THE RELATIONSHIP BETWEEN CO_2 EMISSION AND ECONOMIC GROWTH IN TURKEY: 1977-2014

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Abstract

Recently, the relationship between carbon emission-environmental pollution and sustainability of economic growth in both developed and developing countries has been investigated empirically in the economic literature. The relationship between per capita real Gross Domestic Product (GDP) and carbon emission (CO2) has been intensively analyzed empirically over the past ten years in Turkey. This study investigates the relationship between CO_2 emission and economic growth in the Turkish economy during the period 1977-2014 by using Toda-Yamamoto and Dolado-Lütkepohl VAR causality analyses. Econometric analyses show that there is a unidirectional positive causality from CO_2 to economic growth in Turkey for the period 1977-2014. The empirical results from the TY and DL VAR causality tests strongly support a unidirectional causality coming from CO_2 emissions to GDP, meaning that CO_2 contains useful information for predicting GDP. The findings in this study indicate that an increase in CO_2 emissions leads to an increase in GDP.

Key Words: *CO_2 Emission, Economic Growth, VAR.*
JEL Classification Codes: *C12, O44.*

TÜRKİYE'DE CO2 EMİSYONU İLE EKONOMİK BÜYÜME İLİŞKİSİ: 1977-2014

Öz

Son dönemde hem gelişmiş hem de gelişmekte olan ülkelerde karbon emisyonu-çevre kirliliği ile ekonomik büyümenin sürdürülebilirliği arasındaki ilişki ekonomik literatürde ampirik olarak araştırılmıştır. Kişi başına düşen Gayri Safi Yurtiçi Hasıla (GSYİH) ile karbon emisyonu (CO2) arasındaki ilişki son on yılda Türkiye'de ampirik olarak yoğun bir şekilde analiz edilmiştir. Bu çalışmada, CO_2 emisyonu ile ekonomik büyüme arasındaki ilişki Toda-Yamamoto ve Dolado-Lütkepohl VAR nedensellik yöntemleriyle 1977-2014 dönemi Türkiye ekonomisi için incelenmiştir. Ekonometrik analizler, 1977-2014 dönemi Türkiye'de CO_2 emisyonundan ekonomik büyümeye doğru tek yönlü ve pozitif bir nedensellik ilişkisinin olduğunu göstermektedir. TY ve DL VAR nedensellik testlerinden elde edilen ampirik sonuçlar, CO2 emisyonundan GSYİH'ye doğru giden tek yönlü nedenselliğin kuvvetli bir şekilde desteklenmesini sağlar; bu, CO2'nin GSYH'yi tahmin etmek için yararlı bilgiler içerdiği anlamına gelir. Bu çalışmada elde edilen bulgular, CO2 emisyonlarındaki artışın GSYH'da bir artışa neden olduğunu göstermektedir.

Anahtar Kelimeler: *CO_2 Emisyonu, Ekonomik Büyüme, VAR*
JEL Sınıflandırma Kodları: *C12, O44.*

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1. Introduction

Since the Industrial Revolution, greenhouse gas emissions and deforestation activities, first in the developed countries and then in the developing countries that went through a rapid industrialization process, have caused global warming to reach dangerous levels. Especially since the early years of the 1990s, climate changes, global warming and environmental degradation have become an issue of concern. Increased amount of carbon dioxide in the air has been considered as the reason of such negative environmental outcomes. The problem of taking control of these activities that are harmful to ecological life and achieving sustainability of development has become one of the most important issues of today’s world. Therefore, attention was drawn to the increase in the amount of carbon dioxide (increased CO_2 emissions) and the potential relation of this increase to the income level has been questioned. As a result, the relationship between environmental pollution and economic growth has taken its place in the field of environmental economics (Arı and Zeren, 2011; Çınar et al., 2012).

In the literature, there is an agreement on the existence of a positive relationship between environmental pollution and economic growth. On the other hand, Grossman and Krueger (1991) suggested that the level of environmental pollution first increases during the economic growth process, and then decreases, showing the presence of an inverted U-shaped relationship between income per capita and the level of pollution. Grossman and Krueger (1991) also adopted the Kuznets Curve approach to environment and re-interpreted the curve based on the relationship between income per capita and environmental quality. This relationship is called Environmental Kuznets Curve (EKC) hypothesis in the economics literature. This hypothesis postulates that production activities increase CO_2 emissions and environmental pollution in the early stages of economic growth, but then production technique reaches a level that would not pollute the environment after a certain threshold due to the use of cleaner technologies (Yılmazer and Açıkgöz, 2009; Koçak, 2014).

Related to the EKC hypothesis, the Pollution Haven Hypothesis (PHH) posits that polluting industries are shifting from developed to developing countries. Accordingly, developed countries employ strict environmental policies, thus the companies operating in such countries are face to face with increased production costs due to the environmental policies. On the other hand, low wage costs and loose environmental policies in developing countries make these countries attractive for polluting industries. The foreign capital required by developing countries for industrial development is provided by the migration of these polluting industries. As a result of such change, developed countries become net importers of the outputs provided from polluting industries, while developing countries become net exporters (Atıcı and Kurt, 2007). However, decreased pollution with increased income levels in developed countries is not that meaningful at a global scale; because, developed countries reduce their greenhouse gas emissions by shifting their pollution-intensive industries to developing countries, but this does not lead to an environmental improvement at a global scale (Çetin and Şeker, 2014). Therefore, there is an ambiguity in the literature about the relationship between environmental pollution and economic growth.

From a critical point of view, Stern et al. (1996) explains the reasons of such ambiguity in their studies examining the relationship between environmental pollution and economic growth by emphasizing that the other variables in the data about different countries might affect the relationship between environmental pollution and economic growth. Coondoo and Dinda (2002) argue that this relationship might change from one group of countries to another (Çetin and Şeker 2014). In the light of these, this study aims to examine the causality relationship between CO_2 emissions and economic growth in Turkey for the period between 1977 and 2014 and to reveal whether economic growth in Turkey depends on pollution. The study is comprised of four sections. Following the introduction, Section 2 includes the literature review. Section three presents the data set and methodology as well as the empirical findings. Finally, the conclusion includes the evaluation of the findings together with some suggestions.

2. Literature Review

There are various empirical studies in the literature on the relationship between economic growth and CO_2 emissions. Table 1 shows the summary of some empirical studies conducted in Turkey and abroad on the relationship between economic growth and CO_2 emissions.

Table 1: **Literature Review**

Author(s)	*Country/Period*	*Method*	*Findings (Causality)*
Grossman and Krueger, (1991)	42 NAFTA Countries/ 1977-1985	Panel analysis	GDP→CO_2
Coondoo and Dinda, (2002)	88 Countries/ 1960-1990	Panel Granger causality	CO_2→GDP (North America, Eastern-Western Europe), GDP→CO_2 (Central-south America, Japan), GDP↔CO_2 (Africa,Asia)
Lise, 2006)	Turkey /1980-2003	EKK, Decomposition analysis	CO_2→GDP
Soytaş and Sarı, (2009)	Turkey /1960-2000	TY-VAR	No causality
Halıcıoğlu, (2009)	Turkey /1960-2005	ARDL, Granger causality	GDP→CO_2
Lean and Smyth, (2010)	5 Asian Countries/ 1980-2006	Panel Granger VECM	CO_2→GDP
Chang, (2010)	China/1981-2006	VECM, Granger causality	GDP→CO_2
Acaravci and Öztürk, (2010)	19 European Countries/ 1960-2005	ARDL, Granger causality	GDP→CO_2
Öztürk and Acaravci, (2010)	Turkey /1968-2005	ARDL	No causality
Çınar, (2011)	31 OECD Countries/ 1971-2007	Pedroni, Kao, Westerlund)-cointegration	GDP↑→CO_2↑
Pao and Tsai, (2011)	BRIC Countries/ 1971-2005	Panel data ECM	CO_2→GDP
Arı and Zeren, (2011)	17 Mediterranean Countries 2000-2005	Panel data	GDP→CO_2
Saatçi and Dumrul, (2011)	Turkey /1950-2007	Cointegration	GDP→CO_2
Farhani and Rejeb, (2012)	15 MENA Countries/ 1973-2008	Panel- cointegration, causality	GDP→CO_2
Adom and diğerleri, (2012)	Ghana, Senegal, Morocco/ 1971-2007	TY-VAR ARDL	GDP↔CO_2 (Ghana and Morocco) GDP→CO_2 (Senegal)
Altıntaş, (2013)	Turkey /1970-2008	TY-VAR ARDL	GDP→CO_2
Khan, (2013)	Bangladesh/ 1965-2007	TY-VAR	CO_2↔GDP
Vidyarthi, (2013)	India/1971-2009	VECM, JJ	CO_2→GDP
Yöntem,	Turkey /	JJ- Granger causality	GDP→CO_2

(2013)	1961-2010		
Lihn and Lin, (2014)	Vietnam/ 1980-2010	ECM, JJ	CO_2↔GDP
Mbrek et al., 2014)	Tunisia/1980-2010	VAR	GDP→CO_2
Koçak, (2014)	Turkey / 1960-2010	ARDL, Bounds Testing	No causality
Cowan et al., (2014)	BRIC Countries/ 1990-2010	Granger causality	GDP↔CO_2 (Russia) GDP→CO_2 (South Africa) CO_2→GDP (Brasil)
Bozkurt and Akan, (2014)	Turkey / 1960-2010	JJ	CO_2↑→GDP↓
Aytun, (2014)	10 Countries/ 1971-2010	Panel analysis	GDP→CO_2
Mensah, (2014)	6 African Countries/ 1971-2009	TY-VAR	GDP→CO_2 (Nigeria, Senegal, Egypt, Kenya) CO_2→GDP (South Africa)
Çetin and Şeker, (2014)	Turkey / 1980-2010	ARDL, VECM	GDP→CO_2
Kivyiro and Arminen, (2014)	Sub-Saharan African Countries/ 1971-2009	ARDL Granger causality	GDP→CO_2 (Democratic Republic of Kongo*, Kenya, Zambia and South Africa)*
Alshehry and Belloumi, (2015)	Saudi Arabia/ 1971-2010	VECM, JJ	CO_2↔GDP
Çoban and Kılınç, (2015)	Turkey / 1990-2012	Regression analysis	GDP→CO_2
Büyükyılmaz and Mert, (2015)	Turkey / 1960-2010	MS-VAR	GDP↔CO_2
Balıbey, (2015)	Turkey / 1974-2011	VAR, JJ	GDP→CO_2
Keskingöz and Karamelikli, (2015)	Turkey / 1960-2011	ARDL	GDP→CO_2
Artan et al., (2015)	Turkey / 1981-2012	VECM, VAR, JJ	GDP→CO_2
Akay et al., (2015)	MENA Countries/ 1988-2010	Panel analysis	GDP→CO_2
Bozkurt and Okumuş, (2015)	Turkey /1966-2011	Hatemi J-cointegration	GDP→CO_2
Gülmez, (2015)	24 OECD Countries/ 2000-2012	Panel analysis	GDP→CO_2
Magazzino, (2015)	Israel/ 1971-2006	TY-VAR, JJ	GDP→CO_2
Işık et al., (2015)	157 Countries/ 1980-2012	Panel data	GDP→CO_2
Genç and Tandoğan, (2015)	Turkey / 1980-2010	ARDL	CO_2↑↔GDP↑
Uysal and Yapraklı, (2016)	Turkey / 1968-2011	Hatemi J-cointegration	GDP→CO_2
Narayan et al.,	181 Countries/	Cross correlation	GDP→CO_2

(2016)	1960-2008		
Topallı, (2016)	India, China, Brazil, South Africa/1980-2010	Panel- cointegration causality	GDP→CO_2
Pata and Terzi, (2016)	Turkey/ 1972-2011	DL-VAR, JJ	CO_2↑↔GDP↑
Pata, (2018a)	Turkey/ 1974-2013	ARDL	GDP↑→CO_2↑
Pata, (2018b)	Turkey/ 1974-2014	ARDL, Gregory Hansen, Hatemi J-cointegration	GDP↑→CO_2↑

Note: CO_2: Carbon dioxide Emission, GDP: Economic Growth, DL: Dolado-Lütkepohl causality, TY: Toda-Yamamoto causality, JJ: Johansen-Juselius cointegration, ARDL: Autoregressive distributed lag model, VECM: Vector error correction model

As shown in Table 1, the studies on the causality relationship between economic growth and CO_2 emissions yielded different results. Such different findings may be the result of different data, methods and countries. This study is different in that it uses the TY and DL VAR causality tests, generalized impulse-response functions and variance decomposition to analyze the relationship between economic growth and CO_2 emissions in Turkey for the period between 1977 and 2014.

3. Data Set, Method and Findings

3.1. Data Set and Method

In this study, the relationship between economic growth and CO_2 emissions in Turkey for the period 1977-2014 was analyzed using the data on CO_2 emissions and GDP per capita. Table 2 shows the information about the variables used in the study.

Table 2: **Variables**

Variables	*Explanation*	*Source*
C	Carbon dioxide emissions (kt)	WDI
Y	Income per capita (in TL, fixed prices, 2005)	WDI

After taking the logarithms of the variables, they were analyzed. We used the expanded Dickey Fuller-ADF (1979), Phillips-Perron-PP (1988) and Ng-Perron (NP) (2001) unit root tests to determine the variables' level of stationarity. The relationship among the series was analyzed using the Toda-Yamamoto (1995) (TY) and Dolado-Lütkepohl (1996) (DL) causality tests. What is common in these approaches is that they use series at their level in the estimation of VAR models and they are sensitive to the unit root and cointegration properties of the series (Barış and Uzay, 2015: 137). In the TY and DL VAR causality tests, determination of maximum integration order (d_{max}) is of high importance for the performance of the unit root test (Çetin and Şeker 2013, 133). In the TY causality analysis, the maximum integration order must be 2 at most. TY causality test cannot be performed if stationarity is higher than I(2). In the DL causality test, d_{max}=1 is used as it shows better causality performance than any other cointegration orders (Apergis and Tang, 2014: 26). Therefore, applied studies usually (Barış and Uzay, 2015; Çetin and Şeker, 2013 etc.) agree that the VAR model should be estimated as VAR(k+1) instead of VAR(k+d_{max}) in the DL test. However, although d_{max}=1 is preferred in the DL test, the maximum integration order might be more than 1 in some cases (Dolado-Lütkepohl 1996: 16). The TY and DL VAR causality tests are performed in two steps. In the first step, the maximum cointegration order and the optimal lag length for VAR(k) model are determined by means of the unit root testing of the series. Then a developed VAR model with k+d_{max} lag length is estimated. To find out whether the estimated VAR model is stable and trouble-free, AR unit root stability test and diagnostic tests (autocorrelation, heteroscedasticity, normality) are performed. In the second step, Wald test (MWALD) is applied to the k coefficient matrix of the VAR(k+d_{max}) model to find out the causality relationship between the variables. Equations (1) and (2) are established in the TY causality analysis of the causality relationship between the variables Y and C which have been included in the analysis after their logarithm have been taken.

$$Y_t=\phi_0+\sum_{i=1}^{k}\mu_i Y_{t-i}+\sum_{i=k+1}^{k+d_{max}}\delta_i Y_{t-i}+\sum_{j=1}^{k}\theta_j C_{t-j}+\sum_{j=k+1}^{k+d_{max}}\alpha_j C_{t-j}+u_{1t} \quad (1)$$

$$C_t=\gamma_0+\sum_{i=1}^{k}\sigma_i C_{t-i}+\sum_{i=k+1}^{k+d_{max}}\pi_i C_{t-i}+\sum_{j=1}^{k}\omega_j Y_{t-j}+\sum_{j=k+1}^{k+d_{max}}\beta_j YKL_{t-j}+u_{2t} \quad (2)$$

As a result of the Wald test (MWALD) is applied to the k coefficient matrix of the VAR(k+d_{max}) model, if $\theta_j\neq 0$ in Equation (1), there is a unidirectional causality running from C to Y; if $\omega_j\neq 0$ in Equation (2), there is a unidirectional causality running from Y to C. If $\theta_j\neq 0$ and $\omega_j\neq 0$, then there is a bidirectional causality between the variables. Equations (3) and (4) are established in the DL causality analysis of the causality relationship between the variables Y and C.

$$Y_t=\phi_0+\sum_{i=1}^{k+d_{max}}\delta_i Y_{t-i}+\sum_{j=1}^{k+d_{max}}\alpha_j C_{t-j}+u_{1t} \quad (3)$$

$$C_{2t}=\gamma_0+\sum_{i=1}^{k+d_{max}}\pi_i C_{t-i}+\sum_{j=1}^{k+d_{max}}\beta_j Y_{t-j}+u_{2t} \quad (4)$$

As a result of the Wald test (MWALD) is applied to k coefficient matrix of the VAR(k+d_{max}) model, if $\alpha_j\neq 0$ in Equation (3), there is a unidirectional causality running from C to Y; if $\beta_j\neq 0$ in Equation (4), there is a unidirectional causality running from Y to C. If $\alpha_j\neq 0$ and $\beta_j\neq 0$, then there is a bidirectional causality between the variables. In this study, we also examined the dynamic relationship between Y and C by means of generalized impulse-response functions and variance decomposition (Pesaran and Shin, 1998: 17-29) which are derived from VAR(k+d_{max}) and are not affected from the order of variables. The generalized impulse-response analysis was used to show the cumulative responses of variables to any unit shock, and variance composition was used to show how much of the percentage of variation is explained by the variable itself and by the other variables. The variance analysis that shows what percentage of any change in the variables are caused by themselves and by other variables also gives information about the extent of causality relationships between the variables (Mucuk and Alptekin, 2008: 171).

3.2. Empirical Findings

Some pre-tests were conducted on the variables before the analysis for examining the causality relationship between carbon emission and economic growth. Table 3 shows the descriptive statistics of the variables. As shown in Table 3, the variables are normally distributed.

Table 3: **Descriptive Statistics**

	Mean	*Median*	*Std. Error*	*Skewness*	*Kurtosis*	*Normality (JB Test)*	*Probability*
C	5.22	5.25	0.20	-0.24	1.90	2.23	0.32
Y	4.02	4.02	0.12	0.28	2.04	1.96	0.37

Note: Pearson's correlation coefficient: r_{cy}=0,97[a]; a: significant at 1%.

Table 4**: ADF and PP Unit Root Test**

Test	*Model*	*At level I(0)* C(P)	k	Y (P)	k	*1. At difference I(1)* C(P)	k	Y (P)	k
ADF	C	-0.024(0.92)	0	0.981(0.99)	0	-6.185(0.00)[a]	0	-5.784(0.00)[a]	0
	C+T	-2.273(0.43)	0	-2.787(0.21)	0	-6.118(0.00)[a]	0	-6.018(0.00)[a]	0
PP	C	-0.239(0.92)	1	1.042(0.99)	2	-6.289(0.00)[a]	3	-5.782(0.00)[a]	1
	C+T	-2.447(0.35)	2	-2.787(0.21)	0	-6.256(0.00)[a]	4	-6.026(0.00)[a]	3

Note: t table critical values for the model with intercept; 1%: -3.6, 5%: -2.95, 10%: -2.61; t table critical values for the model with intercept-trend 1%: -4.24, 5%: -3.54, 10%: -3.20; k: lag length; P: p-value; a: significance at 1%, b: significance at 5%, c: significance at 10%.

According to the results of the Pearson's correlation analysis shown in Table 3, there is a positive, strong and statistically significant (at 1%) relationship between the variables. Table 4 and 5 show the results of the ADF, PP and NP unit root tests performed to determine the maximum integration order (d_{max}) to be used in the TY and DL VAR causality tests to analyze the causality relationships between the variables. According to Table 4, if the absolute values of t-statistics of series calculated by the ADF and PP tests are smaller (greater) than the absolute value of MacKinnon (1996) critical values, the series are not stationary (stationary) and have a unit root (does not have a unit root).

Table 5: **NP Unit Root Test**

Model	*At level I(0) C*				*k*	*At level I(0) Y*				*k*
C	MZa 1.508	MZt 1.992	MSB 1.320	MPT 128.110	0	MZa 2.175	MZt 2.060	MSB 0.947	MPT 77.355	0
C+T	MZa -7.762	MZt -1.956	MSB 0.252	MPT 11.770	0	MZa -7.380	MZt -1.744	MSB 0.236	MPT 12.657	0
Model	*At difference I(1) C*				*k*	*At difference I(1) Y*				*k*
C	MZa -15.872[a]	MZt -2.778[a]	MSB 0.175[b]	MPT 1.688[a]	0	MZa -17.796	MZt -2.974[a]	MSB 0.167[a]	MPT 1.407[a]	0
C+T	MZa -17.106[c]	MZt -2.923[b]	MSB 0.170[c]	MPT 5.330[b]	0	MZa -17.943[b]	MZt -2.993[b]	MSB 0.166[b]	MPT 5.090[b]	0

Note: Table critical values for the model with intercept; 1%: MZa (-13.8), MZt (-2.58), MSB (0.174), MPT (1.78), 5%: MZa (-8.10), MZt (-1.98), MSB (0.233), MPT(3.17), 10%: MZa (-5.70), MZt (-1.62), MSB (0.275), MPT (4.45); Table critical values for the model with intercept-trend 1%: MZa (-23.8) MZt (-3.42) MSB (0.143) MPT(4.03), 5%: MZa (-17.30), MZt (-2.91), MSB (0.168), MPT (5.48), 10%: MZa (-14.20), MZt (-2.62), MSB (0.185), MPT (6.67); k: lag length; a: significance at 1%, b: significance at 5%, c: significance at 10%.

As shown in Table 5, there are four test statistics in the Ng-Perron which is an alternative unit root test. These statistics, namely MZ_a and MZ_t and MSB and MPT show differences in terms of the H_0 hypothesis during the unit root testing. In the MZ_a and MZ_t tests, H_0 assumes that series have a unit root (just like in ADF and PP). In the MSB and MPT tests, H_0 assumes that series do not have a unit root, i.e. they are stationary (just like in KPSS). If the absolute values of the MZ_a and MZ_t statistics estimated for the series are greater than the critical absolute values estimated by the Ng-Perron (2001) and the critical absolute values of the MSB and MPT test statistics are smaller than the critical absolute values, series are confirmed to be stationary. According to the results of the ADF, PP and NP unit root tests shown in Table 4 and 5, series are stationary at first difference I(1). In the TY and DL VAR causality tests, the maximum integration order was found to be (d_{max}=1). When d_{max}=1, the results of the VAR model estimated with the same method are the same as those of the TY and DL VAR causality tests. Therefore, the VAR model constructed for the TY causality test was estimated using least squares (OLS) and the one constructed for the DL causality test was estimated using the seemingly unrelated regression (SUR) method. Optimal lag length (k) of the VAR model constructed for both causality tests was found to be 1 according to the LR, FPE, AIC, SIC and HQ information criteria[2]. Since the cointegration order was found to be d_{max}=1 and the optimal lag length of the VAR model was found to be 1 for all criteria, the k+d_{max}(1+1) lagged VAR model constructed for the TY and DL causality tests was estimated as VAR (2).

Table 6: **TY and DL VAR Causality Test Results**

TY-VAR Causality Test (Inverse roots of the characteristic AR <0.88)							
VAR (2) Model (OLS)	*k+dmax*	*Wald stat.*	*P-value*	*Causality*	*Jarque-Bera (P-value)*	*LM*	*White*
1. C=f(Y) *2. Y=f(C)*	1+1	1.02 3.00	0.31 0.08[c]	- + C→Y(0.13)	4.95 (0.29)	<0.83	0.77
DL-VAR Causality Test (Inverse roots of the characteristic AR <0.95)							
VAR(2) Model (SUR)	*k+1*	*Wald stat.*	*P-value*	*Causality*	*Jarque-Bera (P-value)*	*LM*	*White*
1. C=f(Y) *2. Y=f(C)*	1+1	1.11 3.27	0.29 0.07[c]	- + C→Y(0.13)	4.95 (0.29)	<0.83	0.77

Note: c: significant at 10%.

[2] *The tables including the optimal lag lengths estimated for the VAR causality tests are given in Annex 1.*

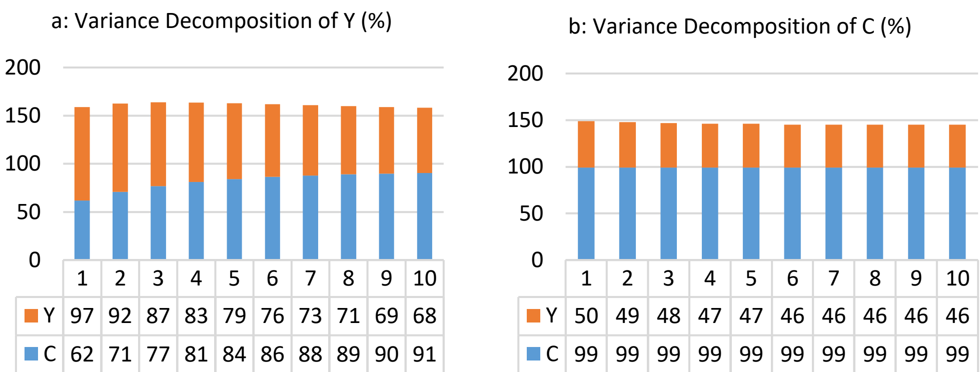
The findings showed that the VAR (2) estimated for the TY and DL causality tests is stable and inverse roots of the characteristic AR polynomial are smaller than 1. CUSUM tests showed that the period studied is stable[3]. Table 6 shows the results of the TY and DL causality tests of the VAR (2) which was estimated by OLS and SUR and found to be stable and trouble-free. Besides, the results of the diagnostic tests also showed that the VAR (2) model does not include any heteroscedasticity or autocorrelation and the error terms are normally distributed. According to the results of the TY and DL VAR causality tests shown in Table 6, there is a positive and statistically significant unidirectional causality running from carbon emissions to economic growth.

Table7: **Generalized Impulse-Response Values between C and Y**

	Period	*1*	*2*	*4*	*6*	*8*	*10*
Response	*From Y to C*	0.013	0.017	0.019	0.018	0.017	0.015
	From C to C	0.023	0.021	0.018	0.016	0.014	0.012
	From Y to Y	0.018	0.018	0.015	0.013	0.012	0.010
	From C to Y	0.016	0.015	0.012	0.010	0.009	0.008

We used Peseran and Shin's (1998) generalized impulse-response and variance decomposition analysis which are not sensitive to variables ordering. Y's cumulative response to shocks from C and C's cumulative response to shocks from Y were both found to be positive. Besides, Table 7 shows that Y's and C's cumulative responses to shocks from themselves are also positive. Graph 1 shows the generalized variance decomposition values between Y and C. As shown in Graph 1a, about 97% of any change in the series Y is explained by itself and about 62% is explained by C in the first period. In the following periods, the percentage of variance in Y explained by itself is decreasing gradually, while that explained by C is increasing. In the 10th period, 91% of variance in Y is explained by C, while 68% is explained by itself. C was observed to have an important impact on Y.

Graph 1: **Generalized Variance Decomposition (%)**



As shown in Graph 1b, about 99% of any change in the C is explained by itself and about 50% is explained by Y in the first period, Graph 1b shows that, in the following periods, the percentage of variance in C explained by Y is decreasing gradually, In the 10th period, 99% of variance in C is explained by itself, while 46% is explained by Y. Y has about 46% explanatory effect on C. According to the variance decomposition analysis of the variables, the percentage of variance in Y explained by C is increasing gradually, while the percentage of variance in C explained by Y is decreasing. C can be said to have an important impact on Y. This finding supports the causality relationship from C to Y which was found by the TY and DL VAR causality tests.

[3] *CUSUM test results for the VAR(2) model are given in Annex 2.*

4. Conclusion and Suggestions

This study examined the relationship between carbon emission and economic growth using the TY and DL VAR causality tests, generalized impulse-response functions and variance decomposition. The findings obtained from the TY and DL VAR causality analysis showed that there is a unilateral, positive and statistically significant causality running from carbon emission to economic growth in Turkish economy for the period between 1977 and 2014, similar to the findings of Pata's (2016) study covering the period 1972-2011 and Genç and Tandoğan's (2015) study covering the period 1980-2010. The results of the generalized impulse-response functions and variance decomposition revealed that carbon emission has more impact on economic growth than the impact of economic growth on carbon emission. In other words, carbon emission has a considerable impact on economic growth. This result supports the findings obtained from the causality tests.

The results of the TY-DL VAR, generalized impulse-response and variance decomposition analyses showed that there is a positive and strong relationship between carbon emissions and economic growth in Turkey. A general overview of the analysis results indicates that economic growth has increased in Turkey with increasing carbon emissions, in other words, the growth of Turkish economy is based on pollution. We can argue that developing countries like Turkey do not pay attention to clean and strict environmental policies to achieve economic growth and they allow for operation of the polluting industries of developed countries willing to gain cost advantage in order to acquire foreign capital, thus leading to an increase in carbon emissions. However, it should not be forgotten that increased carbon emissions which are ignored to support economic growth in developing countries create a barrier to achieving sustainable development goals in the long run. Besides, developing countries should take account of the negative externalities that will be caused by a pollution-based growth policy in the long term.

In conclusion, polluting industries are considered to be a source of foreign capital for developing countries and a source of income that creates employment for individuals; however, increased carbon emissions that diminish environmental quality affect the health of labor force adversely in the long run, thus reducing effectiveness in production. Therefore, to achieve sustainable development, especially the developing countries should implement clean environmental policies and strict environmental laws that will reduce carbon emissions which have a large share in greenhouse gas emissions if they adopt policies based on foreign capital and migration strategies of polluting industries. Furthermore, as indicated by Kumbaroğlu and Arıkan (2009) in their study, Turkey will shape and realize its sustainable development goals better by means of implementing policies that encourage dissemination of environmentally friendly new technologies and approaches, addressing current sanctions and the sanctions that can be redesigned and increasing public awareness.

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Annexes

Annex 1: Optimal Lag in VAR(2)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	93.4	NA	1.3	-5.5	-5.4	-5.5
1	**179.4**	**156.4***	**9.3***	**-10.5***	**-10.2***	**-10.4***
2	181.8	4.12	1.2	-10.2	-9.9	-10.0
3	182.79	1.43	1.4	-10.0	-9.5	-9.8
4	184.6	2.63	1.2	-10.2	-9.2	-9.9

Annex 2: CUSUM Charts of VAR(2) Models