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Foreword

The book 'Interdisciplinary Public Finance, Business and Economics Studies – Volume IV', by bringing together the works of academics and researchers working in the area of economics and administrative sciences, aims to reveal the actual and historical developments experienced in economics and administrative sciences in Turkey and throughout the world, and produce proposals for solutions whilemaking a general evaluation.

The first volume of this book was published in 2018, the second volume in 2019, and the third volume in 2020. I wish to express my gratitude to the authors of the book chapters that contributed to this without losing their research spirit in spite of the Covid-19 epidemic, which is on the global agenda.

This book consists of thirty-five valuable book chapters consisting of theoretical and empirical studies. All publishing rights of the published book chapters belong to the publisher, and the content responsibility of the published articles belongs to the author. The opinions in the book chapters are the personal opinions of the authors; it is not an official opinion of any institution or organization.

Assoc. Prof. Adil AKINCI
Kutahya/Turkey, 2021

Salih Türedi and Vildan Yavuz

Does the Shadow Economy Increase Environmental Pollution in Turkey?

1 Introduction

There are different definitions for the shadow economy in literature, which can also be named the underground, hidden, black and informal economy. For instance; Smith (1994) defined the shadow economy as 'Market-based production of goods and services, whether legal or illegal, that escapes detection in the official estimates of GDP'. Differing from this definition, considering the illegal activities within the scope of shadow economic activities, with a narrower approach, Medina and Schneider (2018) defined the shadow economy as 'all the legal economic and productive activities that are hidden from official authorities for monetary, regulatory and institutional reasons, but will contribute to national GDP when recorded. According to the estimation made by Medina and Schneider (2019), the average size of the shadow economy at the global scale is 31% of the GDP. Considering, from the aspect of income level, this rate is 40.43% in low-income countries (LIC), 31.63% in emerging countries having middle-income levels, and 16.03% in advanced countries having high-income levels.[1] Since it is seen in almost all the countries throughout the world, the effects of shadow economy are being investigated intensively as a global phenomenon by economists. Besides that, these studies generally focused on the effects of the shadow economy on macroeconomic variables such as GDP, tax revenues, budget deficits and employment, but its role in environmental pollution has not yet been adequately discussed.

However, a common theoretical approach stands out in the related studies, which show that shadow economy has a close and positive relationship with environmental pollution, especially in developing countries. For instance, Biswas et al. (2012) noted that most of the environmental problems, such as water quality and air pollution, which are the negative impacts of rapid growth due to the use of coal and fossil fuels, are fostered to a significant extent by the sizeable shadow

1 For more details: Medina, L. and F. Schneider (2019), Shedding Light on the Shadow Economy: A Global Database and the Interaction with the Official One, CESifo Working Paper No. 7981.

economies in developing countries. Similarly, expressing that the size of shadow economy might have significant environmental consequences, Kahn and Ptaff (2000) emphasized that the difficulties in implementing the laws on environmental protection in the shadow sector is due to the absence of accountability, which enables activities that threaten environmental quality. These activities include artisanal mining, fabric bleaching and dyeing, metal processing, tannery works, brick production, automotive repair, production in small-scale factories and urban transportation with old vehicles. For instance, mercury is used in the artisanal mining of gold, which pollutes the rivers. Similarly, when not eliminated appropriately, the effluents originating from bleaching, dyeing and tanning and include toxic chemicals that pollute the rivers and underground waters (Baksi and Bose, 2010: 2; Biswas et al., 2012: 114). In conclusion, the activities of firms in the shadow sector that do not meet the environmental standards will increase the level of environmental pollution.

As in many developing countries, environmental pollution also threatens environmental sustainability in Turkey and has forced the government to take measures on this subject. Within this context, it is important to determine the sources of pollution in order to reduce environmental pollution. Medina and Schneider (2019) estimated the ratio of the shadow economy to national GDP for the period 1991–2017 was 30.4% for Turkey. Thus, the question that will arise will be, if shadow economy increases will environmental pollution in Turkey also rise? In the present study, in which the main objective is to find an answer to this question, the period between 1991 and 2017 is investigated and, differing from the studies in literature, the Fourier ADL cointegration test introduced by Banerjee et al. (2017) has been employed. The rest of the study is organized as follows. Section 2 incorporates a literature review on the shadow economy and environmental pollution nexus; the data and methodology are explained in Section 3. Empirical findings are given in Section 4 and Section 5 includes the conclusion and suggestions.

2 Literature Review

The reasons for environmental problems expressed under various titles such as environmental degradation, CO_2 emissions, and environmental pollution constitute a wide area of research in the empirical literature. In the vast majority of these studies, it can be seen that these problems were related to macroeconomic variables such as the economic growth/EKC hypothesis (Beyene and Kotosz, 2020), energy consumption (Munir and Riaz, 2020), trade openness (Le et al., 2016), foreign direct investments (Demena and Afesorgbor, 2020), financial

development (Ganda, 2019), and urbanization (Salahuddin et al., 2019). On the other hand, few studies investigated the effect of the shadow economy as a source of environmental pollution. An inverted-U shaped relationship was found between the informal sector size and environmental pollution level by Elgin and Oztunalı (2014) using the Johansen cointegration analysis for Turkey for the period of 1950–2009. Accordingly, environmental pollution is at lower levels in the small and large sizes of the shadow economy, whereas it is at a higher level in the medium size of the shadow economy. Stating that environmental degradation is an important obstacle to the improvement of the quality of life in developing countries, Biswas et al. (2012) investigated how the shadow economy affected environmental pollution in more than 100 countries. According to the panel data analysis performed for the period of 1999–2005, the effect of the shadow economy on the local and global air pollution was positive and the magnitude of this effect depended on the level of corruption. If the level of corruption can be reduced, then the destructive effect of the shadow economy on environmental pollution will also be decreased. As a result of their generalized methods of moments (GMM) estimations for thirty states in China, Chen et al. (2018) determined that the strict environmental regulations and the shadow economy are positively related with China's environmental pollution. By analysing annual data for Turkey between 1970 and 2014, Imamoğlu (2018) sought the answer to the question whether the informal economic activity was a determinant of environmental quality. The results obtained from the time-series analysis carried out for this purpose revealed that the formal/official and informal economic activities in Turkey are an important determinant of environmental quality. Both types of economic activities (formal/informal) increased environmental pollution, but the effect of formal economic activities on the environmental pollution was found to be higher than that of informal economic activities. Canh et al. (2019) examined the effect of several macroeconomic variables, including the effect of the shadow economy on greenhouse emissions. The results obtained from system-GMM panel data analysis during the period 1995–2012, for 106 countries, indicated that the shadow economy increased emissions (N_2O: nitrous oxide emissions and CH_4: methane emissions), excepting CO_2 emissions.

For the period 2002–2015, Huynh (2020) performed an analysis on twenty-two Asian countries by using fixed effects and GMM methods, who reported that air pollution was positively affected by the shadow economy; however, an expansionary fiscal policy, such as increasing the public expenditures and/or reducing the taxes, might reduce the damaging effects of shadow economy on environmental quality. Koksal et al. (2020) analysed the role of shadow economies in the ecological footprint of Turkey using annual time-series data for the

period between 1961 and 2014, and employed the Johansen cointegration test. According to the empirical findings obtained, the shadow economic activities have a long-term and positive effect on the ecological footprint level. In other words, a 1% change in the shadow economic activities results in a 1.998% change in ecological footprint in the same direction. Interpreting these results from an economic aspect, the authors emphasized that shadow economic activities are among the main driving forces of environmental pollution in the long-term in Turkey. Reporting that the shadow economy is one of the key factors affecting the environmental quality, Baloch et al. (2021) tested the effect of shadow economy on the environmental degradation in Pakistan, which is subject to high levels of environmental risks. According to the results of the ARDL bounds test covering the period between 1996 and 2008, considering CO_2 emissions as an indicator of environmental degradation, it was determined that there was a long-term significant cointegration relationship between the shadow economy and CO_2 emissions and that the shadow economy has a statistically significant and positive effect on the CO_2 emissions in both the short- and the long-term. Based on the results obtained, the authors pointed out that the shadow economy in Pakistan triggered the environmental degradation. In their dynamic panel analysis on three states in Northwestern China, Pang et al. (2020) found that there was a positive and significant mutual relationship between the shadow economy and pollution levels. Accordingly, a 1% increase in the shadow economy resulted in a 0.78% increase in environmental pollution and a 1% increase in the pollution level increased the shadow economy by 0.06%. Finally, in their analysis on thirty-one states in China, Pang et al. (2021) concluded that, as reported in Pang et al. (2020), there was a positive interplay between the shadow economy and pollution levels. They pointed out that one unit increase in shadow economy resulted in a 35% increase in the pollution level, and one unit increase in the pollution level increased the shadow economy by 0.018‰.

3 Data and Methodology

3.1. Data

In the present study, we examine whether the shadow economy increases environmental pollution in Turkey. For this purpose, the annual dataset covering the period between 1991 and 2017 was used. In the estimation model, besides CO_2 emissions and the shadow economy which are the main variables, control variables such as financial development, energy consumption, and economic growth, which are reported in literature to have significant effects on the

environmental pollution, were included. The model created for the empirical analysis is shown in Eq. (1):

$$\ln CO_2 = \beta_0 + \beta_1 lnSE_t + \beta_2 lnFD_t + \beta_3 lnGDPpc_t + \beta_4 lnEC_t + \mu_t \quad (1)$$

In Eq. (1), carbon dioxide emissions (CO_2: metric tons per capita) were used as an indicator of environmental pollution. SE (shadow economy as a percentage of GDP) refers to the size of shadow economy, whereas FD (financial development index), EC (tons of oil equivalent per capita), and GDPpc (GDP per capita, constant 2010 US$) refer to financial development levels, primary energy consumption, and economic growth, respectively; μ_t is the regression error term. CO_2 emissions and GDPpc data were obtained from World Bank Development Indicators (World Bank, 2021), whereas FD data was obtained from the Financial Development Index database (IMF, 2021), SE data was obtained from Medina and Schneider (2019) and EC data from Ministry of Environment and Urbanization of Turkish Republic. In the model, in which the natural logarithmic values of all the variables were used in order to achieve more efficient and reliable results, β_1, β_2, β_3, and β_4 refer to the long-term coefficients of the shadow economy, financial development, economic growth, and energy consumption, respectively. The sign of β_1 is expected to be positive. It means that an increase in the level of shadow economy would increase the environmental pollution, because operating illegally allows firms to avoid the environmental regulation policies (Huynh, 2020: 370). The sign of β_2 is also expected to be positive. Financial development increases pollution by increasing the sales and consumption of energy-consuming products and by increasing credit opportunities, in addition to increasing energy consumption by pioneering an increase in investment (Gyamfi et al., 2020: 94). Finally, the signs of β_3 and β_4 are also expected to be positive because the increase in energy consumption together with economic growth stimulates CO_2 emissions and increases pollution (Pao and Tsai, 2011: 687).

3.2. Methodology

A three-step estimation strategy was followed in the empirical analysis. In the first step, the integration levels of variables were determined using standard ADF and Fourier ADF unit root tests. In the second step, the long-term relationship between the variables was investigated using the Fourier ADL cointegration test, which was developed by Banerjee et al. (2017). In the final step, fully modified

ordinary least squares (FMOLS) and canonical cointegrating regression (CCR) methods were used to obtain long-term coefficients.

3.2.1. Fourier ADF Unit Root Test

Citing the seminal study of Perron (1989), Becker et al. (2006) showed that the number, duration, and form of macroeconomic variables might show various unknown structural breaks and, thus, the unit root tests might be invalid in cases where these structural breaks were wrongly modeled or ignored during the data creation process. In parallel with this, the unit root tests considering the structural breaks and effects were developed in the time-series literature. The tests recommended by Zivot and Andrews (1992), Lumsdaine and Papell (1997), and Lee and Strazicich (2003) can be given as examples. However, these tests employ dummy variables in order to detect the structural changes (breaks) in a series and, thus, they have several disadvantages, such as detecting only the sharp breaks and pre-determining the number of breaks (*Yilancı et al., 2020: 52*). In order to overcome these problems, the unit root tests involving the Fourier functions in the estimation model perform better in detecting the multiple smooth breaks besides the sharp ones in the series were introduced (see Becker et al., 2006; Christopoulos and León-Ledesma, 2010; Enders and Lee, 2012). In this study, the Fourier ADF (FADF) unit root test proposed by Christopoulos and León-Ledesma (2010) is used to test the stationarity of the series. In the first step of the test, performed by following a three-step procedure, the following Eq. (2) is estimated:[2]

$$y_t = \alpha_0 + \alpha_1 sin\left(\frac{2\pi kt}{T}\right) + \alpha_2 cos\left(\frac{2\pi kt}{T}\right) + v_t \qquad (2)$$

where a_1 and a_2 are the coefficients of trigonometric terms (*sin.* and *cos.*), whereas t is a trend term and T is sample size and $\pi = 3.1416$, k is the number of frequencies of the Fourier function and its real value cannot be foreknown. Since FADF test statistics vary depending on the value of k, the optimal k *(k*)* should be found first. For this purpose, Eq. (2) is estimated for every k integer in the range of [1–5] and the k yielding the smallest residual sum of squares (RSS) is chosen as the k^*. Then, using the k^* the OLS residuals of Eq. (2) are obtained:

2 FADF unit root test's methodology is explained by making use of Christopoulos and León-Ledesma (2010).

$$v_t = y_t - \alpha_0 + \alpha_1 sin\left(\frac{2\pi k^* t}{T}\right) + \alpha_2 cos\left(\frac{2\pi k^* t}{T}\right) \quad (3)$$

In the second step, the unit root test is applied to the OLS residuals (v_t) obtained in the first step:

$$\Delta v_t = \gamma_1 v_{t-1} + \sum_{j=1}^{p} \delta_j \Delta v_{t-j} + \mu_t \quad (4)$$

Eq. (4) is a standard/linear ADF regression. The ADF test applied to OLS residuals is named the FADF test. In this test, by using the standard t-test, the null hypothesis of unit root $H_0 : \gamma_1 = 0$ is tested against the alternative hypothesis $H_1 : \gamma_1 \neq 0$. The critical values for different *k* values can be found in Christopoulos and León-Ledesma (2010).

If the null hypothesis is rejected in the second step, then the third step testing, if the trigonometric terms are significant or not, is initiated. Here, the null hypothesis of the insignificance of trigonometric terms $H_0 : a_1 = a_2 = 0$ is tested against the alternative hypothesis $H_1 : a_1 = a_2 \neq 0$ by using the conventional F-test. If the null hypothesis is rejected, the FADF test is a suitable method for investigating the stationarity. Otherwise, the standard ADF test should be used (Furuoka, 2014: 38). The critical values for F-test are available in Beckers et al. (2006).

3.2.2. Fourier ADL Cointegration Test

According to Banerjee et al. (2017), ignoring the structural breaks in time-series analysis, especially in cointegration approaches, yields incorrect results in estimating the cointegration between the variables. On the other hand, although there are many cointegration tests that consider structural breaks, such as Gregory-Hansen (1996), Hatemi-J (2008), and Maki (2012), in the literature these traditional tests with dummy variables can only capture the sharp breaks. However, the effects of structural change can be gradual and they might not be accurately detected by the dummy variables. On the contrary, the Fourier approach, not requiring foreknowing the number and form of breaks accurately, detects the unknown types of structural breaks (both sharp and smooth) in a series. At this point, Banerjee et al. (2017) developed a cointegration test based on the Autoregressive Distributive Lag (ADL) model incorporating a Fourier

function in the deterministic term. Banerjee et al. (2017) used the following model in defining the Fourier ADL (FADL) test procedure:

$$\Delta y_{1t} = d(t) + \delta_1 y_{1,t-1} + \gamma' y_{2,t-1} + \varphi' \Delta y_{2t} + \varepsilon_t \tag{5}$$

where d(*t*) refers to the deterministic term defined using the Fourier approach and is expressed as follows:

$$d(t) = \gamma_0 + \sum_{k=1}^{q} \sigma_{1,k} \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^{q} \sigma_{2,k} \cos\left(\frac{2\pi kt}{T}\right), \qquad q \leq T/2 \tag{6}$$

In Eq. (6), k is a specific number of frequencies and its value is determined by selecting the number of frequencies yielding the minimum RSS, q shows the number of frequencies in the estimation, while T is the number of observations. The null hypothesis asserting that there is no cointegration (H_0: $\delta_1=0$) is tested against the alternative hypothesis emphasizing the presence of cointegration (H_1: $\delta_1<0$). If the calculated $\left(t_{ADL}^{F}\right)$ statistic is greater than the critical values,[3] then the null hypothesis is rejected and the conclusion is that there is a cointegration relationship between the variables.

4 Empirical Findings

Before the cointegration test, the integration levels of variables should be determined first. For this reason, the results obtained using FADF and ADF unit root tests in the analysis are presented in Tab. 1. The results of both tests indicate that the variables are not stationary at level. In addition, according to the tests repeated after taking the first differences of variables, all the variables become stationary.[4] After determining that the variables are integrated of order one, the

3 In the FADL test, Banerjee et al. (2017) provide the critical values for a maximum of three regressors. In this study, since a 4-regressor model is estimated in the FADL cointegration test, the critical values calculated by Hepsag (2020) for 4- and 5-regressor FADL model were used in comparing the $\left(t_{ADL}^{F}\right)$ statistics.

4 Since it was determined in the FADF test that trigonometric terms were insignificant, the decision that variables were stationary at the first difference was made, considering the results of the standart ADF test.

FADL cointegration test was applied, and the results are presented in Tab. 2. It can be seen that the calculated $\left(t_{ADL}^{F}\right)$ statistics is greater than the critical value at the statistical significance level of 1%. Based on this result, the null hypothesis was rejected and it was decided that there is a statistically significant long-term relationship between CO_2 emissions, SE, FD, GDPpc, and EC.

Tab. 1: *FADF and ADF Unit Root Test Results*

Series	**MinSSR**	$\left(\hat{k}\right)$	**FADF**	**F(k)**	**ADF**	**Result**
$\ln CO_2$	0.5714	1	-0.1330 (0)		-1.6175 (0)	Nonstationary
lnSE	0.0813	1	-3.0548 (0)		-1.6846 (0)	Nonstationary
lnFD	2.0745	1	-2.1902 (0)		-0.3186 (3)	Nonstationary
lnGDPpc	0.6234	1	-1.2274 (0)		0.3387 (0)	Nonstationary
lnEC	0.3897	1	-1.2274 (0)		-0.3608 (0)	Nonstationary
$\Delta\ln CO_2$	0.1235	5	-3.7931 (0)***	1.9081	-3.0804 (0)**	Stationary
ΔlnSE	0.0457	3	-6.5134 (0)***	1.9952	-5.4361 (0)***	Stationary
ΔlnFD	0.4075	1	-4.1547 (6)**	2.5013	-3.8288 (0)***	Stationary
ΔlnGDPpc	0.0420	4	-6.0812 (0)***	2.7561	-5.0657 (0)***	Stationary
ΔlnEC	0.0382	3	-6.1668 (1)***	1.0393	-5.5112 (0)***	Stationary

*** and ** denote p<0.01 and p<0.05, respectively. The critical values for the F-test/F(k) are 6.730 (1%), 4.929 (5%), ad 4.133 (10%), respectively. The critical values for the FADF test (k=1) are -4.43 (1%), -3.85 (5%), and -3.52 (10%), respectively. Maximum lag is 6. Schwarz information criterion is used to determine the optimal lag.

Tab. 2: *FADL Cointegration Test Results*

$\left(t_{ADL}^{F}\right)$ **statistics**	**Frequency** $\left(\hat{k}\right)$	**Min_AIC**	**Conclusion**
-6.8359***	3	-4.0661	Cointegration

*** denotes p<0.01. The critical value for the $\left(t_{ADL}^{F}\right)$ is -5.147 (k=3) at the significance level of 1%.

Due to the existence of a cointegration relationship between the variables, we estimated the long-term coefficients of SE and the control variables by using FMOLS and CCR estimators and we report the results in Tab. 3. The results from the two estimators support each other. While the coefficients of financial

development and energy consumption added into the model as control variables are positive, and significant as expected, the coefficient of economic growth is positive but non-significant. Thus, it can be stated that an increase in Turkey's financial development level, especially in energy consumption, increases CO_2 emissions and, consequently, environmental pollution in the long-term. Considering the results within the scope of main subject of the present study, it can be seen that the coefficient of the shadow economy is positive and significant. Such that, 1% increase in the shadow economy increases the CO_2 emissions by 0.367% and 0.515% according to FMOLS and CCR estimators, respectively. This result, which suggests that the shadow economy is an important source of environmental pollution in Turkey in the long-term, is consistent with the findings reported by Koksal et al. (2020), Huynh (2020) and Baloch et al. (2021).

Tab. 3: *Long-Term Coefficient Estimation Results*

Estimation model: $lnCO_2 = f$ (lnSE, lnFD, lnGDPpc, lnEC)						
	FMOLS estimation			**CCR estimation**		
Variables	**coefficient**	**t-statistics**	**p-value**	**coefficient**	**t-statistics**	**p-value**
lnSE	0.3678**	2.1010	0.0492	0.5152**	2.2859	0.0339
lnFD	0.0769*	2.0806	0.0512	0.0805**	2.1477	0.0448
lnGDPpc	0.1262	0.5306	0.6018	0.1125	0.4516	0.6566
lnEC	0.9327***	3.3241	0.0036	1.0277***	3.4713	0.0026
constant	-1.6114	-0.7647	0.4538	-2.0207	-0.9190	0.3696
sin	0.0023	0.2289	0.8214	0.0057	0.5480	0.5900
cos	0.0176	1.4069	0.1756	0.0181	1.5246	0.1438

***, **, and * denote $p<0.01$, $p<0.05$, and $p<0.10$, respectively.

5 Conclusion and Suggestions

The present study investigates whether the shadow economy increases environmental pollution in Turkey. The empirical analysis covering the period between 1991 and 2017 was conducted in three steps. In the first step, the stationarity levels of the variables were investigated using the unit root tests. In the second step, by making use of the Fourier ADL cointegration test proposed by Banerjee et al. (2017), the long-term relationship between the variables was examined. And, in the final step, long-term coefficients were estimated using FMOLS and CCR approaches. The results of cointegration analysis indicated that there is a statistically significant long-term relationship between the shadow economy and

environmental pollution in Turkey. Furthermore, given the long-term coefficient estimations, the shadow economy has had, as expected, a positive and significant effect on the CO_2 emissions identified as an indicator of environmental pollution (the coefficient of the shadow economy according to FMOLS and CCR estimators are 0.367 and 0.515, respectively). Empirical results also showed that financial development and energy consumption stimulated environmental pollution and the effect of economic growth was positive, but statistically non-significant. Based on the empirical results demonstrating that the shadow economy increases environmental pollution, it can be stated that the policies addressing a reduction in the environmental pollution in Turkey should also include measures aimed at decreasing the size of the shadow economy. These measures will not only alleviate the destructive impact of the shadow economy on environmental pollution, they will also reduce the negative effects on macroeconomic indicators such as tax revenues, budget deficits, etc.

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