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# Is the Pollution Haven Hypothesis (PHH) Valid for Turkey?

**Summary:** The relationship between FDI inflows and carbon dioxide (CO<sub>2</sub>) emissions is still one of the most important topics among both environmentalists and economists. In this study, the Toda-Yamamoto augmented Granger causality method is applied to analyze the relationship between FDI inflows and CO<sub>2</sub> emissions by employing annual data from 1974 to 2011 to determine whether the pollution haven hypothesis is valid in Turkey. The results of the causality test indicated that FDI inflows and CO<sub>2</sub> emissions have a short-run univariate causal relationship, with positive causality moving from CO<sub>2</sub> emissions to FDI inflows. One direction effect of CO<sub>2</sub> emissions on FDI inflows supports the pollution haven hypothesis in Turkey.

**Key words:** FDI inflows, CO<sub>2</sub> emissions, TY-VAR causality, Turkey.

**JEL:** C22, F13, O10, Q56.

Today, greenhouse gas (GHG) emissions, which cause climate change, have an important problem. Greenhouse gas emissions and especially carbon dioxide (CO<sub>2</sub>) emissions negatively affect both human health and national economies. Therefore, many empirical studies have been conducted to determine the factors affecting CO<sub>2</sub> emissions. Meanwhile, many hypotheses such as environmental Kuznets curve, pollution haven and halo effect have been established by researchers to determine the factors affecting environmental problems. Gene M. Grossman and Alan B. Krueger (1991) found that there is an inverse U-shaped relationship between some environmental pollution variables and economic growth. On the one hand, this relationship between the variables namely the environmental Kuznets curve hypothesis has been analyzed by numerous studies in the literature (see Ugur Korkut Pata 2018). In addition to economic growth, many other factors such as trade openness, financial development, urbanization, tourism and foreign direct investment (FDI) can affect environmental pollution. On the other hand, the increasing literature on FDI inflows and pollution advocates a significant association between FDI inflows and CO<sub>2</sub> emissions.

This paper is presented as follows: Section 1 describes the pollution haven hypothesis (PHH) and halo effect hypothesis (HEH), Section 2 examines developments in FDI and environmental pollution in Turkey, Section 3 summarizes the literature on the relationships between FDI inflows and CO<sub>2</sub> emissions, Section 4 shows data used in this study, Section 5 presents methodology and empirical findings, and Section 6

offers a summary of the findings, conclusions drawn, and possible directions for future studies.

## 1. Pollution Haven and Halo Effect Hypotheses

The pollution haven hypothesis (also called the pollution haven effect) points out that firms in dirty industries move to countries having light environment protection arrangements and control. The existence of weak environmental and pollution control laws in a country may encourage FDI inflows. Due to increasing environmental arrangements in industrialized countries, intensive polluting firms move from developed to developing countries with relatively less stringent environmental standards. Therefore, FDI inflows cause more industrial pollution and environmental degradation. To reduce the cost of environmental controls, polluting industries in developed countries tend to shift to underdeveloped and developing countries, which are less able to afford the costs of monitoring environmental arrangements and implementing environmental standards. In some low-income countries with little technical or financial ability to monitor pollution, environmental arrangements do not work perfectly. As a result, innocent pollution havens may arise.

Some developing countries with low capital and skilled labor stocks may relax environmental arrangements to attract FDI inflows. They can then have a comparative advantage in the polluting sectors. High environmental standards may push costs up and cause significant harm to the economy. High growth in the FDI inflows in some developing countries has been linked to booming CO<sub>2</sub> emissions and major air-water pollution. According to the PHH, dirty industries have been migrating from developed countries to developing countries, and foreign investors are sensitive to weak environmental standards. Three different views regarding the relationships between FDI inflows and CO<sub>2</sub> emissions have emerged in the existing empirical studies. The first one is that the PHH is valid. Many studies in the literature have found statistically significant support for the PHH in various developing countries (Muthukumara Mani and David Wheeler 1998; Beata K. Smarzynska and Shang-Jin Wei 2001; Yuqing Xing and Charles D. Kolstad 2002; Robert Hoffmann et al. 2005; Muhammad Shahbaz et al. 2015). The second view is that the PHH is valid, but empirical studies have failed to support its validity because of the low quality of aggregate and firm-level data, measurement errors, varying strength of environmental protection laws, corruption, and good environmental protection laws may be limited in practice. The third view is that the PHH is just a myth and does not exist.

Contrary to the PHH, some studies concluded that FDI inflows bring new technologies and reduce the CO<sub>2</sub> emissions of the host countries. According to the HEH, foreign firms help diffuse universal environmental standards in host countries by using high-tech, greener technologies. New production technology may be used as a result of FDI inflows, leading to an improvement in environmental quality due to the enhancement of energy efficiency, thereby causing a reduction in *per capita* CO<sub>2</sub> emissions. Contrary to the PHH, many studies have also found that foreign investors are significantly cleaner than domestic investors, which supports the HEH (Gunnar S. Eskeland and Ann E. Harrison 2003; Richard Perkins and Eric Neumayer 2009; Artur

Tamazian, Juan Piñeiro-Chousa, and Krishna Chaitanya Vadlamannati 2009; Usama Al-Mulali and Chor Foon Tang 2013).

Due to increasing amounts of FDI inflows and CO<sub>2</sub> emissions, it has also become very important to investigate the causality relationship between FDI and CO<sub>2</sub> emissions in Turkey. This study aims to find empirical support for the validity of the PHH or HEH based on FDI inflows rather than trade inflows.

## 2. FDI and Environmental Pollution in Turkey

Turkey has faced strong barriers to both FDI inflows and imports from 1923 to the 1980s. In 1951, Law 5821, entitled the Law to Attract FDI Inflows, was enacted to impose some restrictions with no substantial incentives. After 1980, trade openness and the liberalization policy were recognized as the principal policy tools to boost economic progress. Turkey has initiated export-oriented development policies since the 24 January 1980 decisions. During the past three decades, Turkey moved from an inward-oriented import substitution policy pursued from the early 1930s to a more open, outward-oriented export-led growth policy, seeking to increase exports and FDI inflows. FDI inflows are considered a vital input in the economy to expand Turkey's productive capacity and economic growth. Therefore, since 1980, the Turkish government has implemented new reforms, agencies, and legislation not only to attract FDI inflows, but also to improve the environment for investment by offering several incentives. From 1961 to 1979, FDI inflows totaled \$210.8 million. After removing all restrictive arrangements concerning FDI inflows imposed before 1980, FDI inflows started to increase significantly in the mid-1980s.

**Table 1** FDI, Net Inflows (% of GDP), (1975-2014)

Period	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
GDP %	0.09	0.10	0.29	0.47	0.40	0.76	2.68	1.63

Source: World Bank (2016)<sup>1</sup>.

Table 1 presents the five-year average FDI net inflows as a share of gross domestic product (GDP) for Turkey, showing that the share of FDI has grown since 1980. In June 2003, FDI Law 4875 was enacted to replace Law 6224, guaranteeing that foreign investors have: (a) equal rights with local investors; (b) rights to international arbitration; and (c) rights to own property without any restrictions. After June 2002, restrictions in any sector and performance requirements were removed. In 2004, the Investment Advisory Council of Turkey (IAC) was established to provide an international perspective for foreign investors. IAC seeks to improve investment conditions and attract major international companies to Turkey. In 2006, the Investment Support and Promotion Agency of Turkey (ISPAT), working on a confidential basis with free-of-charge services, was established to provide foreign investors with better service and consultancy before, during, and after coming to Turkey. The FDI inflows into Turkey amounted to only \$180 million in 1980. They increased by more than 1224 times to

<sup>1</sup> **World Bank.** 2016. World Development Indicators. <http://data.worldbank.org/country/turkey> (accessed April 22, 2016).

reach \$22 billion in 2007. The United Nations Conference on Trade and Development (UNCTAD 2014) ranked Turkey in the top 21 (28) countries in 2007 (2013), and Turkey became the largest recipient of FDI in West Asia.

The FDI inflows started to decrease globally due to the 2008-2009 financial crisis. However, the FDI inflows into Turkey started to increase after 2009. The liberalization policies succeeded in raising FDI inflows considerably. FDI inflows, which were less than \$1 billion in 1980, reached about \$16.1 billion in 2011.

Turkey showed a strong performance in terms of FDI inflows in 2011. The FDI inflows in the country rose 78% between 2010 and 2011. Turkey ranked 24<sup>th</sup> (22<sup>nd</sup>), attracting \$13.2 (\$12.9) billion in FDI inflows in 2012 (2013), and was selected as one of the most attractive countries for FDI inflows (UNCTAD 2014). In March 2000, 5024 foreign companies operated in Turkey. The number of companies with foreign capital increased rapidly, reaching 21000 in 2008 and 32604 by the end of 2012. As of 2014, more than 39100 companies with foreign capital are operating in Turkey. As shown in Table 2, the majority of FDI inflows into Turkey came from Europe, North America, and Asia (the Near and Middle East, other Asian, and Arabian Gulf) countries.

**Table 2** Geographic-Sectoral Distribution of FDI Inflows to Turkey (%)

Area	2009	2010	2011	2012	Sectors	2009	2010	2011	2012
Europe	84	79	78	74	Agriculture	1	1	1	1
America	5	6	9	5	Industry	62	46	50	50
Asia	11	15	13	22	Service	37	53	49	49

Source: Presidency of the Republic of Turkey Investment Office (2016)<sup>2</sup>.

A significant part of the FDI inflows came from European countries (84% in 2009, decreasing to 74% in 2012). Table 2 also shows that the biggest share of the total FDI inflows mainly flow into the manufacturing and service sectors. The share of the manufacturing industry's FDI inflows increased sharply from 15% in 2010 to 40% in 2012. In 2009, approximately 62% of FDI inflows took place in industry and 37% in service. The main investment sectors in 2014 were manufacturing (35.8%), finance and insurance (19%), gas, electricity, water, and waste management (16.4%), wholesale and retail trade (14.4%), and mining (5.5%).

As in other developing countries, environmental concerns have increased in Turkey since 1980, and the first Environment Law (No. 2872) referring to sustainable environment and development was enacted in 1983. Later, in 2006, environmental laws were amended to harmonize arrangements with the European Union (EU) standards. These laws define technical and administrative procedures to protect the environment and human health. After intense pressure from both the EU and international environmental climate change organizations in 2009, Turkey signed the Kyoto Protocol to reduce the global greenhouse emissions.

<sup>2</sup> Presidency of the Republic of Turkey Investment Office. 2016.

<http://www.invest.gov.tr/enUS/investmentguide/investorsguide/Pages/FDIinTurkey.aspx> (accessed May 10, 2016).

**Table 3** Greenhouse Gas Emissions (CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O) in Turkey

Greenhouse gas	1990	1995	2000	2005	2010	(1990-2010) %
CO <sub>2</sub>	141362	173900	225432	259605	326472	131
CH <sub>4</sub>	33498	46867	53300	52384	57471	71.8
N <sub>2</sub> O	11566	16224	16617	14182	11571	12.6

Source: United Nations Framework Convention on Climate Change (UNFCCC 2013).

According to the United Nations (UN) Greenhouse Gas Inventory, the greenhouse gas emissions rate increased by 83.6% (131%) between 1990 and 2005 (1990 and 2010) in Turkey, as shown in Table 3, indicating that CO<sub>2</sub> emissions continued to grow throughout the 1990s. Turkey experienced an increase in CO<sub>2</sub> emissions from solid fuel consumption (Kton) (metric ton *per capita*) increased from 298002 (4.1%) in 2010 to 320840 (4.4%) in 2011. Turkey ranked 25<sup>th</sup> (20<sup>th</sup>) in 2008 (2011) among 216 countries, and by 2011 *per capita* fossil-fuel CO<sub>2</sub> emission rates expressed in metric tons of carbon ranked 92<sup>nd</sup>. The value of CO<sub>2</sub> emissions (Kton) in Turkey reached a maximum value of 320840.5 in 2011 over the past 50 years, while this indicator was 16.821 in 1960 and 75763.9 in 1980.

### 3. Literature Review

The number of empirical studies examining the relationships between environmental pollution and FDI inflows have increased rapidly in the last three decades. The CO<sub>2</sub> emissions phenomenon concerning the environment was first analyzed in the early 1990s. Alternative estimation methods were employed to test this topic. It has generally been argued that some developing countries seeking to attract FDI inflows lowered environmental standards and created pollution havens in countries. Yet empirical studies employing different methods and data have not conclusively supported the PHH.

Ayşe M. Erdogan (2014) presented a good survey of literature about FDI inflows and environmental policy to explain the validity of the PHH. She concluded that it is easy to get common support for the PHH, yet most empirical studies failed to find supporting evidence. Because empirical studies are rather new and the studies are rather sparse, there is a lack of information about the environmental arrangements in the host countries. Therefore, researchers need more reliable data to analyze the link between environmental damages and FDI inflows. A number of previous analyses listed in Table 4 sought to establish an association between FDI inflows and CO<sub>2</sub> emissions, and most of the empirical studies utilized the alternative causality tests to find short- and long-run causality in both developed and developing countries.

All over the world, China and India are the leading countries receiving the largest FDI inflows, and many economists argue that China and India have created a “pollution haven”. From 2000 to 2011, the average annual growth rates of CO<sub>2</sub> emissions *per capita* in China (India) were around 8.2% (3.6%). China’s CO<sub>2</sub> emissions continue to increase by about 4.5% per year, well ahead of India, whose CO<sub>2</sub> emissions have increased by 1.4% to about 2.1 billion tons, making it the 4<sup>th</sup> largest CO<sub>2</sub>-emitting country. However, many empirical studies have found that India and China have moved further away from being a pollution haven. Contrary to the PHH, some previous studies have argued that FDI inflows offer potential benefits. For this reason, foreign

investments may include environmentally friendly techniques that would otherwise be used by the host investors. If foreign investors use cleaner technology than their host investors, they may help the host country's environment. As high-polluting foreign industries would worsen environmental pollution, advanced foreign industries would enhance energy efficiency and diminish CO<sub>2</sub> emissions.

**Table 4** Summary of Existing Empirical Studies Analyzing the Causality Link between FDI and CO<sub>2</sub>

Author(s), country, period, method	PHH, causality
Mani and Wheeler (1998), developing countries, 1960-1995	PHH is valid
Raman Letchumanan and Fumio Kodama (2000), developed-developing countries, 1980-1996, multiple regression	PHH is not valid FDI → CO <sub>2</sub> (-)
Smarzynska and Wei (2001), 24 transition countries, 1989-1994, probit	PHH is valid
Debabrata Talukdar and Craig M. Meisner (2001), 44 developing countries, 1987-1995, panel data regression	PHH is not valid
Xing and Kolstad (2002), 22 countries, 1985-1990, OLS, semi-log linear	PHH is valid
Eskeland and Harrison (2003), 4 developing countries, 1982-1993, panel data regression	PHH is not valid FDI → CO <sub>2</sub> (-)
Elif Akbostancı, Gül İpek Tunç, and Serap Türüt-Aşık (2007), Turkey, 1994-1997, 67 sectors	PHH is valid
Hoffmann et al. (2005), 112 countries, 1971-1999, panel data, Granger causality	PHH is valid
Wan-Ping Yang, Yang Yang, and Jie Xu (2008), China, 1982-2006, JJ co-integration, impulse-response, variance decomposition analyses	PHH is valid
Tamazian, Piñeiro-Chousa, and Vadlamannati (2009), BRIC countries, 1992-2004, panel data regression	PHH is not valid FDI → CO <sub>2</sub> (-)
Chew Ging Lee (2009), Malaysia, 1970-2000, ARDL, ECM	FDI → CO <sub>2</sub> <sup>SR</sup>
Perkins and Neumayer (2009), 98 developing countries, 1980-2005, fixed effect, GMM	PHH is not valid FDI → CO <sub>2</sub> (-)
Yue-Jun Zhang (2011), China, 1984-2009, Granger causality, JJ co-integration	No causality
Hsiao-Tien Pao and Chung-Ming Tsai (2011), BRIC 4 countries, 1980-2007, Pedroni co-integration	FDI ↔ CO <sub>2</sub>
Jing Lan, Makoto Kakinaka, and Xianguo Huang (2012), China, 29 provinces, 1996-2006, fixed-random effect	PHH is valid
Fan Yang (2012), China, 27 provinces, 1996-2003, panel regression, fixed-random effect	No causality
Jung Wan Lee (2013), G-20, 1971-2009, Fisher type JJ co-integration, panel regression	No causality
Al-Mulali and Tang (2013), Gulf Cooperation Council, 1980-2009, Pedroni co-integration, Granger causality	PHH is not valid FDI → CO <sub>2</sub> <sup>LR</sup> (-)
Xiaoyan Zhou, Jie Zhang, and Junpeng Li (2013), China, 1995-2009, dynamic panel, GMM	FDI → CO <sub>2</sub> (-)
Anis Omri, Duc Khuong Nguyen, and Christophe Rault (2014), 54 countries, 1990-2011, panel data	FDI ↔ CO <sub>2</sub>
Dinh Hong Linh and Shih-Mo Lin (2014), Vietnam, 1980-2010, Granger causality, JJ co-integration	CO <sub>2</sub> → FDI
Lin-Sea Lau, Chee-Keong Choong, and Yoke-Kee Eng (2014), Malaysia, 1970-2008, ARDL, ECM	FDI → CO <sub>2</sub>
Pendo Kiviyiro and Heli Arminen (2014), Sub-Saharan Africa countries, 1971-2009, ARDL, ECM	PHH is valid
Shenggang Ren et al. (2014), China, 2000-2010, GMM	PHH is valid FDI → CO <sub>2</sub>
Hong Linh and Lin (2015), 1980-2010, panel Granger causality	CO <sub>2</sub> → FDI
Shahbaz et al. (2015), 99 countries, 1975-2012, FMOLS, Pedroni co-integration	PHH is valid FDI ↔ CO <sub>2</sub>
Yu Hao and Yi-Ming Liu (2015), China, 29 provinces, 1995-2011, GMM	FDI → CO <sub>2</sub> (-)

**Notes:** FDI → CO<sub>2</sub> (-) supports the porter hypothesis that FDI can reduce carbon emission; ↔: two-way; →: one-way causality; OLS: Ordinary Least Squares; SR: short-run; JJ: Johansen-Juselius; ARDL: Autoregressive Distributed Lags; ECM: Error Correction Model; GMM: Generalized Method of Moments; FMOLS: Fully Modified OLS.

**Source:** Authors' compilation.

Limited research in the literature has explored the causality link between FDI inflows and CO<sub>2</sub> emissions for Turkey. Past econometric surveys concerning the impact of FDI inflows on CO<sub>2</sub> have yet to provide certain conclusions concerning the path of causality between CO<sub>2</sub> emissions and FDI inflows. Understanding the causality path between CO<sub>2</sub> emissions and FDI inflows is important for design policies that encourage FDI inflows and protect the environment in Turkey. Akbostancı, Tunç, and Türüt-Aşık (2007) focused on the PHH from the trade perspective by looking at the sectoral manufacturing industry covering 67 sectors in Turkey's exports over the period 1994-1997 by using estimation methods with panel data. They concluded that level of pollution in industry encouraged the trade flows and PHH is valid for Turkey. Takvor H. Mutafoğlu (2012) utilized annual national CO<sub>2</sub> emissions series (flaring gas, producing cement, and burning fossil-fuel per thousand metric tons of carbon from the Carbon Dioxide Information Analysis Center (CDIAC 2016)<sup>3</sup> as proxies of pollution and FDI inflows (in millions of US dollars from the International Financial Statistics of the International Monetary Fund (IMF 2016)<sup>4</sup>. Annual Turkish data were transformed into quarterly data (1987q1-2009q4) using the frequency conversion function. Mutafoğlu (2012) found a stable long-term equilibrium while Granger causality moved from CO<sub>2</sub> to FDI inflows. His empirical findings support the PHH, and he concluded that lower environmental standards in Turkey attract FDI inflows. Therefore, in order to prevent negative environmental impacts of FDI inflows in terms of the pollution effect of CO<sub>2</sub> emissions in Turkey, the government should promote effective policies.

Recently, the relationship between CO<sub>2</sub> emissions and FDI has received more attention in Turkey. Ahmet Şahinöz and Zahra Fotourehchi (2014) analyzed the long-run co-integration relationship between FDI and CO<sub>2</sub> emissions based on annual data from 1974 to 2011. Contrary to Mutafoğlu's (2012) findings, Şahinöz and Fotourehchi (2014) concluded that there is a negative causality which means that an increase in the level of FDI leads to the decrease in CO<sub>2</sub> emissions. Consequently, the alternative causality tests indicate that no conclusive results have emerged in causality links between CO<sub>2</sub> emissions and FDI inflows not only in Turkey but also in other developing countries.

## 4. Data

Although many types of pollution indicators other than CO<sub>2</sub> exist, such as methane (CH<sub>4</sub>), water vapour (H<sub>2</sub>O), nitrogen oxide (NO<sub>x</sub>), ground level ozone (O<sub>3</sub>), particulate matter (PM), sulphur dioxide (SO<sub>2</sub>), and suspended particulate matter (SPM), the majority of the literature accepts CO<sub>2</sub> emissions as an indicator of environmental quality. The UNFCCC (2013) report indicated that the main GHG in Turkey was CO<sub>2</sub>, accounting for 81% of total GHG emissions expressed in CO<sub>2</sub>, followed by CH<sub>4</sub> (14.3%) and nitrous oxide (N<sub>2</sub>O) (3.2%). The remaining indicators; hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>) collectively

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<sup>3</sup> **Carbon Dioxide Information Analysis Center (CDIAC)**. 2016. Fossil-Fuel CO<sub>2</sub> Emissions. [http://cdiac.ess-dive.lbl.gov/trends/emis/meth\\_reg.html](http://cdiac.ess-dive.lbl.gov/trends/emis/meth_reg.html) (accessed April 22, 2016).

<sup>4</sup> **International Monetary Fund (IMF)**. 2016. International Financial Statistics Database. <http://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B> (accessed April 22, 2016).

accounted for 1.2% of the overall GHG emissions. Therefore, CO<sub>2</sub> is accepted as one of the most common air pollutants in the world.

This study employed three different measures of CO<sub>2</sub> emissions denoted as  $CO_{2a}$  (CO<sub>2</sub> emissions, kt),  $CO_{2b}$  (CO<sub>2</sub> emissions per year, Kton, Gg), and  $CO_{2c}$  (CO<sub>2</sub> emissions from fossil-fuels and cement production, thousand metric tons) – as well as  $FDI$  in terms of foreign direct investment, net inflows, and balance of payments (BoP), in constant 2005 US dollars. The data were collected from the CDIAC (2016) and the World Bank (2016).  $CO_{2a}$ ,  $CO_{2b}$ , and  $CO_{2c}$ , as major sources of pollution, are used as a proxy for pollution in many empirical studies due to the availability of reliable data. The annual data cover the 1974-2011 period, and the sample size is 38. All values in this data set are expressed in logarithmic level forms. The starting date of 1974 was chosen, and FDI increased significantly after the 1980s. Prior to 1980, the average annual inflows of FDI were only \$90 million, and Turkey has encouraged foreign investors and foreign trade since 1980.

The data analysis ended in 2011 because of the limited availability of CO<sub>2</sub> emissions data. Econometric software – namely, SPSS, TSP, Eviews and Gretl – is used for the estimations. In this study, the technical details of statistic and econometric methods are kept to a minimum level to save space. The basic statistics (mean, median, and standard deviation - s.d.) and Pearson's correlations for the data set covering 38 observations are listed in Table 5. The medians and means are almost the same, and the Jarque-Bera (JB) test's  $p$ -values greater than 10% indicate that series have normal distribution. Table 5 also reports Pearson correlations among the three measures of CO<sub>2</sub> emissions' intensity and FDI are positive and statistically significant.

**Table 5** Basic Indicators for CO<sub>2</sub> Emissions and FDI Inflows

Variables	Mean	Median	Max.	Min.	S	K	s.d.	JB (p-value)
$CO_{2a}$	11.89	11.95	12.68	11.02	-0.20	1.81	0.49	2.49 (0.29)
$CO_{2b}$	11.93	11.99	12.68	11.08	-0.15	1.72	0.48	2.70 (0.26)
$CO_{2c}$	10.60	10.65	11.38	9.72	-0.08	1.81	0.49	2.49 (0.29)
$FDI$	20.72	21.00	23.70	17.25	-0.01	2.32	1.70	0.78 (0.68)

**Notes:** Pearson correlation coefficient ( $r$ ):  $r_{CO_{2a}FDI} = 0.92^a$ ,  $r_{CO_{2b}FDI} = 0.92^a$ ,  $r_{CO_{2c}FDI} = 0.92^a$ ,  $r_{CO_{2a}CO_{2b}} = 0.99^a$ ,  $r_{CO_{2a}CO_{2c}} = 0.99^a$ ,  $r_{CO_{2b}CO_{2c}} = 0.99^a$ ; a: significant at 0.001 level (2-tailed); S: skewness; K: kurtosis.

**Source:** Results obtained by the authors.

Strong positive correlations indicate that CO<sub>2</sub> emissions and FDI inflows move together. The results show that the slopes of the lines are positive, and there are strong positive significant linear correlations among the variables, indicating that a higher value of  $CO_{2abc}$  is associated with a higher value of  $FDI$ . FDI was generally very low (i.e., less than \$1 billion before 1980); in 2001-2012, FDI exceeded \$1 billion. During the 2000-2001 crisis in the Turkish economy, FDI diminished sharply by around 68% in 2001 compared to 2000.

Due to the effect of the 2008-2009 global crisis, many economies, including Turkey's, suffered from a 10% (60) decline in FDI in 2008 (2009) compared to 2007. The average FDI was at nearly \$0.5 billion for the 1980-2001 period and was \$10.7 billion for the 2001-2012 period. Due to the large scale of privatization, annual FDI into Turkey peaked in 2007 at about \$22.1 billion and declined steadily until 2011. This amount was more than the accumulated FDI of 1974-2004. FDI to Turkey

boomed in 2001-2011. Throughout the 1980-2011 period, annual average FDI was \$3.9 billion in Turkey. The average FDI from 2000 to 2011 was about \$10 billion. The total FDI stock from 1980 to 2011 was \$125 billion.

The World Investment Report (UNCTAD 2014) listed Turkey among the most promising countries in FDI. The share of FDI in terms of GDP has been very low, totaling less than 1% from 1974 to 2000. It was 1.7% in 2001, 2.1% in 2005, 3.8% in 2006, and 2.1% in 2011. FDI also increased quite substantially as a share of GDP, from 0.03% in 1980 to 2.1% of GDP in 2005 and 3.8% of GDP in 2006.

Turkey's emission levels along with its rapid economic growth have been growing fast. In sum, FDI and CO<sub>2</sub> emissions drastically increased during the last three decades. As one of the last countries to sign the Kyoto Protocol in 2009, Turkey has been relatively slow in setting up effective emission reduction policies to protect the environment.

## 5. Methodology and Empirical Findings

### 5.1 Unit Root Tests

Before applying the causality tests, the first step in the time series data is to test the entire series for stationarity. Several unit root tests are included in the literature. Augmented Dickey-Fuller (ADF) (David A. Dickey and Wayne A. Fuller 1981) and Peter-Perron (PP) (Peter C. B. Phillips and Pierre Perron 1988), based on the AR(1) process, proposed two alternative equations for the unit root-stationarity test to find the integration order for the series. The PP test is a non-parametric method to control for the higher-level autocorrelation in the regression. The Schwarz Information Criteria (SIC) were used to select an appropriate number of lags.

The unit root equations contain a constant (a constant and a trend), and James G. MacKinnon (1991) derived appropriate critical values for the equations. The level data trend is significant. In the first data difference, the trend is not significant. In absolute terms, although the estimated unit root statistics for the level data are less than the critical values, the estimated unit root statistics for the first difference of each variable are higher than critical values.

**Table 6** ADF and PP Unit Root Tests

Variables		ADF test		PP test	
		Equation (1) C t-statistics	Equation (2) C + T t-statistics	Equation (1) C t-statistics	Equation (2) C + T t-statistics
CO <sub>2a</sub>	Level	(0) -0.869	(0) -2.435	(5) -0.928	(0) -2.435
CO <sub>2b</sub>		(0) -0.921	(0) -2.432	(7) -1.119	(1) -2.580
CO <sub>2c</sub>		(0) -0.868	(0) -2.433	(5) -0.927	(0) -2.433
FDI	1 <sup>st</sup> difference	(0) -1.508 [-2.610]	(0) -3.233 [-3.200]	(10) -1.454 [-2.610]	(0) -3.233 [-3.200]
CO <sub>2a</sub>		(0) -5.794 <sup>a</sup>	(0) -5.726 <sup>a</sup>	(6) -5.992 <sup>a</sup>	(6) -5.912 <sup>a</sup>
CO <sub>2b</sub>		(0) -5.553 <sup>a</sup>	(0) -5.484 <sup>a</sup>	(9) -6.086 <sup>a</sup>	(9) -6.074 <sup>a</sup>
CO <sub>2c</sub>		(0) -5.792 <sup>a</sup>	(0) -5.723 <sup>a</sup>	(6) -8.371 <sup>a</sup>	(6) -5.909 <sup>a</sup>
FDI		(0) -8.409 <sup>a</sup> [-2.611]	(0) -8.367 <sup>a</sup> [-3.202]	(7) -9.151 <sup>a</sup> [-2.612]	(7) -9.090 <sup>a</sup> [-3.202]

**Notes:** C: model without trend; C + T: model with constant and trend; MacKinnon's (1991) one-sided test critical values are in square brackets at 0.10 level; SIC lags are in parenthesis; a: statistical significance at 0.001 level.

**Source:** Results obtained by the authors.

The findings of the ADF and PP tests in Table 6 show the same results. The four variables are non-stationary at level, but stationary at the first difference. Therefore, the conclusion is that all the variables integrated at I(1).

## 5.2 Toda-Yamamoto (TY) Augmented Granger Causality Test

To overcome the limitations of standard Clive W. J. Granger's (1969) causality tests, Hiro Y. Toda and Taku Yamamoto (1995) (TY) proposed a modified version of the Granger causality test based on the Augmented Vector Autoregression (VAR) modeling and a Modified Wald (MWALD) test. TY's augmented Granger causality test involves four stages, using the MWALD test to test for restrictions on the parameters of the VAR( $p$ ) model without preliminary testing co-integration:

(i) application of stationarity test to determine time series properties and the maximum order of integration ( $d_{max}$ ) of the variables in the VAR system;

(ii) identification of the optimal lag length ( $k$ ) of the VAR system by using *lag length* selection criteria;

(iii) estimation of the VAR system using a suitable estimation method (mostly Seemingly Unrelated Regressions (SUR) technique); and

(iv) application of the MWALD test, asymptotic chi-square distribution with degrees of freedom ( $k$ ) when a VAR( $k + d_{max}$ ), to the first  $k$  VAR coefficient by ignoring the last  $d_{max}$ .

$$FDI_t = a_0 + \sum_{i=1}^k a_{1i} FDI_{t-i} + \sum_{i=k+1}^{k+d_{max}} a_{2i} FDI_{t-i} + \sum_{i=1}^k b_{1i} CO_{1,2,3t-i} + \sum_{i=k+1}^{k+d_{max}} b_{2i} CO_{1,2,3t-i} + e_{1t}, \quad (1)$$

$$CO_{2abc} = c_0 + \sum_{i=1}^k c_{1i} CO_{2abc,t-i} + \sum_{i=k+1}^{k+d_{max}} c_{2i} CO_{2abc,t-i} + \sum_{i=1}^k d_{1i} FDI_{t-i} + \sum_{i=k+1}^{k+d_{max}} d_{2i} FDI_{t-i} + e_{2t}. \quad (2)$$

In Equation (1) the Granger causality is going from  $CO_{2abc}$  to  $FDI$ , if  $H_0: b_{1i} \neq 0$ . In Equation (2) the Granger causality running is from  $FDI$  to  $CO_{2abc}$ , if  $H_0: d_{1i} \neq 0$ . Because the time trend component is statistically significant, all VAR equations in levels are estimated by including a time trend regressor.

**Table 7** TY-VAR Lag Order Selection Criteria for Models

Model	Lag	LR	FPE	AIC	SIC	HQ
$CO_{2a}-FDI$	1	144.30*	0.00086*	-1.39*	-1.12*	-1.29*
$CO_{2b}-FDI$	1	151.27*	0.00071*	-1.57*	-1.31*	-1.38*
$CO_{2c}-FDI$	1	144.38*	0.00086*	-1.39*	-1.12*	-1.30*

**Notes:** LR: sequential modified Likelihood Ratio test statistic; FPE: Final Prediction Error; AIC: Akaike Information Criterion; HQ: Hannan-Quinn Information Criterion; \* each test at 0.05 level.

**Source:** Results obtained by the authors.

According to the unit root tests results,  $d_{max}$  is found to be 1. Roots of characteristic polynomial are less than one in all TY-VAR models. Therefore, no root lies outside the unit circle, and TY-VAR models satisfy the stability condition. Table 7 explains the results of TY-VAR lag order criteria for optimal lag selection and shows that the five lag order selection criteria (LR, FPE, AIC, SIC, and HQ) suggest that the optimal lag length of TY-VAR( $k$ ) is 1.

The residual correlation matrices ( $r_{CO2aFDI} = 0.03$ ,  $r_{CO2bFDI} = -0.10$ ,  $r_{CO2cFDI} = 0.03$ ) in TY-VAR models are less than 0.2 in the TY-VAR tests. Therefore,

the ordering of variables in the VAR model is not significant (Walter Enders 2014). The residual autocorrelation (LM) test, normality (JB) test, and heteroscedasticity (no cross term) (White) test are also used to examine the econometric and statistical adequacy of the TY-VAR model.

**Table 8** TY-VAR Augmented Granger Causality Tests [ $k(1) + d_{\max}(1)$ ]

Model	$\chi^2$ -(OLS) statistics	$\chi^2$ -(SUR) statistics	Sign of $b_{11}$	LM-lags ( $p$ -value)	White ( $p$ -value)	JB ( $p$ -value)
$FDI = f(CO_{2a})$ $CO_{2a} = f(FDI)$	3.85 (0.05) <sup>b</sup> 2.03 (0.15)	4.62 (0.03) <sup>b</sup> 2.44 (0.12)	+(4.07) <sup>b</sup> ...	1(0.74) 2(0.38)	0.33	1.961 (0.74)
$F = f(CO_{2b})$ $CO_{2b} = f(FDI)$	6.81 (0.01) <sup>a</sup> 3.10 (0.08) <sup>c</sup>	8.17 (0.00) <sup>a</sup> 3.72 (0.05) <sup>b</sup>	+(5.74) <sup>a</sup> +(0.02) <sup>c</sup>	1 (0.40) 2 (0.34)	0.36	2.968 (0.56)
$FDI = f(CO_{2c})$ $CO_{2c} = f(FDI)$	3.87 (0.05) <sup>b</sup> 2.01 (0.16)	4.65 (0.03) <sup>b</sup> 2.41 (0.12)	+(4.08) <sup>a</sup> ...	1 (0.75) 2 (0.38)	0.32	1.80 (0.77)

**Notes:** a, b and c denote statistical significance at 0.001, 0.05 and 0.10 levels. The way of causality:  $CO_{2a} \rightarrow FDI$ ;  $CO_{2b} \leftrightarrow FDI$ ;  $CO_{2c} \rightarrow FDI$ . LM test is residual serial correlation test (null hypothesis is no serial correlation). JB test based on residual normality tests (orthogonalization: Cholesky (Lütkepohl)) and null hypothesis is residuals are multivariate normal. White test is residual heteroscedasticity test with only levels, squares and no cross terms.

**Source:** Results obtained by the authors.

The TY-VAR augmented Granger causality tests [ $k(1) + d_{\max}(1)$ ] are estimated in levels by two lags, and the results of all lag selection criteria are presented in Table 8.  $p$ -values of the LM test for equations are more than 0.33,  $p$ -values of JB are more than 0.55, and White tests for the equations are more than 0.31. In all models,  $R^2$  between  $CO_{2a}$ - $CO_{2b}$ - $CO_{2c}$  and  $FDI$  is also more than 0.90. The TY-VAR causality results proposed a positive one-sided causality relationship going from  $CO_{2a}$  and  $CO_{2c}$  to  $FDI$  as well as a positive and two-sided causality relationship between  $CO_{2b}$  and  $FDI$ . The results mainly support the PHH. In the Table 9, all models the values of cumulative sum (CUSUM) and CUSUM squared (CUSUMSQ) tests (except  $FDI$ - $CO_{2c}$  model) indicate that parameters are constant throughout the sample period. Therefore, there is no structural instability.

**Table 9** CUSUM and CUSUMSQ Test Results

Models	CUSUM test value	$p$ -value	CUSUMSQ test value	$p$ -value
$FDI = f(CO_{2a})$	0.69	0.27	0.18	0.44
$FDI = f(CO_{2b})$	0.71	0.23	0.18	0.42
$FDI = f(CO_{2c})$	0.44	0.81	0.36	0.01
$CO_{2b} = f(FDI)$	0.49	0.68	0.11	0.96

**Source:** Results obtained by the authors.

### 5.3 Variance Decomposition (VD) and Impulse-Response Function (IRF)

The Variance Decomposition (VD) analysis of the VAR model commonly utilized in the literature shows the amount of information one variable contributes to the other variables. It shows the proportion of the forecast error variance in one of the variables that is due to residuals in estimating itself and each of the other variables (Helmut Lütkepohl 2005). The VDs help determine the extent of the forecast error variance of the variables.  $CO_{2abc}$  and  $FDI$  can be explained by exogenous shocks to the variables.

If the percentage of the variance of  $FDI$  due to  $CO_{2abc}$  shocks is high, the hypothesis of  $CO_{2abc}$  causing  $FDI$  is supported; however, if the percentage of the variance of  $FDI$  due to  $CO_{2abc}$  shocks is small, the hypothesis of  $CO_{2abc}$  causing  $FDI$  is not supported. In the average 10-year time horizon of the VD analysis by the Cholesky ordering,  $CO_{2abc}$  ( $CO_{2a}$ ,  $CO_{2b}$  and  $CO_{2c}$ ) and  $FDI$  show that 95% of the variation in  $CO_{2abc}$  is explained by itself while 5% of the variation in  $CO_{2abc}$  is explained by  $FDI$ . In addition, 71% of the variation in  $FDI$  is due to changes by itself while 29% of the variation in  $FDI$  is due to changes in  $CO_{2abc}$ . Thus,  $CO_{2abc}$  accounts for 29% of the variation in the forecast error of  $FDI$ . The results of VDs show that  $CO_{2abc}$  is also an important factor in explaining the variance of  $FDI$ . After 6 years,  $CO_{2abc}$  explains about 35% of the variance of  $FDI$  while about 65% of the variance is due to its own shocks. This result supports the hypothesis that there is a causal effect from  $CO_{2abc}$  to  $FDI$ . The Accumulated Impulse-Response Function (AIRF) to generalized one s.d., derived from TY-VAR(2),  $[k(1) + d_{max}(1)]$  between  $CO_{2abc}$  and  $FDI$ , is illustrated in Table 10.

**Table 10** AIRF (Based on Cholesky Ordering:  $CO_{2abc}$ ,  $FDI$ )

Year	2	6	10	Year	2	6	10
AIRF of $CO_{2a}$	0.09	0.19	0.26	AIRF of $FDI$	0.74	0.88	1.01
$FDI$	0.02	0.05	0.07	$CO_{2a}$	0.02	0.85	1.23
AIRF of $CO_{2b}$	0.08	0.21	0.33	AIRF of $FDI$	0.66	1.02	1.35
$FDI$	0.01	0.06	0.10	$CO_{2b}$	0.18	1.16	2.07
AIRF of $CO_{2c}$	0.09	0.19	0.26	AIRF of $FDI$	0.67	0.88	1.00
$FDI$	0.01	0.05	0.07	$CO_{2c}$	0.22	0.85	1.24

Source: Results obtained by the authors.

It must be noted that the AIRF based on summing up all impulse-responses displays a positive relationship between  $CO_{2abc}$  and  $FDI$  and a sustained positive effect, as can be seen over the period considered in Table 10. The AIRF of  $FDI$  ( $CO_{2abc}$ ) to an innovation in  $CO_{2abc}$  ( $FDI$ ) is positive. The AIRF also shows that the response from  $CO_{2abc}$  to  $CO_{2abc}$  and from  $FDI$  to  $FDI$  is greater than zero, and the AIRF of  $FDI$  ( $CO_{2abc}$ ) to an innovation in  $CO_{2abc}$  ( $FDI$ ) is positive. Thus,  $CO_{2abc}$  and  $FDI$  positively stimulate each other. Clearly, the accumulated responses to shocks in  $CO_{2abc}$  are positive for  $FDI$ , whose accumulated responses sustained positive impacts.

In a new Generalized Forecast Error Variance Decomposition (GFEVD) for variables, the total impact of all innovations may not sum to unity due to the shocks that are not necessarily uncorrelated (Markku Lanne and Henri Nyberg 2016). To prevent effects from particular ordering, GFEVD is used instead of an orthogonalized analysis. In other words, the sum of forecast error variance decompositions does not necessarily add up to 100%. GFEVDs for variables  $CO_{2a}$ ,  $CO_{2b}$ ,  $CO_{2c}$ , and  $FDI$  are shown in Table 11 and indicate that the variations in  $CO_{2abc}$  are primarily explained by the shocks of  $CO_{2abc}$ , based on a 10-year average.

The findings mostly point out that  $CO_{2abc}$  is the major source of  $FDI$  and  $CO_{2abc}$  shocks are a major cause of shocks to  $FDI$ . Furthermore, GFEVDs show that the effect of  $CO_{2abc}$  to  $FDI$  is much larger than the effect of  $FDI$  to  $CO_{2abc}$ . Findings in the VDs and GFEVDs exhibit almost the same patterns.

**Table 11** GFEVD for FDI

Year	1	2	4	6	8	10
$CO_{2a}$	0.11	0.18	0.27	0.31	0.33	0.35
$FDI$	0.89	0.82	0.74	0.70	0.68	0.66
$CO_{2b}$	0.16	0.28	0.42	0.50	0.56	0.60
$FDI$	0.82	0.36	0.55	0.46	0.41	0.37
$CO_{2c}$	0.11	0.19	0.27	0.31	0.33	0.35

Source: Results obtained by the authors.

M. Hashem Pesaran and Yongcheol Shin (1998) suggested using the Generalized Impulse-Response Function (GIRF) to see one standard error shock in the equations. The GIRF, which is invariant to variables ordering in the  $VAR(k + d_{max})$  model, can also be utilized to examine the response of  $FDI$  ( $CO_{2abc}$ ) to changes in  $CO_{2abc}$  ( $FDI$ ). The GIRF indicated that the findings are consistent with findings of the AIRF, and  $CO_{2abc}$  is an important determinant of  $FDI$  – that is,  $FDI$  responds to  $CO_{2abc}$  positively. The GIRF and AIRF results provided the same conclusions regardless of the order of decomposition.

## 6. Conclusions

The relationship between FDI inflows and  $CO_2$  emissions has been a popular debated topic in the last years due to increasing  $CO_2$  emissions becoming a central issue of discussion among the environmentalists and economists. The PHH refers to the possibility that foreign firms, especially those operating in highly polluting activities, move and cause pollution havens because of lower environmental standards in these countries. Determining the causal relationship between FDI inflows and  $CO_2$  emissions is critical for developing policies about the environment, investments, and economic growth.

Existing literature offers limited support for the validity of PHH. This paper aims to find the possibility that one of the two variables ( $CO_2$  emissions and FDI inflows) could cause the other by using alternative causality models for the 1974-2011 period, during which FDI inflows to Turkey picked up rapidly. Turkey has made strong efforts to attract FDI inflows; therefore, it is expected that Turkey will be a major FDI destination in the coming years. Turkey ranked 19<sup>th</sup> in total  $CO_2$  emissions among the world's countries by 2011 and was also identified as one of the major countries in Europe emitting more  $CO_2$  emissions into the air. The results show that strong, significant, and positive correlations exist between  $CO_2$  emissions and FDI inflows.

According to causality tests results, there are unidirectional and bidirectional positive causality relationships between  $CO_2$  emissions and FDI inflows. However, mainly causality effect running from  $CO_2$  emissions to FDI supports the existence of PHH, and indicates that  $CO_2$  emissions have a significant role in increasing FDI. Furthermore, increasing  $CO_2$  and relatively low regulation standards attracting FDI also validate the PHH, and the conclusion is that increasing  $CO_2$  emissions have positive effect on promoting FDI inflows. The results of this study, along with those of Akbostancı, Tunç, and Türüt-Aşık (2007) and Mutafoglu (2012), indicate that PHH is valid in Turkey.

Based on the conclusive causality test results, two conclusions and policy implications for policymakers have been identified.

(1) It appears that Turkey has focused on encouraging FDI inflows to speed up economic growth since 1974, without paying more attention to CO<sub>2</sub> emissions. To protect the environment and reduce CO<sub>2</sub> emissions, Turkey should apply new environmental policies and implement strict arrangements to reduce the level of pollution and prevent negative effects of FDI inflows because less stringent environmental laws would accelerate the country's environmental degradation and attract more pollution-intensive investment as FDI inflows increase.

(2) Turkey should design effective financial and technical incentives to replace dirty industries with green and clean industries to reduce CO<sub>2</sub> emissions.

Finally, the results above are valid for the limited aggregate-level data used in this study. Therefore, further empirical studies are needed to analyze the relationship between FDI inflows and CO<sub>2</sub> emissions by using disaggregate, sectoral-level data including other forms of pollutants with alternative estimation techniques.

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