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An analysis of the Pollution Haven Hypothesis in the context of Turkey: A nonlinear approach[1]

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Abstract: Foreign direct investment (FDI) is an important driver of countries' economic development. Factors such as looser environmental regulations may cause dirty FDI to flow mainly to developing countries. This is explained by the Pollution Haven Hypothesis. The paper aims to investigate whether the Pollution Haven Hypothesis is valid in Turkey using the nonlinear autoregressive distributed lag (NARDL) approach for the period 1974–2017. The results show that FDI inflows and carbon emissions have asymmetric effects in both the short and long term for Turkey, supporting the Pollution Haven Hypothesis. Furthermore, there is a link between carbon emissions and trade openness, manufacturing and economic growth. Policymakers should develop the policies necessary to transfer clean technologies to Turkey by providing improvements and technical advances for a more efficient energy use.

Keywords: Pollution Haven Hypothesis, foreign direct investments (FDI), emissions, nonlinear autoregressive distributed lag model, Turkey.

JEL codes: C33, E1, Q52.

Introduction

The environmental impact of international trade is one of the critical issues of trade policy. The Pollution Haven Hypothesis is an important issue examined in the literature on countries' international trade policies and their effects on the environment. The hypothesis links environmental regulations to country differences in international trade flows. The Pollution Haven Hypothesis suggests that pollution-intensive production will move from countries with high income

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and stricter environmental regulations to low-income countries that place little emphasis on environmental regulation. The hypothesis states that this international movement depends on the absence of trade barriers (Taylor, 2004). The Pollution Haven Hypothesis implies that the pollution-intensive industries of developed countries move to developing countries through foreign direct investment. Thus these countries will be in a worse environmental situation (Gill, Viswanathan, & Abdul Karim, 2018). The main point of the hypothesis is that dirty industries damage the environment and its valuable resources that need to be protected by environmental policies (Zaman & Abd-el Moemen, 2017).

Foreign direct investments play an essential role in developing economies that do not have sufficient capital for investment (Gokmenoglu & Taspinar, 2016). Foreign direct investment inflows are an essential tool for developing countries with resource problems to finance high-cost investments (Destek & Okumus, 2019). Foreign direct investments contribute to capital formation in developed and developing countries that aim for long-term growth (Iamsiraroj, 2016; Ben-Salha & Zmami, 2020). They have an important impact on many factors such as providing financial resources, human capital formation, the development of markets, international trade integration, research and development, labour force and macroeconomic indicators (Bayraktar, 2013; Opoku & Boachie, 2020). In addition to economic development benefits environmental problems can also be created in countries with low environmental regulations that attract foreign investments with cheap resources (Zheng & Sheng, 2017). Industrialisation and foreign direct investments can increase carbon emissions and thus have a negative impact on the environment. The Pollution Haven Hypothesis partially explains why foreign direct investment flows from developed countries to developing countries. Environmental regulations in developing countries may be looser, leading to dirty production in these countries (Balsalobre-Lorente, Gokmenoglu, Taspinar, & Cantos-Cantos, 2019; Akbostanci, Ipek Tunc, & Turut-Asik, 2007).

There is an increasing trend in industrialisation and economic growth among developing countries with foreign direct investment increasing towards the 1990s (Akbostanci et al., 2007). After the 1980s the liberalisation of financial markets and international trade policies played an important role in economic growth in Turkey. After the Customs Union agreement signed by Turkey in 1995 and implemented in 1996 it can be said that relatively clean exports have tended to increase compared to dirty exports (Akbostanci, Ipek Tunc, & Turut-Asik, 2008). Multinational companies also have a significant share in the increase in investments in dirty industries in Turkey (Sat, 2016).

The increase in energy demand caused by fossil fuels in the last five years constituted the highest share of energy demand in 2018. The world's carbon dioxide (CO_2) emissions have increased by 2% in the last seven years. When the period between 2007 and 2017 is studied it can be seen that the rate of CO_2 emissions averaged 3.6% in Turkey. This is above the world average of 1% (BP

Statistical Review of World Energy, 2019). With Turkey's increase in gross domestic product from 2000 to 2018, its population increase of 27% an increase in CO_2 emissions has arisen (IEA, 2021). Compared to 2008 emissions from the manufacturing and the trade and services sectors had increased by approximately 19% and 6%, respectively, in 2016 (IEA, 2016).

A carbon tax can be applied according to the carbon produced by products or the content of fossil fuels. The purpose of this tax is to reduce carbon dioxide emissions (Assuncao & Zhang, 2002). Governments must take measures at the national level so that businesses and consumers demand products that are not harmful to the environment. Financing and technological cooperation between developing and developed countries are essential factors in reducing emissions (WTO/UNEP, 2009; Chmielewska & Sławiński, 2021). Although Turkey is taking steps to reduce emissions it has no carbon tax as yet. The National Climate Change Adaptation Strategy and Action Plan 2011–2023 emphasises the reduction of CO_2 emissions in the industrial sector in Turkey. It does so through various activities, such as access to financial tools, supporting low carbon intensity, developing financing models for the transition to low-carbon development and R&D activities (Çevre ve Şehircilik Bakanlığı, 2012).

This paper investigates the relationship between foreign direct investments and carbon dioxide emissions in Turkey in the years 1974–2017. The effects of negative and positive shocks of foreign direct investments on carbon dioxide emissions are investigated using the NARDL approach. Thus whether foreign direct investments are responsible for environmental pollution will be revealed within the framework of the Pollution Haven Hypothesis. This study contributes to the empirical literature by focusing on Turkey within developing countries and using the NARDL model that accounts for asymmetric effects. Foreign direct investments and international trade can indirectly affect CO_2 emissions by promoting economic growth (Huang, Chen, Zhu, Huang, & Tian, 2019). At the same time this study is important for Turkey in terms of revealing the impact of manufacturing and trade openness on carbon dioxide emissions. The study also contributes to the empirical literature by including these factors in the analysis.

The paper is structured as follows. The first section presents the literature review. The second section depicts data and methodology. The third section discusses results of the study. The last section presents concluding remarks.

1. Literature review

There are many studies in the literature examining the relationship between foreign direct investments and CO_2 emissions. Table 1 presents brief literature on the relationship between foreign direct investments and carbon emissions. Some of these studies have suggested that the relationship between foreign direct investment and CO_2 emissions is positive (Lee, 2013; Kivyiro & Arminen, 2014; Solarin, Al-Mulali, Musah, & Ozturk, 2017; Sun, Zhang, & Xu, 2017; Gür, 2019; Isiksal, Samour, & Resatoglu, 2019; Shao, Wang, Zhou, & Balogh, 2019; Huang et al., 2019; Ozturk & Saygin, 2020). However, other studies have shown a negative relationship between foreign direct investments and CO_2 emissions (Pao & Tsai, 2011; Sbia, Shahbaz, & Helmi, 2014; Akın, 2014; Tang & Tan, 2015; Neequaye & Oladi, 2015; Doytch & Uctum, 2016; Zhu, Duan, Guo, & Yu, 2016; Sung, Song, & Park, 2018). The other group of studies have obtained mixed results (Ur Rahman, Chongbo, & Ahmad, 2019; Ansari, Khan, & Ganaie, 2019; Dhrifi, Jaziri, & Alnahdi, 2020).

Panel data approaches are mostly preferred in studies where different country groups are examined within the Pollution Haven Hypothesis's scope in the literature. Al-Mulali and Tang (2013) examine whether the Pollution Haven Hypothesis is valid within the Gulf Cooperation Council's scope from 1980 to 2009. The Granger causality analysis results conclude that there is no causality between foreign direct investments and CO_2 or energy consumption in the short term. On the contrary they find that energy consumption and gross domestic product growth positively correlate with CO_2. Sapkota and Bastola (2017) examine the impact of foreign direct investment on pollution for Latin American countries within the scope of the Pollution Haven Hypothesis and the Environmental Kuznets Curve hypothesis. As a result of the panel fixed and random effects models it is seen that the Pollution Haven Hypothesis is valid for Latin American countries. The results of the panel VAR model and causality approaches used by Bakirtas and Cetin (2017) for MIKTA countries (Mexico, Indonesia, South Korea, Turkey and Australia) within the period of 1982–2011 show one-way causality from foreign direct investments to CO_2 emissions. Kathuria (2018) tests whether the Pollution Haven Hypothesis is valid for India's different regions between 2002 and 2010. The results of the pooled ordinary least squares (OLS) estimates do not support the Pollution Haven Hypothesis. Ayadi, Mlanga, Ikpor and Nnachi (2019) conclude that past periods of foreign direct investments are a determinant of current foreign direct investments in the short and long term for Nigeria. The results support the validity of the Pollution Haven Hypothesis for Nigeria.

In studies examining countries in different income groups, there are differences in the results. Hoffmann, Lee, Ramasamy, and Yeung (2005) state that the Pollution Haven Hypothesis is not valid for middle- and high-income countries. They conclude that CO_2 causes foreign direct investments for low-income countries; on the other hand they conclude that foreign direct investments cause CO_2 emissions for middle-income countries. There is no evidence of Granger causality between foreign direct investments and CO_2 emissions for high-income countries. Shahbaz, Nasreen, Abbas, and Anis (2015) state a long-term relationship between CO_2 emissions, foreign direct investments, economic growth and energy consumption as the results of Pedroni and Johansen Fisher panel cointegration tests. They emphasise that foreign direct investments reduce CO_2 emissions for high-income countries due to fully modified ordinary least squares (FMOLS); their results for low-income countries do not support these findings. For middle-income countries there is an inverse U-shaped relationship between foreign direct investments and CO_2 emissions.

Many studies using panel data approaches for ASEAN countries have reached different findings. Rasit and Aralas (2017) examine OECD and ASEAN countries in the period 2000–2010 in their study. Pooled OLS estimates show that the Pollution Haven Hypothesis is not valid in the study. There are studies in the literature for MINT countries, and these studies find the Pollution Haven Hypothesis is invalid (Balsalobre-Lorente et al., 2019). Shao and others (2019) examine BRICS as well as MINT with Johansen Fisher, Pedroni and Kao panel cointegration tests and obtain similar findings. Furthermore they conclude that CO_2 emissions affects foreign direct investments in the short term.

Table 1. Summary of studies examining the effect of Foreign Direct Investments (FDI) on CO_2

Author(s)	Period	Country/group	Method	Relationship
FDI—CO_2 (Positive)				
Ozturk & Saygin (2020)	1974–2016	Turkey	ARDL, Toda Yamamoto causality	Positive
Gür (2019)	1990–2017	Turkey	Fully ordinary least square (FMOLS)	Positive
Isiksal et al. (2019)	1980–2014	Turkey	ARDL, Hatemi J cointegration, Granger causality	Positive
Shao et al. (2019)	1982–2014	BRICS, MINT	Johansen Fisher panel cointegration, Granger causality	Positive
Huang et al. (2019)	1997–2014	China	Panel quantile regression	Positive
Sun et al. (2017)	1980–2012	China	ARDL	Positive
Solarin et al. (2017)	1980–2012	Ghana	ARDL	Positive
Kivyiro & Arminen (2014)	1971–2009	6 sub-Saharan Africa countries	ARDL, Granger causality	Positive
Lee (2013)	1971–2009	G20 countries	Johansen Fisher cointegration,	Positive

Author(s)	Period	Country/group	Method	Relationship
FDI—CO_2 (Negative)				
Sung et al. (2018)	2002–2015	China	System GMM estimation	Negative
Zhu et al. (2016)	1981- 2011	ASEAN-5	Fixed effect panel quantile regresion	Negative
Doytch & Uctum (2016)	1984–2011	148 countries	Panel GMM	Negative
Neequaye & Oladi (2015)	2002–2008	27 countries	Panel fixed effect model	Negative
Tang & Tan (2015)	1976–2009	Vietnam	Johansen cointegration, Granger causality	Negative
Sbia et al. (2014)	1975–2011	United Arab Emirates	Vector error correction model (VECM)	Negative
Pao & Tsai (2011)	1992–2007	BRIC	Panel VECM	Negative
FDI—CO_2 (Mixed)				
Ansari et al. (2019)	1994–2014	29 countries	Pedroni cointegration, fully modified OLS	East Asia (positive) Southeast Asia (negative)
Ur Rahman et al. (2019)	1975–2016	Pakistan	NARDL	Positive (FDI positive) Negative (FDI negative)

Source: Authors' preparation.

Foreign direct investment—CO_2 emissions in Turkey

The studies in the literature that examine the relationship between foreign direct investment inflows and carbon emissions in Turkey generally assume that this relationship is linear. In these studies approaches such as the autoregressive distributed lag (ARDL), Johansen cointegration, Maki cointegration, Granger causality and Toda-Yamamoto causality are used, and they show that the Pollution Haven Hypothesis is valid (Mutafoglu, 2012; Balibey, 2015; Gokmenoglu & Taspinar, 2016; Kaya, Kayalica, Kumaş, & Ulengin, 2017; Kılıçarslan & Dumrul, 2017; Kocak & Sarkgünesi, 2018; Terzi & Pata, 2019; Udemba, 2020).

Kaya and others (2017) find that foreign direct investments and trade openness positively affect CO_2 emissions in the long run. Yıldırım, Destek and Özsoy (2017) examine the validity of the Pollution Haven Hypothesis for Turkey with ARDL and Granger causality approaches in the 1974–2013 period. They conclude that increasing real national income reduces CO_2 emissions, while energy consumption and foreign direct investments increase CO_2 emissions. According to the results of the causality approach, it is seen that there is bidirectional causality between energy consumption and CO_2 emissions. Ozatac, Gokmenoglu and Taspinar (2017) conclude that trade openness positively affects CO_2 emissions for Turkey covering the period 1960–2013. Gür (2019) suggests that foreign direct investments positively affect CO_2 emissions in the long run. In addition, the results show that the short run effect is also positive and is greater that in the long run. Ozturk and Saygin (2020) reach a conclusion that foreign direct investments have a positive effect on CO_2 emissions. Şahin, Gökdemir and Ayyıldız (2019) examine the Pollution Haven and Pollution Halo hypotheses for Turkey between 1990 and 2015. The findings of their study support the Pollution Haven Hypothesis.

However, some of the studies using the linear ARDL approach to examine the relationship between foreign direct investments in Turkey and CO_2 emissions have concluded that the Pollution Haven Hypothesis is not valid (Üzar, 2019; Bulut, 2021). Likewise, Mert and Caglar (2020) also concluded that the Pollution Haven Hypothesis is not valid in Turkey. As a result of the hidden cointegration approach the authors show an asymmetric causality relationship between positive shocks of foreign direct investments and positive movements in emissions in the short run as well as an asymmetric causality relationship between positive and negative shocks of foreign direct investments and positive emissions in the long run.

2. Data and methodology

In this study carbon dioxide emission (CO_2), gross domestic product (GDP), the ratio of the total exports and imports to the gross domestic product (TRADE), the ratio of manufacturing to gross domestic product (MANUFACTURING) and foreign direct investments, net inflows % of gdp (FDI) variables are used. Positive and negative shocks of the foreign direct investment variable are included as two additional variables in the model. The data are determined as the period between 1974 and 2017 for Turkey. The study's data are obtained from the World Bank and International Energy Agency databases. The natural logarithms of all variables were considered.

2.1. Nonlinearity ARDL approach

The ARDL approach allows testing of short- and long-term asymmetries between variables. Nonlinear models can be examined by NARDL analysis. Shin, Yu and Greenwood-Nimmo (2014) introduce the NARDL approach to examine the explanatory variables' positive and negative shocks. The NARDL approach, based on the linear ARDL model, can be applied regardless of whether the series examines I(0) or I(1). However if the unit root test results are I(2), the NARDL approach cannot be applied (Ibrahim, 2015; Bahmani-Oskooee & Saha, 2018). The NARDL model is estimated with the ordinary least squares (OLS) approach (Bildirici & Türkmen, 2015; Yacouba & Altintas, 2019). The asymmetric long-run regression is formed as follows in order to examine the effects of negative and positive changes in foreign direct investments on carbon emissions.

$$LCO2_t = \alpha + \delta_1 LFDI_t^- + \delta_2 LFDI_t^+ + \varepsilon_t \tag{1}$$

δ_1 and δ_2 are the long-run parameters, and $LFDI_t^-$ and $LFDI_t^+$ express negative and positive shocks in equation (1). The asymmetric cointegration model, which has all variables, is shown below.

$$\begin{aligned} LCO2_t = {} & \alpha_0 + \alpha_1 LFDI_t^- + \alpha_2 LFDI_t^+ + \alpha_3 LMANUFACTURING_t + \\ & + \alpha_4 LTRADE_t + \alpha_5 LGDP_t + \mu_t \end{aligned} \tag{2}$$

μ_t denotes the error term and α_0 is the constant term in equation (2). $LFDI_t$ is included as two separate variables to indicate the negative shocks ($LFDI_t^-$) and positive shocks ($LFDI_t^+$) of foreign direct investments in the model. $LFDI_t^-$ and $LFDI_t^+$ can be obtained to take negative and positive partial sums as in equations (3) and (4), respectively.

$$LFDI_t^- = \sum_{j=1}^{t} \Delta LFDI_t^- = \sum_{j=1}^{t} \min(\Delta LFDI_j^-, 0) \tag{3}$$

$$LFDI_t^+ = \sum_{j=1}^{t} \Delta LFDI_t^+ = \sum_{j=1}^{t} \max(\Delta LFDI_j^+, 0) \tag{4}$$

The NARDL model is constructed using equation (2) and shown in equation (5). This model aims to examine the effect of foreign direct investments symmetrically or asymmetrically on carbon dioxide emissions.

$$\begin{aligned} \Delta LCO2_t = {} & \omega_0 + \sum_{i=1}^{p} \beta_i \Delta LCO2_{t-i} + \sum_{i=0}^{p} \partial_i \Delta LTRADE_{t-i} + \\ & + \sum_{i=0}^{p} \gamma_i \Delta LMANUFACTURING_{t-i} + \sum_{i=0}^{p} \delta_i \Delta LGDP_{t-i} + \\ & + \sum_{i=0}^{p} (\theta_i^- \Delta LFDI_{t-i}^- + \theta_i^+ \Delta LFDI_{t-i}^+) + \\ & + \varphi_1 LCO2_{t-1} + \varphi_2 LFDI_{t-1}^- + \varphi_3 LFDI_{t-1}^+ + \\ & + \varphi_4 LMANUFACTURING_{t-1} + \varphi_5 LTRADE_{t-1} + \varphi_6 LGDP_{t-1} + e_t \end{aligned} \tag{5}$$

β_i, ∂_i, γ_i, and δ_i are short term coefficients; φ_1, φ_2, φ_3, φ_4, φ_5, and φ_6 represent long term coefficients in the NARDL model. The cointegration relationship between the variables is examined with the F test using this equation. The error correction model with short dynamics is shown in equation (6).

$$\Delta LCO2_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta LCO2_{t-i} + \sum_{i=0}^{p} \partial_i \Delta LTRADE_{t-i} + \\ + \sum_{i=0}^{p} \gamma_i \Delta LMANUFACTURING_{t-i} + \sum_{i=0}^{p} \delta_i \Delta LGDP_{t-i} + \\ + \sum_{i=0}^{p} (\theta_i^- \Delta LFDI_{t-i}^- + \theta_i^+ \Delta LFDI_{t-i}^+) + \nu_t \quad (6)$$

After estimating equation (5) with the OLS method, the asymmetric effect of foreign direct investments on carbon dioxide emissions is tested for the short and long term using the Wald test. The null hypothesis $H_0 : \frac{-\theta_i^-}{\beta_i} = \frac{-\theta_i^+}{\beta_i}$ states an asymmetrical relationship between foreign direct investments and carbon dioxide emissions in the short term. In the long term, the null hypothesis is established as $H_0 : \frac{-\varphi_2}{\varphi_1} = \frac{-\varphi_3}{\varphi_1}$ to test this relationship between variables. $\sum_{i=0}^{p} \theta_i^+$ indicates the short-run effects of increases in foreign direct investment on carbon emissions, while $\sum_{i=0}^{p} \theta_i^-$ measures the short-term effects of decreases in foreign direct investment on carbon emissions.

2.2. Brock, Dechert, and Scheinkman (BDS) test

The BDS test is one of the most commonly preferred tests in nonlinearity. The test statistics developed by Brock, Dechert, and Scheinkman (1987) is as follows:

$$V_{m,\varepsilon} = \sqrt{T} \frac{C_{m,\varepsilon} - C(\varepsilon)^m}{S_{m,\varepsilon}} \quad (7)$$

$S_{m,\varepsilon}$ is expressed as the standard error of $\sqrt{T} C_{m,\varepsilon} - C(\varepsilon)^m$ and is also a consistent estimator (Caporale, Ntantamis, Pantelidis, & Pittis, 2005). In the BDS test, which is considered a nonlinearity test, x_t means that a T-length observation sequence is independently and identically distributed. The correlation dimension $C_{m,T}(\varepsilon)$ at dimension m is defined as in equation (7) (De Graaff, Florax, & Nijkamp, 2001).

$$C_{m,T}(\varepsilon) = \sum_{t<s} I_\varepsilon (x_t^m, x_s^m) \left[\frac{2}{T_m (T_m - 1)} \right] \quad (8)$$

If the significance level is smaller than the test statistics, the null hypothesis based on the linearity of the series will be rejected. In other words it means the series is not linear (Weng, Chang, & Lee, 2008). The BDS test statistics converge to the N(0,1) distribution. The test statistics have a significant advantage because they do not have any distribution assumptions. Detailed information about the test can be found in the study of Brock, Scheinkman, Dechert and LeBaron (1996).

3. Results

It is necessary to test whether the series contains a unit root before analyzing the time series and unit root tests are important for the true analysis. The study examines the series' unit root tests through Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) unit root tests and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationary test. ADF and PP unit root test results show that the null hypothesis is not rejected, which means that the variables' levels have a unit root. The null hypothesis which means that the series is stationary is rejected at the 5% and 10% significance levels in the KPSS tests. The first differences of all variables are stationary at a 1% significance level according to the ADF and PP unit root tests in Table 2. The test results also show that the series is stationary when the first difference is taken.

Table 2. Results of ADF, PP and KPSS Unit Root Tests

Variables	Level			First difference		
	ADF	PP	KPSS	ADF	PP	KPSS
LC02	–0.69	–0.80	0.84***	–7.01***	–7.61***	0.12
LFDI	–1.76	–1.47	0.74***	–9.23***	–10.23***	0.08
LGDP	0.47	0.51	0.84***	–6.28***	–6.27***	0.09
LMANUFACTURING	–1.64	–1.61	0.18**	–7.32***	–7.35***	0.22
LTRADE	–1.43	1.44	0.68**	–4.78***	–5.61***	0.08

Note: ***, ** significance at the 1%, 5% level. In the ADF and PP unit root tests, the null hypothesis expresses the existence of a unit root, that is, it is not stationary, while in the KPSS test, the null hypothesis expresses that there is no unit root, that is, stationary.

Source: Authors' estimation.

Tests such as BDS can be used to determine whether a series is linear. The series' BDS test results are given in Table 3. According to the results, all variables are nonlinear at a 1% significance level. A nonlinear ARDL approach is used because the series is not linear.

Table 3. BDS non-linearity test results

Variables	*m* = 2	*m* = 3	*m* = 4	*m* = 5	*m* = 6
LC02	28.70***	29.95***	31.83***	34.93***	39.50***
LFDI	13.11***	13.76***	14.92***	16.19***	17.46***
LGDP	27.07***	28.65***	30.50***	33.35***	37.48***
LMANUFACTURING	17.55***	18.07***	18.21***	18.50***	18.65***
LTRADE	11.82***	12.58***	13.30***	14.35***	15.77***

Note: *** significance at the 1% level.

Source: Authors' estimation.

Cointegration analysis and Wald test statistics results are given in Table 4. According to the F test result, the null hypothesis, which means no cointegration among the CO_2, FDI, GDP, MANUFACTURING and TRADE variables, is rejected at the 1% significance level. The W_L and W_S test results show that the null hypothesis stating that there is symmetrical relationship among the variables in the short and long term is rejected at 5% and 10% significance levels, respectively. As a result it is determined that there is a cointegration relationship among the variables and an asymmetric relationship among the variables in the short and long term.

Seker, Ertugrul and Cetin (2015) concluded a long-term relationship between the variables of gross domestic product, square of gross domestic product, energy consumption, foreign direct investments and CO_2 emissions for Turkey. Besides which they concluded that foreign direct investments positively impact environmental pollution in their long-term estimation. These results support this study's findings.

The NARDL approach is used because the series is not linear. These test statistics show whether there is symmetry or asymmetry between the short- and long-term variables. W_L test statistics provide information about the long-term relationship between variables. According to the test statistics results if the null hypothesis is rejected then the existence of an asymmetrical relationship between the variables is reached in the long term. W_S test statistics provide explanations about the short-term relationships of variables. The null hypothesis means a symmetrical relationship between variables in the short term for the test statistics. According to the results in Table 4, there is an asymmetrical relationship between foreign direct investments and carbon dioxide emissions at the 10% significance level in the long term.

Table 5 shows the short- and long-term coefficients obtained from the estimation of the NARDL model. According to the results all the coefficients are statistically significant except for the lmanufacturing coefficient obtained by long-term estimation. The long-term results show that a 1% increase in

Table 4. Short-term and long-term asymmetry results

Test	*F* statistic	Probability	Null hypothesis
F	1732.57	0.00***	there is no cointegration relationship among the variables
W_S	9.36	0.01**	there is symmetry relationship in the short term
W_L	3.39	0.08*	there is symmetry relationship in the long term

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively. W_L is the Wald test that examines the presence of asymmetry for the long term. W_S is the Wald test that examines the presence of asymmetry for the short term.

Source: Authors' estimation.

Table 5. Results of NARDL model estimation

Variables	Coefficients	*t* statistic	Probability
Constant	−13.00***	−5.14	0.00
LCO2(−1)	0.38***	3.41	0.00
LFDI−(−1)	0.07**	2.82	0.01
LFDI+(−1)	0.02*	1.79	0.09
LTRADE(−1)	0.24***	4.99	0.00
LGDP(−1)	0.59***	5.26	0.00
LMANUFACTURING(−1)	−0.11	−1.51	0.15
ΔLGDP	0.51***	4.06	0.00
ΔLFDI−	0.07**	2.91	0.01
ΔLFDI−(−1)	−0.04***	−3.35	0.00
ΔLFDI+	−0.04**	−2.76	0.01
ΔLFDI+(−1)	0.04**	2.85	0.01
ΔLGDP(−1)	−0.37**	−2.66	0.01
ΔLGDP(−2)	−0.47***	−3.48	0.00
ΔLTRADE	0.13***	3.35	0.00
ΔLTRADE(−1)	−0.09**	−2.38	0.03
ΔLTRADE(−2)	−0.15***	−3.66	0.00
ΔLMANUFACTURING(−1)	0.18*	1.82	0.08
N	41		
R^2	0.99		
F	893.000		

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively. Δ denotes the first difference of the series.

Source: Authors' estimation.

GDP increases CO_2 by 0.51%. These results are in line with the results of Üzar (2019) and Ozturk and Saygin (2020) for Turkey. In contrast the short-term results show that GDP(−1) and GDP(−2) negatively affect CO_2. While a 1% increase in trade causes a 0.24% increase in CO_2 in the long term it also increases it by 0.13% in the short term. However, it is observed that TRADE(−1) and TRADE(−2) negatively affect CO_2 emissions in the short term. Foreign direct investments for Turkey are seen as damaging to the environment. As foreign direct investments increase the amount of carbon dioxide emissions increases in Turkey. These findings reveal that the Pollution Haven Hypothesis is valid in Turkey for the period 1974–2017.

The results also show similarities with many studies covering the period up to 2010 which show that the hypothesis is valid (Mutafoglu, 2012; Gokmenoglu & Taspinar, 2016; Kaya et al., 2017). This situation shows that foreign direct investment inflows to Turkey increase CO_2 emissions as seen in previous studies. In this context foreign direct investments to Turkey can be evaluated within the scope of the Pollution Haven Hypothesis. In parallel with this situation if foreign direct investments are clean and substituted for existing dirtier domestic industries, it is expected to reduce pollution. However the study shows that foreign industries (this needs more elaboration/definition) do not replace more polluting industries. In this context it can be said that foreign direct investments do not reduce carbon emissions. In addition the results of prior studies which examine the relationship between foreign direct investments and CO_2 emissions and consider the asymmetric effects are in line with the findings of this study (Haug & Ucal, 2019; Ur Rahman et al., 2019).

In addition, analysis results in the short-run reveal that if foreign direct inflows increase at lag 1 ($FDI^+(-1)$), carbon emissions will increase, while a decrease in foreign direct investment inflows at lag 1 ($FDI^-(-1)$) will reduce carbon emissions. In this context, it is considered that it may be suitable for Turkey to pay attention to the pollution effect of investments when deciding on foreign direct investment inflows.

Table 6. Results of normality, heteroscedasticity and autocorrelation tests

	Statistics	**Probability**
Jarque-Bera Test	0.82	0.66
Breusch-Pagan Test	14.78	0.61
ARCH(1)	2.24	0.13
ARCH(6)	6.68	0.35
LM(1)	1.86	0.17
LM(6)	8.42	0.21

Source: Authors' estimation.

Diagnostic tests are applied to the NARDL model. Table 6 shows the Jarque--Bera normality test results, heteroscedasticity results from the Breusch-Pagan and ARCH tests and autocorrelation results from the Breusch-Godfrey LM test. According to the test statistics the model's error terms have a normal distribution and there is no heteroscedasticity and autocorrelation.

Conclusions

This study examines the asymmetrical effects of foreign direct investment on carbon emissions in Turkey. In this context, the NARDL approach is used to investigate the effect of negative and positive shocks of foreign direct investments on carbon emissions for the period 1974–2017. As a result of the diagnostic tests it is found that the NARDL model met the necessary conditions.

Both short- and long-run NARDL model estimation results show that negative and positive shocks of foreign direct investments have significant effects on CO_2 emissions in Turkey. This shows that there is an asymmetrical relationship between foreign direct investments and CO_2 emissions for the country. These results reveal that the increase in foreign direct investment inflows to Turkey and the policies in this direction may have an impact on the environment. When evaluated within the scope of the Pollution Haven Hypothesis for Turkey, it is concluded that foreign direct investments have an increasing effect on carbon emissions.

In international trade the Pollution Haven Hypothesis assumes a negative relationship between environmental regulation and trade openness. Analysis results indicate that trade openness positively affects CO_2 emissions in the long run. These results are similar to Rasit and Aralas' (2017) results. On the contrary it has been determined that this situation is valid for trade openness lagged values in the short run. This may indicate that trade openness may cause dirty industries to move from developed countries due to the deficiencies in environmental regulations in developing countries (Ozatac et al., 2017). As Turkey is a developing country where environmental regulations are more flexible attracting foreign investments to the country may affect trade openness.

The NARDL model estimation results indicate that there is a relationship between economic growth and carbon emissions. According to the findings economic growth increases CO_2 emissions by 0.59% and 0.51% in the short and long run respectively. This may be because an increase in economic activities will require more energy use which may lead to an increase in CO_2 emissions. In the short-run estimation results manufacturing is found to increase CO_2 emissions. It can be concluded that industrialisation and growth can also increase CO_2 emissions.

The findings of the study can provide important information for developing countries, including Turkey. Foreign direct investments are important for developing countries targeting industrialisation and economic growth. However, since these countries lack environmentally friendly policies, such investment may cause an increase in carbon emissions. The study results can provide information on reducing carbon emissions as developing countries make their environmental policies more stringent.

The findings show that international trade increases environmental pollution in general. In this context the government should follow stricter environmental policies and require more environmentally friendly production by foreign direct investments. Investors from other countries can be encouraged to make foreign direct investments in activities that are less harmful to the environment. The Ministry of Environment and Urbanisation of Turkey, in the National Climate Change Adaptation Strategy and Action Plan 2011–2023, has set important targets for developing new technologies and information infrastructure to reduce emissions. Encouraging more environmentally friendly production in foreign direct investments within the scope of these policies can play a significant role in reducing carbon emissions. In this direction incentives for investments in sectors such as services and renewable energy can be increased to prevent a decrease in foreign direct investment inflows. The production and development of green technology through research and development at the national level and the realisation of the national action plan can also reduce CO_2 emissions.

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