relationship between carbon emissions and the health indicators in the long run. The results are consistent with theoretical expectation. According to the results of Johansen co-integration analysis, 1 unit increase in carbon emissions decreases life expectancy at birth by -0.73 and increases infant mortality rates by 0.70. On the other hand, according to the results of Dynamic OLS analysis, a 1 unit increase in carbon emissions decreases life expectancy at birth by -0.14 and increases infant mortality by 0.19 percent. The results obtained from the dynamic OLS analysis shows that the impact of carbon emissions on health quality is weaker than the results obtained from Johansen co-integration analysis.

Here are some key measures to reduce the negative impacts of increased carbon dioxide emissions due to the use of energy resources that increase environmental degradation on health indicators:

- First of all, as stated by Farooq et al. (2019), it is not a rational strategy to increase health expenditures to reduce health problems. The resources to increase health expenditures mean the reduction of funds allocated to areas such as improving the quality of the environment or education expenditures, which are vital for the development of human capital.

- The monitoring and use of technological developments that will increase energy efficiency and minimize the harmful effects of wastes should be encouraged in all areas where energy resources that cause environmental destruction are used.

- Investments in this area should be supported in order to increase the use of renewable energy sources that cause the least damage to environmental quality. In addition to the positive impacts on the quality of the environment, renewable energy sources will contribute to the decrease in the dependence on foreign sources in terms of energy supply and mitigate the damage of the volatility in energy prices on macroeconomic balances.

- Reduction of green areas is one of the reasons triggering the increase in carbon dioxide emissions. Green areas that are compatible with afforestation and regional conditions need to be increased.

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