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INFORMAL ECONOMIC ACTIVITY AND AIR POLLUTION: IS THERE A LINK?

Hatice İMAMOĞLU*

ABSTRACT

This study investigates the relationship between informal economic activity and carbon emissions in Turkey through the Environmental Kuznets Curve hypothesis. Implementation of second-generation econometric methods and procedures in consideration of multiple structural breaks in the series for the period 1970 to 2015, will be conducted an investigate the impact of the size of informal economic activity on environmental degradation. The findings imply that informal economic activity significantly contributes to CO2 emissions. Furthermore, this article indicates that both legal (formal) and illegal (informal) economies exert a notable influence on environmental quality. Nevertheless, the formal economy demonstrates a notably stronger positive influence on CO2 emissions in comparison to the informal economy. Turkish authorities must prioritize precautionary measures to reduce informal economic activities, thereby safeguarding environmental quality and leveraging growth in the official economy.

Keywords: Air Pollution, Informal Economy, Financial Development, MIMIC Model Approach

JEL Classification Codes: C51, E26, O44

KAYIT DIŞI EKONOMİK FAALİYET VE HAVA KİRLİLİĞİ: BİR BAĞLANTI VAR MI?

ÖZET

Bu çalışma, Türkiye'de kayıt dışı ekonomik faaliyet ile karbon emisyonları arasındaki ilişkiyi Çevresel Kuznets Eğrisi hipotezi aracılığıyla incelemektedir. Kayıt dışı ekonomik faaliyet boyutunun hava kirliliği üzerindeki etkisini incelemek için 1970 ila 2015 dönemi için zaman serilerindeki çoklu yapısal kırılmayı dikkate alan ikinci nesil ekonometrik prosedürler uygulanacaktır. Bulgular, kayıt dışı ekonomik faaliyetin CO2 emisyonlarına önemli ölçüde katkıda bulunduğunu göstermektedir. Ayrıca bu makale hem resmi hem de kayıt dışı ekonomik aktivitelerin çevre kalitesi üzerinde dikkate değer bir etkiye sahip olduğunu göstermektedir. Bununla birlikte resmi ekonomi, kayıtdışı ekonomiyle karşılaştırıldığında CO2 emisyonları üzerinde belirgin şekilde daha güçlü bir olumlu etki göstermektedir. Otoritelerin kayıt dışı ekonomik faaliyetleri azaltmaya yönelik ihtiyati tedbirlere öncelik vermesi, böylece çevre kalitesinin korunması ve resmi ekonomideki büyümenin desteklenmesi gerekiyor.

Anahtar Kelimeler: Hava Kirliliği, Kayıtdışı Ekonomi, Finansal Gelişme, MIMIC Model Yaklaşımı

JEL Klasifikasyon Kodları: C51, E26, O44

* Doç Dr., Cyprus Science University, haticeimamoglu@csu.edu.tr , 0000-0002-3299-499X

1. INTRODUCTION

The examination of the interactions among economy, energy, and greenhouse gas emissions has garnered considerable attention in the field of energy economics literature. The energy economics literature investigates the relationship between economic growth and environmental quality in the form of linear modeling, quadratic function models, and cubic function models (de Vita et al., 2015; Halicioglu, 2009; Stern, 2004). Several pollutant variables have been used to investigate environmental issues such as SO2 emission and the energy-intensity indexes (Elgin and Oztunalı, 2015; Elgin and Oztunalı, 2014; among many others), and remarkable that CO2-based emissions have been widely used to measure for GHG emissions in various literature, which stated in the sphere of energy economics (see Katircioglu and Taspinar, 2017).

The conventional environmental Kuznets curve hypothesis investigates the relationship between environmental quality and economic growth: environmental degradation tends to get worse as economic growth occurs until a peak point over the course of development, while average income reaches its maximum point. Overall, the gross domestic product (GDP) is used as an economic growth indicating specific country development, however illegal and laundered financial activities can lead to inaccurate economic measurement of the real GDP, which results in misleading findings while investigating its relations with other economic variables (Karanfil, 2008). Informal economic activities are global issues that are suffered by all the countries in the world.

The study conducted by Schneider (2007) found the level of the unofficial economy fluctuated between 28% and 43% in developing countries of its real GDP, nearly 40% of GDP in transition countries, and between 14% and 17% of its GDP in developed countries. The motivation behind this paper is to discover the reason while assessing the environmental quality of a particular country to validate that without taking into account the scale of its illegal economic activities could lead to erroneous conclusions.

The nexus between GDP and environmental quality has been thoroughly explored, alongside factors such as energy consumption, including various macroeconomic indicators such as trade openness at the international range, volume of foreign direct investment, performance in financial development, improvement of the tourism sector, urbanization, and other economic parameters. On the other hand, there has been a limited focus in the literature on the connection between air quality and the informal economy, only a few studies have investigated the aforementioned relationship (see Dada et al., 2022; Sohail et al., 2021; Imamoglu, 2018; Elgin and Öztunalı, 2014; Elgin and Öztunalı, 2015; Mahzar and Elgin, 2013). The studies on environmental degradation and the informal economy can be classified into two categories: panel and time series data analysis. The level of unofficial economy and air pollution affecting ambient degradation has been validated in most research papers while providing empirical evidence referring to a negative correlation between the mentioned variables.

Mazhar and Elgin (2013) suggested that firms dealing with underground activities may use environmentally damaging production methods and result in environmental degradation in 100 countries of panel estimation. Dada et al. (2022) highlighted the positive impact of the informal economy on ecological footprints. On the other hand, Elgin and Öztunalı (2015) provide empirical evidence on the inverse-U relationship between the informal economy and pollution in 152 countries of panel settings. Cross-country panel analyses result in a lack of consensus because of the diversity of the scale of the countries with unofficial economic activities; therefore, applying the time-series data analyses ensures a better understanding of the intended relations. Moreover, Elgin and Oztunalı (2014) have investigated the interaction of the scale of the unofficial economic sector concerning environmental pollution in the case of Turkey and have discovered proof of a relationship between the unofficial economy and air pollution as well as their interdependency of an inverted U-shape. The study by Imamoglu (2018) suggested the positively significant effect of the illegal economy on ecological footprints. On the other hand, the study of Sohail et al., (2021) investigated the same nexus in South Asia countries and suggested a mixed result. While it causes an enhancing effect in some countries, this effect is decreasing in some countries.

Since Turkey is ranked at the top of the 20 countries with the largest CO2 emission, in this context, it will be a good case to investigate the relations, economic performances, and environmental issues. The contribution of this study will add available relevant literature, which investigates the effects of formal and illegal economies on air pollution in newly industrialized countries with the highest CO2 emissions. Additionally, apart from available literature, the current paper is one of the first analyses that examine such an effect, investigating the mentioned connection while accounting for structural breaks in series. This will be accomplished by employing modern econometric techniques to deliver dependable empirical results.

In this paper, empirical analysis will be carried out by using second-generation econometric methods and procedures in consideration of multiple structural breaks in the series for the period. The stationarity of the series will be tested by using Carrion-i-Silvestre et al. (2009)'s unit root tests. Next, Maki (2012)'s cointegration test will be employed to detect the cointegration vector. In the case of the long run relationship between the variables of interest, Dynamic Ordinary Least Square (D-OLS) and Fully Modified Otdinary Least Square (FM-OLS) will be adopted to estimate long run estionation of the model. This paper attemps to consider a long time dimention, 45 years, on this research. Unfortunately, the limitation of this study is its the data avaliability on both financial development index and the size of informal economy. Therefore, it brings the necessity to measure both of the series prior to proceed with empirical estimations.

This paper is organized as follows; section 2 describes the theoretical framework, section 3 discusses data and methodology, section 4 provides results and discussion, and finally, section 5 will conclude.

2. THEORETICAL SETTINGS

The starting point of the discussion is that informal economic activities can be considered the determinants of air pollution. Energy consumption has been added to the model as an important determinant of CO2 emissions, meanwhile, financial development and trade openness have been added to the model as control variables for defining the expected effect. The equation depicting the correlation between CO2 emissions and economic growth is proposed within the Environmental Kuznets Curve framework (see Stern, 2004). Thus, equation (1) is proposed as follows:

$$CO2_t = f\ (y_t^{\beta_1}\ , iny_t^{\beta_2}, E_t^{\beta_3}, F_t^{\beta_4}, T_t^{\beta_5}) \qquad (1)$$

And following the logarithmic model assess the long-run impact;

$$ln\ \ CO2_t = \beta_0 + \beta_1 lny_t + \beta_2 lniny_t + \beta_3 lnE_t + \beta_4 lnF_t + \beta_5 lnT_t + u_t \qquad (2)$$

Where;

CO2-carbon dioxide emission as an indicator of air pollution,

y-formal/official economy,

iny-informal economy,

E-energy usage,

F-financial development,

T-trade openness,

Betas (β)-are the coefficients of the regressors.

ln -natural logarithm, and finally

ε-error term expected to possess white noise properties.

3. DATA & METHODOLOGY

3.1 DATA

This paper utilizes annual data spanning from 1970 to 2015 to investigate the impact of both formal and informal economic activities on air pollution. This study utilized secondary data in empirical estimations. Carbon dioxide emissions (CO2) as a widely used proxy will be used as an indicator for air pollution. Gross domestic product will be used as an indicator of the official economy (y). Additionally, energy usage (E), trade openness (T), and financial development index (F) will be used as control variables in this study. Carbon dioxide emissions, gross domestic product, energy usage, and trade openness have been acquired from the World Data Bank (WDI, 2020). On the other hand, the financial improvement indexing is designed employing variance decomposition, and the rate of the informal economic activity was assessed by utilizing the MIMIC (multiple indicators multiple causes) model approach in order. Table 1 represents descriptive statistics of all considered time series in this study.

Table 1. Descriptive Statistics of Variables

		CO2		y		iny		E		F		T
Mean	57	11.8	66	26.6	79	4.1	76	6.8	55	3.5	31	3.4
Median	39	11.9	80	26.6	10	4.2	84	6.8	98	3.3	63	3.5
Maximum	54	12.7	56	27.6	61	4.3	69	7.3	11	4.1	07	4.0
Minimum	61	10.6	15	25.7	85	3.7	58	6.2	29	3.1	08	2.2
Std. Dev.	1	0.59	5	0.54	35	0.1	05	0.3	79	0.2	13	0.5
Observations		45		45		45		45		45		45

Source: CO2, Y, E, and T Retrieved From World Bank (WDI, 2020).; İny and F are the Author's Own Calculations.

In this paper, the sample size that has been ulitlized in emprical estimations are 45 years. The mean value as a measure of central tendency of a probability distribution is 11.857 for CO2, 26.666 for y, 4.179 for iny, 6.876 for E, 3.555 for F, 3.31 for T. The average size of the CO2 emission is 11.857 while the minimum is 10.661 and maximum is 12.754; the average size of the official economy is 26.666 while the minimum is 25.715 and maximum is 2 7.656; the average size of the informal economy is 4.179 while the minimum is 3.785 and maximum is 4.361; the average size of the energy usage is 6.876 while the minimum is 6.258 and maximum is 7.369; the average size of the financial sector development is 3.555 while the minimum is 3.129 and maximum is 4.111; and finally the average size of the trade openess is 3.431 while the minimum is 2.208 and maximum is 4.007. On the other hand, the standard deviation that is the spread od the data is 0.591 for CO2, 0.545 for y, 0.135 for iny, 0.305 for E, 0.379 for F, 0.513 for T. The standard deviation shows how dispersed the data is in respect to the mean value.

As the variables of the interest, carbon dioxide emissions (CO2), gross domestic product will be used as an indicator of the official economy (y), energy usage (E), trade openness (T) are readly avaliable statistics of World Development Indicators of World Data Bank (WDI, 2020). However, the financial development index (F) and the size of informal economy are not readily avaliable statistics. Therefore, it brings the necessity to measure both of the series prior to proceed with empirical estimations. Section 3.2 will presenting the detailed information for how to construct an index for financial sector development, and Section 3.3 will provide an detailed information for how to measure the informal economy in Turkey.

3.2 FORMATION OF FINANCIAL DEVELOPMENT INDEX (FDI)

The financial development index of components includes;

- The ratio of commercial and central banks to commercial bank assets, AS;

- Domestic Credit Bank (DCB);

- Domestic Credit Private (DCP);

- Money supply (M2) and finally

- Liquid liabilities (M3).

The FDI is created through principal component factor (Chen, 2010, and Ang, 2009). For the construction of a composite FDI, the following functional relationship is proposed in the current study;

$$F = f(AS, CDB, CDP, M2, M3) \tag{3}$$

AS and M3 have been obtained from the Banks Association of Turkey, while the rest of the variables were obtained from the World Data Bank.

3.3 ESTIMATION OF THE INFORMAL ECONOMY

As stated in an earlier stage of this paper, Turkey has a significantly large ratio of unofficial economic activities. Turkey's informal economy is estimated by using several approaches namely discrepancy method, physical input, currency demand, currency ratio, tax auditing, expenditure-based, and DYMIMIC approaches (see Dell'Anno and Halicioğlu; 2010; Davutyan, 2008; Karanfil and Özkaya, 2007; Schneider and Savaşan, 2007; Us, 2004; Çetintaş and Vergil, 2003; Öğünç and Yilmaz 2000; Halicioglu, 1999; Yayla, 1995; Temel et al., 1994; Kasnakoğlu, 1993). Schneider (2007) estimates the rate of the unofficial economy in Turkey as nearly 34.3 percent of the local GDP in 2002 by employing DYMIMIC and currency demand methods; Schneider and Savaşan (2007) estimate the size of the informal economy in Turkey as 35.1% of GDP in 2005 by adapting the DYMIMIC approach; on the other hand, Dell'Anno and Halicioğlu (2010) estimate unrecorded economy in Turkey by using currency demand approach and pointed out the size of underground economy is 10.7% of GDP in 1987, and it reaches to peak 27.4% of GDP in 2004.

The rate of illegal economic activity proposed to be estimated by the MIMIC model approach taking into account the ability of the model which considers multiple indicators and causes simultaneously, unlike the other estimation approaches (see Imamoglu, 2016). As a cause variable to be used unemployment and self-employment as well as tax burden, on the other hand, as an indicator variable has been chosen a rate of labor force participation and GDP growth rate. Consequently, the estimation going to involve both structural and measurement models respectively, outlined as follows;

$$\eta_t = \gamma^{'} x_t + \varepsilon_t \tag{4}$$

$$y_t = \lambda \eta_t + \omega_t \tag{5}$$

Where;

η -represents the latent variable,

x_t -vector of causal variables,

$\gamma^{'}$ -coefficient vector,

ε_t - structural equation error terms,

y_t -vector of indicator,

λ - vector of loading factors, representing the expected change of the magnitudes, for a unit change in the latent variables, and

ω_t - measurement error terms.

To estimate the size of the unofficial economy, all the used time-series data are withdrawn from the database provided by OECD, apart from the GDP's growth rate which has been taken from the World Data Bank.

4. ESTIMATION PROCESS

4.1 UNIT ROOT TESTS

Gained popularity as a contemporary econometric technique the unit root test with structural breaks was introduced by Perron (1989) and future developed by Zivot and Andrews (1992); Lumsdaine and Papell (1997); Lee and Tarasevich (2003); Kim and Perron (2009) and Carrion-i-Silvestre et al. (2009). The current study uses the unit root test up to five structural breaks proposed by Carrion-i-Silvestre et al. (2009), to test existing of the null hypothesis of a unit root under multiple structural breaks, applying all five different test statistics according to the following equations;

$$P_T^{GLS}(\lambda^0) = \frac{\{S(\underline{\alpha},\lambda^0) - \underline{\alpha} S(1,\lambda^0)\}}{S^2(\lambda^0)} \tag{5}$$

$$MP_T(\lambda^0) = \frac{[c^{-2}T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2 + (1-\bar{c})T^{-1}\tilde{y}_T^2]}{s(\lambda^0)^2} \quad (6)$$

$$MZ_\alpha(\lambda^0) = (c^{-2}\tilde{y}_t^2 - s(\lambda^0)^2)(2T^{-2}\sum_{t=1}^{T}\tilde{y}_T^2) \quad (7)$$

$$MSB(\lambda^0) = (s)(\lambda^0)^{-2}T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2 \quad (8)$$

$$MZ_T(\lambda^0) = \left(T^{-1}\tilde{Y}_T^2 - s(\lambda^0)^2\right)(4s(\lambda^0)^2T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2)^{1/2} \quad (9)$$

Referring to the bootstrapping approach by Carrion-i-Silvestre et al. (2009) the theoretical hypothesis is tested by applying critical values.

4.2 THE COINTEGRATION TEST

The model of the standard cointegration test in the presence of structural breaks may lead to an incorrect value and provide biased findings (see Gregory et al., 1996). Cointegration techniques that account for structural breaks are the other contemporary econometric techniques that overcome bias estimations. Cointegration techniques that account for structural breaks were first introduced by Gregory and Hansen (1996a, 1996b). It was further developed by Hatemi-J (2008) and Maki (2012).

The cointegration test developed by Maki (2012) allows for consideration of up to five structural breaks. Using four different regression models to test for cointegration with developed context models are illustrated as follows:

$$y_t = \mu + \sum_{i=1}^{k}\mu_i D_{i,t} + \beta' x_t + u_t \quad (10)$$

$$y_t = \mu + \sum_{i=1}^{k}\mu_i D_{i,t} + \beta' x_t \sum_{i=1}^{k}\beta_i' x_t D_{i,t} + u_t \quad (11)$$

$$y_t = \mu + \sum_{i=1}^{k}\mu_i D_{i,t} + \gamma t + \beta' x_t \sum_{i=1}^{k}\beta_i' x_t D_{i,t} + u_t \quad (12)$$

$$y_t = \mu + \sum_{i=1}^{k}\mu_i D_{i,t} + \gamma t + \sum_{i=1}^{k}\gamma_i t\, D_{i,t} + \beta_i' x_t D_{i,t} + u_t \quad (13)$$

Where, D_i is imply for dummy variables defined by Maki (2012) and demonstrated as follow:

$$D_i = \begin{cases} 1 & when\, \mathrm{t} > \mathrm{T_B} \\ 0 & otherwise \end{cases}$$

Where, the T_B is representing structural break years.

Therefore, Maki's (2012) cointegration test has a null hypothesis of no cointegrations under structural breaks. Critical values for testing the null hypothesis have been received from Monte Carlo simulation while tabulated in Maki's (2012) study.

3.4 LONG-RUN COEFFICIENTS

If the presence of the cointegration vector is detected, the long-run estimations will be carried out by using equation (2), across three different estimation options while applying both dynamic ordinary least square (D-OLS) and fully modified ordinary least square (FM-OLS) to determine the long-run coefficients.

4. RESULTS & DISCUSSION

Table 2 provides the GLS-based unit root test results from Carrion-i-Silvestre et al. (2009) for all the series under consideration. As presented in Table 2, the series exhibited three notable years with significant structural breaks. Taking into account structural break years in the level form, the null hypothesis of a unit root cannot be rejected in any of the series, however, in the first difference, the null hypothesis has been rejected at a 5% significance level for every series that indicates all the series are integrated in the first order, I(1).

Table 2. The Quasi-GLS Based Unit Root Tests

	Levels					Break Years
	P_T	MP_T	MZ_{α}	MSB	MZ_t	
$lnCO_2$	7.746 [4.926]	7.971 [4.926]	-18.663 [-29.023]	0.163 [0.136]	-3.054 [-3.754]	1977; 1980;1987
lny	10.118 [5.120]	10.085 [5.120]	-14.774 [-27.267]	0.183 [0.140]	-2.715 [-3.684]	1977; 1980; 2009
lniny	7.832 [5.854]	8.029 [5.854]	-18.920 [-25.357]	0.161 [0.141]	-3.057 [-3.567]	2001; 2007; 2009
lnE	8.702 [5.228]	8.972 [5.228]	-17.876 [-29.866]	0.167 [0.133]	-2.989 [-3.815]	1977; 1981; 1987
lnF	10.375 [6.333]	10.647 [6.333]	-18.450 [-30.039]	0.162 [0.129]	-2.995 [-3.859]	1993; 2001; 2003
lnT	8.202 [5.440]	8.435 [5.440]	-18.508 [-28.572]	0.163 [0.136]	-3.030 [-3.718]	1974; 1979; 1982
	First Difference					
$\Delta lnCO_2$	4.445*	4.411*	-21.270*	0.152*	-3.240*	-

		[5.543]	[5.543]	[-17.325]	[0.168]	[-2.896]	
	Δlny	4.081* [5.543]	4.246* [5.543]	-21.475* [-17.325]	0.152* [0.168]	-3.276* [-2.896]	-
y	Δlnin	4.280* [5.543]	4.476* [5.543]	-21.132* [-17.325]	0.152* [0.168]	-3.223* [-2.896]	-
	ΔlnE	4.084* [5.543]	4.250* [5.543]	-21.470* [-17.325]	0.152* [0.168]	-3.275* [-2.896]	-
	ΔlnF	4.199* [5.543]	4.384* [5.543]	-20.974* [-17.325]	0.154* [0.168]	-3.231* [-2.896]	-
	ΔlnT	4.498* [5.543]	4.414* [5.543]	-20.735* [-17.325]	0.155* [0.168]	-3.216* [-2.896]	-

Notes:* denotes the rejection of the null hypothesis at 5% significance level.

Source: The author's own calculations.

As long as all the series are integrated in the first difference, Maki's (2012) cointegration test can proceed as the next step to investigate the existance of cointegration vector. The cointegration test results are presented in Table 3.

Table 3. Maki (2012) Cointegration Test

Number of Break Points	Test Statistics [Critical Values]	Break Points
$T_B \leq 1$		
Model 0	-6.723* [-6.550]	1981
Model 1	-6.940* [-6.937]	1993
$T_B \leq 2$		

Model 0	-8.178* [-7.362]	1981; 1984
Model 1	-9.098* [-7.811]	1984; 1993

Notes:* denotes the rejection of the null hypothesis at 5% significance level.

Source: CO2, y, E, and T Retrieved from World bank (WDI, 2020). Iny and F are the author's own calculations.

As can be seen in Table 3, the null hypothesis of no cointegration can be rejected at a 5% significance level under the existence of structural break years. Cointegration relationships were established in two models.

The result of equation (1) cointegrates, and the estimating parameters are robust in the long term. Dummy variables representing the structural break years identified from the cointegration test are incorporated into equation (2) which estimates the long-run coefficient (see Katircioğlu, 2014), as presented in Table 4.

Table 4. Long-Run Coefficients Estimations

Dependent Variable	lnCO2					
	D-OLS	D-OLS	D-OLS	FM-OLS	FM-OLS	FM-OLS
Explanatory Variables		With Constant	With Trend		With Constant	With Trend
Intercept	-	-11.064*** (0.000)	-14.642** (0.031)	-	-10.802*** (0.000)	-10.324 (0.114)
Trend	-	-	-0.004 (0.580)	-	-	0.001 (0.932)
lny	-0.058 (0.171)	0.571*** (0.000)	0.717** (0.012)	-0.052 (0.161)	0.575*** (0.000)	0.555** (0.045)
lniny	0.085 (0.354)	0.304*** (0.000)	0.352*** (0.001)	0.074 (0.340)	0.256** (0.00[illegible])	0.253* (0.01[illegible])

			1.8		0.9		0.8		1.8		0.9		0.9
	lnE	54***		44***		71***		40***		26***		37***	
			(0.0		(0.0		(0.0		(0.0		(0.0		(0.0
		00)		00)		00)		00)		00)		00)	
			-		-		-		-		-		-
	lnF	0.072		0.104**		0.079		0.105		0.142***		0.143**	
			(0.3		(0.0		(0.2		(0.1		(0.0		(0.0
		66)		20)		13)		25)		01)		25)	
			0.1		0.0		0.0		0.1		0.1		0.1
	lnT	67***		84***		85***		93***		06***		04***	
			(0.0		(0.0		(0.0		(0.0		(0.0		(0.0
		00)		00)		00)		00)		00)		00)	
	R^2		0.9		0.9		0.9		0.9		0.9		0.9
		94		98		98		94		98		98	
	Adj.		0.9		0.9		0.9		0.9		0.9		0.9
R^2		94		98		98		93		98		98	
	S.E.		0.0		0.0		0.0		0.0		0.0		0.0
of Reg.		45		23		23		45		24		24	
	Long		0.0		0.0		0.0		0.0		0.0		0.0
run var.		03		01		01		02		01		01	

Notes:* Denotes the Rejection of the Null Hypothesis At 5% Significance Level.

Source: The Author's Own Calculations.

The long-run coefficients presented in equation (2) have been estimated by applying both D-OLS and FM-OLS approaches across six different models. Both methods are calculated utilizing three variations: excluding both a drift and trend, including only a drift, and incorporating both a drift and trend. Even though both D-OLS and FM-OLS estimations indicate a substantial influence of formal and illegal economies on air pollution, the trend does not provide a significant effect. In models including constants, both D-OLS and FM-OLS estimations reveal a positively significant coefficient for the official economy on air pollution, (β= 0.571, p < .01) and (β = 0.575, p < .01), respectively. Also, the coefficient of informal economy suggests enhancing effect on emission in both D-OLS and FM-OLS estimations (β = 0.304, p <.01) and (β = 0.256, p <.01), respectively. The empirical results reveal that any increase in any kind of economic activity enhances air pollution. Yet, the influence of any forms of extension in the formal/official economy overcomes the impact of the unofficial economy on environmental quality. The evidence indicates a notably positive impact on environmental degradation from both energy consumption and trade openness. Consistent with previous findings from the energy literature, energy consumption is exerting increasing effect on carbon-based emissions. However, the estimated elasticity coefficient of financial development in D-OLS estimation with constant models is negatively significant, indicating that a 1 % increase in the development in the financial sector leads to a reduction of 10.4 % in CO2 emissions. Similarly, the estimated elasticity coefficient of financial development in FM-OLS estimation with constant models is negatively significant, indicating that a 1 % increase in the development in the financial sector leads to a reduction of 14.2 % in CO2 emissions. Meanwhile, in models with constants, both

D-OLS and FM-OLS estimations suggest that highly significant and negative intercepts indicate a considerable decline in carbon dioxide emissions when there is no growth in income, energy, and informality.

Besides, both D-OLS and FM-OLS estimations with constant and trend models suggest similar results to support the findings. The coefficient of official economy boosts emission levels in both D-OLS and FM-OLS, (β = 0.717, p <.05) and (β = .555, p <.05), accordingly. Likewise, the coefficient of unofficial economy highlights the effect in both D-OLS and FM-OLS estimations, (β = 0.352, p < .01) and (β = 0.253, p < .05), respectively. Like the results of prior estimations, in both D-OLS and FM-OLS estimations with constant and trend models, the impact of the official economy has a greater influence on environmental degradation compared to the informal economy. Additionally, energy usage and trade coefficients provide similar results to prior findings. Once again, consistent with previous findings from the energy literature, energy consumption exerts a positively significant impact on carbon emissions. On the other hand, the estimated elasticity coefficient of financial development in FM-OLS estimations with constant and trend models is negatively significant, indicating that a 1 % increase in the development in the financial sector leads to a reduction of 14.3 % in CO2 emissions. Additionally, D-OLS estimations with constant and trend models suggest negatively significant intercepts indicate a considerable decline in carbon dioxide emissions when there is no growth in income, energy, and informality.

5. CONCLUSION

This article attempts to investigate toward implications of air pollution, arising as a result of legal and illegal forms of economic activities. In this context, developing countries such as Turkey have a large portion of unofficial economic activities, which results in the interests of both scholars and policymakers. However, it does not prevent, the process of financial success and achieving a considerable in the trade volume as well as comprehensive industrial development of the country. Due to the lack of kind research in the relevant literature dedicated to Turkey, the purpose of this paper is to reveal a statistical relationship with environmental quality by investigating the impact of both official and unofficial economies to define the level of negative implications via various channels of financial sector development as well as trade openness.

The findings provide empirical support to the above assumptions, indicating the existence of a long-run relationship between informal economic activities and carbon dioxide emissions in Turkey throughout the channels of the formal/official economy, including financial development, energy consumption, and trade openness. Obviously, both legal and illegal economic activities lead to deterioration in air quality in the long run, however, the impact of legal economic activities is higher than unofficial economic activities which influence environmental degradation. Illegal economic activities also contributed to environmental degradation in the case of Turkey. The volume due to trade openness and use of energy resources boost air pollution, which validates the theoretical expectations, on the other hand, financial development has indicated a negative implication on environmental degradation.

Finally, the results of this study revealed the upcoming obligation of the Turkish officials and government which is necessary to take control of economic activities concerning legal directions as well as prevent illegal methods of accounting, in order to mitigate environmental degradation to meet the environmental requirements, upon closeness for EU membership. Taking into account the largest cashflow volumes of unofficial economic activities in Turkey, it is recommended to minimize illegal economic activities which will lead to the protection of the environmental quality while contributing growth of its legal economy. Future research might be applied to countries similar to Turkey's situation, investigating for useful comparative purposes, which has a highest volume of illegal economic activities.

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