Güler, C. (2023). *"Testing Sectoral Validity of Pollution Haven Hypothesis for Türkiye's Energy and Waste Sector", International Journal of Entrepreneurship and Management Inquiries, 07(12), 1-13*

Doi: 10.55775/ijemi.1322710 ***https://dergipark.org.tr/en/pub/ijemi***

Başvuru Tarihi/Received Date: 05.07.2023 Kabul Tarihi/Accepted Date: 07.08.20223 Araştırma Makalesi/Research Article

Testing Sectoral Validity of Pollution Haven Hypothesis for Türkiye's Energy and Waste Sector

Res. Asst. Cengizhan GÜLER, *ORCID: 0000-0002-9059-3676, İstanbul Gelişim University, Turkey; ceguler@gelisim.edu.tr*

Testing Sectoral Validity of Pollution Haven Hypothesis for Türkiye's Energy and Waste Sector

Abstract

The increase in environmental standards in developed countries and the efforts of developing countries to attract foreign direct investments (FDI) offer both a theoretical and an empirical research area. In practice, this situation, which can be seen as a shift of investments to countries with looser policies in order to avoid the costs of environmental regulations, is called the pollution haven hypothesis (PHH). In this study, the existence of the mentioned hypothesis for Türkiye's waste and energy sector is investigated. In order to test the hypothesis, linear time series analysis methods are used in the study. When the findings are examined, it is observed that the hypothesis is valid in both sectors.

Keywords: *Environmental economics, pollution haven hypothesis, time series analysis*

Jel Classification: *C22, F18, Q50*

Türkiye'nin Enerji ve Atık Sektörü İçin Kirlilik Cenneti Hipotezinin Sektörel Geçerliğinin Test Edilmesi

Özet

Gelişmiş ülkelerde çevre standartlarının artması ve gelişmekte olan ülkelerin doğrudan yabancı yatırımları (FDI) çekme çabaları hem teorik hem de ampirik bir araştırma alanı sunmaktadır. Uygulamada, çevresel düzenlemelerin maliyetlerinden kaçınmak için yatırımların daha gevşek politikalara sahip ülkelere kayması olarak görülebilecek bu durum, kirlilik cenneti hipotezi (PHH) olarak adlandırılmaktadır. Bu çalışmada söz konusu hipotezin Türkiye atık ve enerji sektörü için varlığı araştırılmaktadır. Çalışmada hipotezi test etmek için doğrusal zaman serileri analiz yöntemleri kullanılmıştır. Bulgular incelendiğinde hipotezin her iki sektörde de geçerli olduğu görülmektedir.

Anahtar Kelimeler: *Çevre ekonomisi, kirlilik cenneti hipotezi, zaman serisi analizi*

JEL Sınıflandırması: *C22, F18, Q50*

Araştırma ve Yayın Etiği Beyanı: *Bu çalışmada, araştırma ve yayın etiği kurallarına uyulduğu yazarlar tarafından taahhüt edilmektedir.*

Yazar Katkı Oranları: *Birinci yazarın katkı oranı %100*

Çıkar Beyanı: *Yazarlar açısından ya da üçüncü taraflar açısından çalışmadan kaynaklı çıkar çatışması bulunmamaktadır.*

1. Introduction

Increasing environmental pollution in the world exists with its negative effects on all parts of life. The source and effects of this negative effect contain many asymmetries. The source of these asymmetries is that environmental pollution is a negative externality. While the economic gain of polluting the environment is obtained by the polluters, the resulting negative situation affects all individuals in the society and the total welfare level in the society decreases.

The dangerous situation brought about by the increasing trend of environmental pollution in the world necessitated the development of various solution proposals in many national and international places. However, although environmental pollution can be reduced on a national scale, the fact that environmental pollution is a negative externality for all countries in the world has increased the importance of international organizations.

On the other hand, in the globalizing world, Foreign Direct Investments (FDI) can affect an economy in many ways. Especially considering the lack of capital in developing countries, FDIs from other countries can contribute to economic growth by filling this capital deficiency. Along with these investments comes a technology transfer; this also positively affects economic growth (Chowdhury & Mavrotas, 2006). The decisions of January 24, 1980 have an important place when it is looked at the history of FDIs in the economic history of Türkiye. These decisions brought important structural developments and changes to Türkiye's economy. The direction of the changes can be interpreted as the implementation of the policies of adaptation to globalization. Following the globalization and liberalization steps in economic policies, international capital flows have become more liberal in Türkiye (Karagöz, 2007).

Considering the relationship between environmental pollution and FDI, there are two different approaches that stand out in the applied economics literature. The first of these is Pollution Heaven Hypothesis (PHH) and the second is Pollution Halo Hypothesis (PLH). FDIs flowing to developing countries and environmental regulations in the country are the basis of these approaches. The fact that environmental quality has a welfare-enhancing effect in society in general is possible with strict environmental regulations. These strict regulations make production methods compatible with the environment and increase the abatement costs undertaken by companies. In particular, the marginal abatement costs incurred by companies during the transition to environmentally friendly methods are quite high. On the other hand, the ability of individuals to pay for goods and services that increase environmental quality is realized with an increase in per capita income, and the marginal benefit of not polluting the environment turns positive. In this context, in developed countries, companies can pay for products and services that increase environmental quality and individuals can produce in accordance with strict environmental regulations.

In developing countries, the situation may be the opposite. Since FDIs can encourage economic growth, developing countries are trying to make these investments attractive to their countries. One of the things that can be done about environmental quality to make it attractive in this regard is to relax environmental regulations. Due to the strict regulations in developed countries, companies operating with high abatement costs can invest their capital by shifting their capital to developing countries where there are relatively looser regulations and capital deficits. As seen in the general equilibrium model made by Copeland & Taylor (1994), if there is an asymmetry between environmental regulations between countries, the relative price of pollution-intensive production methods is higher in countries with strict environmental regulations. In this context, countries with loose regulations on capital flows between countries have a kind of comparative advantage and are attractive for pollution-intensive FDIs. The theoretical framework brought about by such a capital flow is called PHH in the literature. In the presence of PHH, the total pollution level in the world increases (Rezza, 2013).

On the other hand, PLH, unlike PHH, paints a more positive picture about FDIs. According to PLH, new investments entering the country can reduce environmental pollution by bringing environmental technologies and effective management practices related to environmental problems. In order for the effect predicted by the hypothesis to occur, the foreign investor should not currently continue their activities as a pollutant. In this context, companies operating in developed countries carry out their activities in line with the strict environmental regulations of the countries they come from. For this reason, since they have more effective environmental management systems and cleaner production methods, they can transfer this information to the companies of the host country. Companies in the host country can increase the environmental performance of the developing country by incorporating such know-how information (Zarsky, 1999; Wang, Dong & Liu, 2019). In this context, this effect can be seen as a kind of technological spillover.

In general, PHH and PLH approaches try to explain the relationship between FDI and the environment in terms of dynamics from micro sources. Both hypotheses assess the impact of FDIs on the environmental quality of the host country on a firm basis. In this context, PHH argues that FDI flows from developed countries to developing countries will have negative effects, whereas PLH, on the contrary, will have positive effects. In this study, it will be investigated whether PHH, one of the aforementioned hypotheses, is valid for Türkiye's waste and energy sector.

2. Literature Review

The theoretical foundations of the relationship between FDI and environmental pollution within the scope of PHH were laid in the studies of Siebert (1977), McGuire (1982) and Grossman & Krueger (1991) and a specific framework was created. In the establishment of this relationship, the welfare gains and losses of the countries that trade with each other in the presence or absence of environmental regulations from international trade are compared.

In the study of Siebert (1977), it is concluded that if the country producing and exporting pollution-intensive products will gain from international trade, welfare losses will occur due to environmental quality. In addition to the increase in welfare brought about by the introduction of environmental regulations, the production of pollution-intensive products will decrease, and then there is a loss of welfare by decreasing exports and imports based on these products. The main criterion for this welfare increases and gain to lead to an increase in welfare in the society in general is that the marginal value obtained by the companies from the consumption of their pollution-intensive products is lower than the marginal social cost. Within the scope of PHH, the production of the product in question can be continued through FDI in countries with lower environmental regulations, and maximization can be made without being restricted by any social cost loss. This situation was also stated in the McGuire (1982) study. In this context, in the presence of free trade, factors of production are shifted from countries with more regulation to countries with less regulation. In other words, countries with loose regulations provide a competitive advantage over countries with tight regulations. As a result, the superiority gained by dirty industries increases the export of pollution-intensive products.

However, these studies are based on economic theory and the studies are a kind of theoretical extension. In this context, one of the prominent studies that empirically tested the theoretical foundations was done by Grossman & Krueger (1991). In the study, the trade route between America, which produces with the costs of environmental regulations, and Mexico, where environmental regulations are already lax, is investigated. When the factor shares between the two countries are examined, it is seen that unskilled labor is intense in the total factor costs of the products exported from Mexico to America. The effect of resource reallocation on environmental practices in modeling and estimation based on Mexico's comparative advantage in unskilled labor and America's superiority over high-skilled labor over this factor share has been examined. In this context, it has been observed that the reallocation of resources, in other words, the increase in Mexico's capital stock within the scope of FDIs has increased the manufacturing industry. This result means that the emissions that cause environmental pollution will increase.

When it is looked at more recent studies, it is seen that the relationship between FDI and the environment is the opposite in the study of Dietzenbacher & Mukhopadhyay (2006) for India. In this context, while it is expected that there will be welfare losses due to trade for developing countries within the scope of PHH, this approach is rejected for India. On the other hand, the results obtained in the study conducted by Eskeland & Harrison (2003) for developing countries cannot be evaluated as a complete integrity and it cannot be said that there is empirical evidence for PHH. However, contrary to these results, in the study conducted by Singhania & Saini (2021), it was concluded that PHH is valid in developing countries. Institutional factors have an important relationship with environmental regulations and these factors are also analyzed in the study. In this context, the results obtained about the pollution haven also include the effect of institutional factors. Chaudhry & et al. (2022), on the other hand, the theoretical structure in question was investigated for another group of developing countries, the BRICS countries. Looking at the results of the analysis, it is seen that FDIs increase environmental pollution in the determined country group, but the institutional efficiency factor contributes to mitigate this negative effect.

The pollution intensities of various industries in Türkiye's manufacturing exports and their determinants in exports were investigated by Akbostancı, Tunç & Aşık (2004). In general, it has been observed that the increase in pollution in the sectors occurs with the increase in the demand for Türkiye's export goods. In this context, it is concluded that the pollution intensity in export goods is a determinant in Türkiye's exports and it can be interpreted that the PHH is valid. However, in the study conducted by Haug & Ucal (2019) within the scope of Türkiye's export and import goods, the opposite of this inference was obtained. It has been observed that the increase in the demand for export goods does not cause environmental pollution in the long run. On the other hand, when looking at imported goods, it is seen that the increasing demand is related to environmental pollution. In this context, it can be interpreted that the PHH is invalid.

Looking at the macro scale, Mert & Caglar (2020) found a long-term asymmetric positive relationship between FDI and carbon emissions, an indicator of environmental pollution, for Türkiye, and concluded that PHH is valid. In another study by Terzi & Pata (2020), PHH was found to be valid for Türkiye and the existence of the said long-term relationship was confirmed. In another study that makes sectoral analysis for Türkiye, Tayyar (2022) examined the relationship between emissions from the energy sector and FDIs and concluded that PHH is valid in Türkiye's energy sector.

When it is looked at the studies in the literature in general, it is seen that there are many studies in which the empirical results obtained for PHH are either rejected or accepted. In other words, the results obtained are kind of mixed. In this study, emissions from Türkiye's waste sector and energy sector will be analyzed and the validity of PHH in the relevant sectors will be tested.

3. Data Set, Methodology and Results

3.1. Data Set

In this study, annual macro data were used in the testing phase of PHH for Türkiye. The time interval for the data used in the study consists of the years 1990-2020. Explanations and sources for the data used are given in the table below.

Table 1. Explanations for Variables

Variables	Abbreviations	Source
$WASTECO_2$	Co2 Emissions from Waste Sector (Million-Ton)	TURKSTAT
$ENERGYCO_2$	Co2 Emissions from Energy Sector (Million-Ton)	TURKSTAT
FDI	Foreign Direct Investment Inflows ($)	World Bank
ENUSE	Energy Consumption Per Person (Kilowatt-Hours)	Our World In Data
GDP	Gross Domestic Product Per Capita ($)	World Bank
POP	Population Growth (%)	World Bank

Table 1 shows the level values, sources and explanations of the variables used in the study. All of the subject variables were used in the model by taking their logarithms. There are two different sectors that are the subject of analysis in the study. The first of these is the waste sector and the second is the energy sector. The main purpose of these two models is to determine whether there is a relationship between emission changes in these sectors and FDIs within the scope of PHH. The model created for the waste sector is important in terms of whether the economic gain brought by the increasing waste imports in recent years causes environmental pollution. On the other hand, investigating whether there is a relationship between emissions originating from the energy sector and FDIs enables important inferences to be made about the energy transformation process that Türkiye is going through. There are variables related to the models created in Equations 1 and 2.

$$LWASTECO_2 = \alpha LFDI_t + \varphi Z_t + \varepsilon_t \quad (1)$$

$$LENERGYCO_2 = \delta LFDI_t + \gamma Z_t + \varepsilon_t \quad (2)$$

Equation 1 contains the equation of the first model, and equation 2 contains the equation of the second model. The only difference between the two models is the dependent variables, and Z_t represents the control variables used. The control variables are energy consumption (ENUSE), gross domestic product per capita (GDP) and population growth (POP). The abbreviations related to the related variables are used as in Table 1.

3.2. Methodology and Empirical Results

In this study, analyzes were carried out using time series econometric techniques. The techniques used are linear. Vector Error Correction Models (VECM) were used to investigate the long-term dynamics of the theoretical framework examined in the study. The cointegration approach created by Johansen (1995) was used as the VECM model. This approach, unlike the Engle-Granger (1987) approach, considers that in the presence of more than two variables, there may be more than one equilibrium relationship between the variables in the model. In this context, multi-equation models are used instead of single-equation error correction terms. On the other hand, the Johansen method can simultaneously evaluate the estimation of short-term dynamics and increases the efficiency of the estimations obtained.

In the Johansen approach, by accepting all variables as endogenous, the lags of the mentioned variables and the lags of other variables are made into functions in a linear form. This process creates a set of equations that is written as a vector autoregressive (VAR) equation. The VAR transformation of these equations gives the vector error correction equation. The terms of this vector are presented in the form of a lagged levels term indicating the error correction phenomenon. The Johansen approach, on the other hand, tests whether the number of co-integrating vectors and the coefficients of the level variables in the VECM equation are equal to the rank of the matrix formed. After that, the parameters presented by the obtained equation system are estimated simultaneously with the maximum likelihood (ML) method (Kennedy, 2006; Sevüktekin & Çınar, 2017).

Before proceeding with the VECM estimation, the stationarity levels of the variables used and the appropriate lag length should be checked. Then, the existence of long-term cointegration of the models used should be investigated. Finally, the appropriate short- and long-run relationship can be analyzed. Descriptive statistics about the variables used before the analysis is presented in the table below.

Table 2. Descriptive Statistics

Variables	LWASTE CO_2	LENERGY CO_2	LFDI	LENUSE	LGDP	LPOP
Mean	2.70609	5.48877	22.0603	9.62707	8.69115	0.83621
Median	2.77685	5.49899	22.7813	9.58243	8.90508	0.84040
Maximum	2.87846	5.94643	23.8164	9.99757	9.43409	1.41600
Minimum	2.40521	4.93879	20.2256	9.24428	7.71480	0.34084
Std. Dev.	0.15183	0.32108	1.36468	0.24090	0.58618	0.20399
Sum	83.8888	170.151	683.870	298.439	269.425	25.9225
Sum Sq. Dev.	0.69162	3.09291	55.8710	1.74104	10.3084	1.24837
Lag Length	**Model 1 – AIC (2):** -10.97000			**Model 2 – AIC (2)**: -9.531077		

In addition to the descriptive statistics, Table 2 also shows the appropriate lag length for the models used in the bottom line. In this context, the appropriate lag length for both models were determined as 2 according to the AIC criteria. At another stage, unit root tests were used to determine the stationarity levels in the study. In the presence of unit root in time series analysis, the results obtained in the model estimation may be false and biased. In this context, unit root tests for the variables used in the study are shown in Table 3.

Table 3. Unit Root Test Results

Test Name	Augmented Dickey Fuller (ADF) – Trend & Intercept		Phillips-Perron (PP)- Trend & Intercept	
Variable	**I (0)**	**I (1)**	**I (0)**	**I (1)**
LWASTECO₂	0.3543 (-2.435169)	0.0071*** (- 4.473606)	0.9951 (0.053251)	0.0082*** (-3.760994)
LENERGYCO₂	0.6475 (-2.331697)	0.0000*** (-5.806507)	0.3818 (-2.379826)	0.0000*** (-7.325002)
LFDI	0.7916 (-1.542163)	0.0008*** (-5.345489)	0.7916 (-1.542163)	0.0008*** (-5.345489)
LENUSE	0.4054 (-3.083918)	0.0000*** (-6.561137)	0.1120 (-3.157506)	0.0000*** (-7.559564
LGDP	0.6649 (-1.101768)	0.0003*** (-5.717674)	0.8899 (-1.211244)	0.0003*** (-5.717674)
LPOP	0.5972 (-1.959522)	0.0499** (-3.633054)	0.2417 (-2.705137)	0.048** (-3.585731)

Note: ***, ** and * shows confidence intervals, respectively. In paranthesis, t-Statistics are shown.

As can be seen in Table 3, all variables used as a result of ADF and PP unit root tests contain unit root in their level states. When the differences of the variables are taken, it is seen that the unit root disappears. In this context, it can be interpreted that the VECM model presented by Johansen can be used. If one of the variables is stationary at the level, that is, I (0), the variable creates a cointegration relationship on itself and reduces the efficiency of the Johansen method. However, before moving on to VECM model estimations, the existence of a long-term relationship between the related variables should be examined. In this context, the tests performed for both models are given in Table 4.

Table 4. Johansen Cointegration Test Results

Unrestricted Cointegration Rank Test (Trace) – Model 1				
Hypothesized No. Of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.**
None *	0.746874	92.69529	69.81889	0.0003
At most 1 *	0.632357	54.22698	47.85613	0.0112
At most 2	0.430828	26.20897	29.79707	0.1226
At most 3	0.197720	10.42894	15.49471	0.2492
At most 4 *	0.141153	4.260598	3.841465	0.0390
Unrestricted Cointegration Rank Test (Maximum Eigenvalue) – Model 1				
Hypothesized No. Of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.**
None *	0.746874	38.46831	33.87687	0.0132
At most 1 *	0.632357	28.01801	27.58434	0.0440
At most 2	0.430828	15.78003	21.13162	0.2380
At most 3	0.197720	6.168344	14.26460	0.5917
At most 4 *	0.141153	4.260598	3.841465	0.0390

Unrestricted Cointegration Rank Test (Trace) – Model 2				
Hypothesized No. Of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.**
None *	0.721993	80.99783	69.81889	0.0049
At most 1	0.470475	45.15480	47.85613	0.0878
At most 2	0.367141	27.35313	29.79707	0.0933
At most 3	0.300837	14.54293	15.49471	0.0692
At most 4 *	0.149149	4.522524	3.841465	0.0334
Unrestricted Cointegration Rank Test (Maximum Eigenvalue) – Model 2				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.**
None *	0.721993	35.84303	33.87687	0.0288
At most 1	0.470475	17.80167	27.58434	0.5117
At most 2	0.367141	12.81020	21.13162	0.4698
At most 3	0.300837	10.02041	14.26460	0.2106
At most 4 *	0.149149	4.522524	3.841465	0.0334

Note: * indicates that H_0 is rejected at %95 confidence interval.

Table 5. VECM (2) Estimation Results for Model 1

Dependent Variable: $LWASTECO_2$			
Variables	**Test Statistics**	**Standart Errors**	**Coefficient**
LNFDI	[-6.16984]	(0.11432)	0.705347***
LNENCONS	[-3.18462]	(0.64991)	2.069714***
LGDP	[5.51746]	(0.38671)	-2.133656***
LNPOP	[-1.75255]	(0.40724)	0.713700*
C	-	-	-14.80904

Variables	D(LWASTECO2)	D(LFDI)	D(LENUSE)	D(LGDP)	D(LPOP)
Cointegration Equation	-0.064266*** (0.02400) [-3.199578]	1.159605 (0.56891) [2.03831]	-0.106873 (0.05711) [-1.87139]	-0.227705 (0.21779) - 1.04555]	0.104410 (0.07283) [1.43365]
D($LWASTECO_2$(-1))	0.149285 (0.22532) [0.66255]	1.471120 (5.34101) [0.27544]	0.088404 (0.53615) [0.16489]	1.569451 (2.04462) [0.76760]	0.758227 (0.68372) [1.10897]
D($LWASTECO_2$(-2))	0.215587 (0.24572) [0.87737]	1.902740 (5.82461) [0.32667]	-0.078848 (0.58470) [-0.13485]	1.518646 (2.22975) [0.68108]	-0.163525 (0.74563) [-0.21931]
D(LFDI(-1))	-0.022164 (0.01210) [- 1.83190]	0.325643 (0.28679) [1.13548]	-0.016456 (0.02879) [-0.57159]	-0.097944 (0.10979) [-0.89213]	0.026847 (0.03671) [0.73128]
D(LFDI(-2))	-0.033971 (0.01211) [-2.80447]	0.060985 (0.28714) [0.21239]	-0.028175 (0.02882) [-0.97750]	-0.036755 (0.10992) [-0.33438]	0.018884 (0.03676) [0.51376]
D(LENUSE(-1))	-0.190136 (0.12820) [-1.48316]	5.451950 (3.03879) [1.79412]	-0.362329 (0.30505) [-1.18778]	-0.583117 (1.16330) [-0.50126]	-0.022365 (0.38901) [-0.05749]
D(LENUSE(-2))	-0.502481 (0.15997) [-3.14106]	-0.386036 (3.79199) [-0.10180]	-0.452202 (0.38066) [-1.18795]	-0.195263 (1.45163) [-0.13451]	0.241283 (0.48543) [0.49705]
D(LGDP(-1))	0.126166 (0.04887) [2.58152]	-1.338449 (1.15849) [-1.15534]	0.102220 (0.11629) [0.87898]	0.200965 (0.44349) [0.45315]	-0.051290 (0.14830) [-0.34585]
D(LGDP(-2))	0.135919 (0.04820) [2.81978]	-0.012835 (1.14259) [-0.01123]	0.141142 (0.11470) [1.23055]	0.236778 (0.43740) [0.54133]	-0.081638 (0.14627) [-0.55814]

D(LPOP(-1))	0.088362 (0.07608) [1.16142]	-0.673485 (1.80344) [-0.37344]	-0.073144 (0.18104) [-0.40403]	0.012676 (0.69038) [0.01836]	0.744834 (0.23087) [3.22627]
D(LPOP(-2))	-0.034491 (0.06309) [-0.54666]	0.667958 (1.49558) [0.44662]	0.221572 (0.15013) [1.47584]	0.502091 (0.57253) [0.87697]	-0.380850 (0.19145) [-1.98924]
C	0.020971 (0.00665) [3.15560]	-0.073876 (0.15753) [-0.46898]	0.045481 (0.01581) [2.87616]	0.030216 (0.06030) [0.50106]	-0.027190 (0.02017) [-1.34833]

Note: ***, ** and * shows confidence intervals %99, %95 and, %90 respectively. In parentheses standard errors and in brackets, t-statistics are shown.

According to the results in Table 4, the H_0 hypothesis is rejected, showing that there is no cointegrating equation number in the model, according to both max-eigenvalue statistical values and trace statistics values.

The VECM (2) analysis results obtained for Model 1, which is approximately obtained from the long-term cointegration relationship, are given in Table 5. Considering the coefficient obtained for the LFDI variable, it is seen that the results are significant in the 99% confidence interval. In this context, a positive relationship has been identified between carbon emissions from the waste sector and FDIs. As the theoretical structure indicates, it can be interpreted that the PHH hypothesis is valid for Türkiye's waste sector. Coefficient of error correction vector for Model 1 is less than 0, greater than -1 and statistically significant. In this sense, approximately 6% of a short-term shock in emissions in the waste sector is eliminated in the next period.

Table 6. VECM (2) Estimation Results for Model 2

Dependent Variable: $LENERGYCO_2$			
Variables	**Test Statistics**	**Standart Errors**	**Coefficient**
LNFDI	[-5.72496]	(0.08401)	0.480938***
LNENCONS	[-4.84796]	(0.42799)	2.074876***
LGDP	[4.39426]	(0.28777)	- 1.264542***
LNPOP	[-3.83977]	(0.25284)	0.970830***
C	-	-	- 14.90169

Variables	D(LENERGYCO2)	D(LFDI)	D(LENUSE)	D(LGDP)	D(LPOP)
Cointegration Equation	-0.202021*** (0.02400) [-3.199578]	1.159605 (0.56891) [2.03831]	-0.106873 (0.05711) [-1.87139]	-0.227705 (0.21779) - 1.04555]	0.104410 (0.07283) [1.43365]
D($LWASTECO_2$(-1))	0.149285 (0.22532) [0.66255]	1.471120 (5.34101) [0.27544]	0.088404 (0.53615) [0.16489]	1.569451 (2.04462) [0.76760]	0.758227 (0.68372) [1.10897]
D($LWASTECO_2$(-2))	0.215587 (0.24572) [0.87737]	1.902740 (5.82461) [0.32667]	-0.078848 (0.58470) [-0.13485]	1.518646 (2.22975) [0.68108]	-0.163525 (0.74563) [-0.21931]
D(LFDI(-1))	-0.022164 (0.01210) [-1.83190]	0.325643 (0.28679) [1.13548]	-0.016456 (0.02879) [-0.57159]	-0.097944 (0.10979)[- 0.89213]	0.026847 (0.03671) [0.73128]
D(LFDI(-2))	-0.033971 (0.01211) [-2.80447]	0.060985 (0.28714) [0.21239]	-0.028175 (0.02882) [-0.97750]	-0.036755 (0.10992) [-0.33438]	0.018884 (0.03676) [0.51376]
D(LENUSE(-1))	-0.190136 (0.12820) [-1.48316]	5.451950 (3.03879) [1.79412]	-0.362329 (0.30505) [-1.18778]	-0.583117 (1.16330) [-0.50126]	-0.022365 (0.38901) [-0.05749]

D(LENUSE(-2))	-0.502481 (0.15997) [-3.14106]	-0.386036 (3.79199) [-0.10180]	-0.452202 (0.38066) [-1.18795]	-0.195263 (1.45163) [-0.13451]	0.241283 (0.48543) [0.49705]
D(LGDP(-1))	0.126166 (0.04887) [2.58152]	-1.338449 (1.15849) [-1.15534]	0.102220 (0.11629) [0.87898]	0.200965 (0.44349) [0.45315]	-0.051290 (0.14830) [-0.34585]
D(LGDP(-2))	0.135919 (0.04820) [2.81978]	-0.012835 (1.14259) [-0.01123]	0.141142 (0.11470) [1.23055]	0.236778 (0.43740) [0.54133]	-0.081638 (0.14627) [-0.55814]
D(LPOP(-1))	0.088362 (0.07608) [1.16142]	-0.673485 (1.80344) [-0.37344]	-0.073144 (0.18104) [-0.40403]	0.012676 (0.69038) [0.01836]	0.744834 (0.23087) [3.22627]
D(LPOP(-2))	-0.034491 (0.06309) [-0.54666]	0.667958 (1.49558) [0.44662]	0.221572 (0.15013) [1.47584]	0.502091 (0.57253) [0.87697]	-0.380850 (0.19145) [-1.98924]
C	0.020971 (0.00665) [3.15560]	-0.073876 (0.15753)[-0.46898]	0.045481 (0.01581) [2.87616]	0.030216 (0.06030) [0.50106]	-0.027190 (0.02017) [-1.34833]

Note: ***, ** and * shows confidence intervals %99, %95 and, %90 respectively. In parenthesis standard errors and in brackets t-statistics are shown.

The results obtained in Model 2 are given in Table 6. When the results obtained are examined, it is seen that parallel results with model 1 are obtained in terms of coefficients. Although the coefficient obtained for the LFDI variable is positive, the value of the coefficient is lower than model 1. However, the results obtained are statistically significant in the 99% confidence interval. In this context, it can be interpreted that the PHH regarding Türkiye's energy sector is valid. The results obtained are consistent with Tayyar (2022). At the same time, when the error correction term coefficient is examined, the result obtained is less than 0, greater than -1 and statistically significant. In this context, approximately 20% of a short-term shock in the energy sector is eliminated in the next period. Looking at Table 7, there are diagnostic tests obtained as a result of the VECM (2) model used for both models. According to the results, both models are normally distributed and there is no heterogeneity and autocorrelation problem.

Table 7. Diagnostic Tests

Model 1						
LM Autocorrelation Test						
Lag	**LRE* stat**	**df**	**Prob.**	**Rao F-stat**	**df**	**Prob.**
1	19.50958	25	0.7721	0.714055	(25, 27.5)	0.8004
2	27.31406	25	0.3404	1.115931	(25, 27.5)	0.3880
Jarque-Bera Normality Test						
Component	**Jarque-Bera**	**df**	**Prob.**			
Joint	2.420990	10	0.9920			
White Heteroskedasticity Test						
Chi-sq	**df**	**Prob.**				
330.5466	330	0.4812				
Model 2						
LM Autocorrelation Test						
Lag	**LRE* stat**	**df**	**Prob.**	**Rao F-stat**	**df**	**Prob.**
1	10.07757	25	0.9964	0.324355	(25, 27.5)	0.9971
2	17.79872	25	0.8508	0.636197	(25, 27.5)	0.8710
Jarque-Bera Normality Test						
Component	**Jarque-Bera**	**df**	**Prob.**			
Joint	3.591312	10	0.9639			
White Heteroskedasticity Test						
Chi-sq	**df**	**Prob.**				
351.8347	330	0.1955				

When the control variables are examined for both models, the signs of all variables are the same in both models. Energy consumption and population growth have a positive relationship with carbon emissions from related sectors. Energy consumption increases carbon emissions at almost the same rate in both sectors. In this context, it can be interpreted that the energy used is not carbon neutral and increases carbon emissions. Findings Karasoy (2019); It is supported by the findings obtained by Say & Yücel (2006). On the other hand, the coefficient of the population is larger in model 2. In this sense, the increase in energy demand in parallel with population growth and the creation of carbon emissions by the energy used can be considered as the natural reason for the population increase to increase carbon emissions. On the other hand, when the waste sector is considered, it is expected that the population increase will increase the amount of waste. It can be commented that the recycling of the resulting wastes is not sufficient and that these wastes increase carbon emissions. The results that the population increase increases the carbon emission are in parallel with Karakaya, Bostan & Özçağ (2019).

Finally, it is seen that the sign of the gross domestic product variable is negative in both models. This result contradicts the basic prediction of approaches such as the Environmental Kuznets Curve (EKC). Contrary to this approach, which predicts that the demand for goods that increase environmental quality will increase as income increases, it is seen that carbon emissions in these sectors decrease as per capita income increases in the relevant time period. Considering the current data for Türkiye, the share of liquid fuels such as oil, especially in electricity generation, decreased to 1% as of 2020, while the share of natural gas increased to 48% and renewable energy sources to 16% (TEİAŞ, 2021). This transformation between 1970 and 2020, integrated with economic growth, may have contributed to the reduction of carbon emissions in the relevant sectors.

After confirming the PHH for both sectors investigated in the model, the Toda-Yamamoto test was used to measure the causality of the said relationship. Although this test is Granger causality-based, it can be applied without looking for stationarity in the level. For the test in question, dmax (maximum stationary level of variables used) was determined as 1, lag length was determined as k= 2 and the equations were solved as dmax+k=3. Then, causality was calculated with the Modified Wald test among the obtained equations. The causality of the objective variables is shown in Table 8.

Table 8. Toda-Yamamoto Casuality Test

Causality	Chi-Square	Prob.	Status
LFDI → $LWASTECO_2$	6.242956	0,044091952	H_0 reject. **
$LWASTECO_2$ → LFDI	13,72558	0,001045992	H_0 reject. ***
LFDI → $LENERGYCO_2$	5,831857	0,054153726	H_0 reject. *
$LENERGYCO_2$ → LFDI	27,36195	1,14401E-06	H_0 accept.

Note: ***, ** and * shows H_0 is rejected at %99, %95 and %90 confidence intervals, respectively.

The H_0 hypothesis shown in Table 8 states that there is no causality between the variables. Looking at the findings, it is seen that there is a positive bidirectional causality between carbon emissions in the waste sector and FDIs. On the other hand, when we look at the energy sector, it is seen that there is a one-way causality from FDIs to carbon emissions in the energy sector. The fact that there is causality to emissions from FDIs in both sectors reinforces the validation for PHH.

4. Conclusion

In this study, the PHH hypothesis, which reveals the positive relationship between environmental pollution and FDIs in developing countries, is tested for Türkiye, covering the years 1990-2020. In the light of the findings, it was concluded that PHH is valid for both sectors. In the absence of environmental regulations, the economic profit of adopting polluting production methods is spread to those who carry out this activity, and the cost is spread to the whole society. In this context, the benefit of foreign investments in the relevant sectors reduces the benefit to those who make this investment, but to the whole society.

While political practices to increase environmental quality determine the standards and rules that companies must comply with, the abatement costs of companies operating in the sectors are increasing. These increasing costs are essentially parallel to the increase in the total benefit of the society. In this context, it is important to target the point where the abatement costs that the companies experience in their activities to reduce the current environmental pollution and the benefit gained by the individuals in the society are in an optimal balance. For this reason, policy makers can reduce emissions by choosing carbon tax and tradable emission rights and cost factors of similar companies in the relevant sectors, as well as policy practices that can maximize social welfare.

References

- Akbostanci, E., Tunc, G. I., & Türüt-Aşik, S. (2007). Pollution haven hypothesis and the role of dirty industries in Türkiye's exports. Environment and Development Economics, 12(2), 297-322.
- Chaudhry, I. S., Yin, W., Ali, S. A., Faheem, M., Abbas, Q., Farooq, F., & Ur Rahman, S. (2021). Moderating role of institutional quality in validation of pollution haven hypothesis in BRICS: a new evidence by using DCCE approach. Environmental Science and Pollution Research, 1-10.
- Chowdhury, A., & Mavrotas, G. (2006). FDI and growth: what causes what?. World economy, 29(1), 9-19.
- Copeland, B. R., & Taylor, M. S. (1994). North-South trade and the environment. The quarterly journal of Economics, 109(3), 755-787.
- Dickey, D. A., and Fuller, W. A. (1979), "Distribution of the Estimators for
- Autoregressive Time Series With a Unit Root," Journal of the American Statistical Association, 74, 427A31.
- Dietzenbacher, E., & Mukhopadhyay, K. (2007). An empirical examination of the pollution haven hypothesis for India: towards a green Leontief paradox?. Environmental and Resource Economics, 36, 427-449.
- Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. Econometrica: journal of the Econometric Society, 251-276.
- Eskeland, G. S., & Harrison, A. E. (2003). Moving to greener pastures? Multinationals and the pollution haven hypothesis. Journal of development economics, 70(1), 1-23.
- Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement.
- Haug, A. A., & Ucal, M. (2019). The role of trade and FDI for CO2 emissions in Türkiye: Nonlinear relationships. Energy Economics, 81, 297-307.
- Johansen, S. (1995). Identifying restrictions of linear equations with applications to simultaneous equations and cointegration. Journal of econometrics, 69(1), 111-132.

- Karagöz, K. (2007). TÜRKİYE'DE DOĞRUDAN YABANCI YATIRIM GİRİŞLERİNİ BELİRLEYEN FAKTÖRLER: 1970–2005. Yaşar Üniversitesi E-Dergisi, 2(8), 929-948.
- Karakaya, E., Bostan, A., & Özçağ, M. (2019). Decomposition and decoupling analysis of energy-related carbon emissions in Türkiye. Environmental Science and Pollution Research, 26, 32080-32091.
- Karasoy, A. (2019). Drivers of carbon emissions in Türkiye: considering asymmetric impacts. Environmental Science and Pollution Research, 26(9), 9219-9231.
- Kennedy, P. (2008). A Guide to Econometrics. 6. Edition, Blackwell Publishing.
- McGuire, M. C. (1982). Regulation, factor rewards, and international trade. Journal of public economics, 17(3), 335-354.
- Mert, M., & Caglar, A. E. (2020). Testing pollution haven and pollution halo hypotheses for Türkiye: a new perspective. Environmental Science and Pollution Research, 27, 32933-32943.
- Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. Biometrika, 75(2), 335-346.
- Rezza, A. A. (2013). FDI and pollution havens: Evidence from the Norwegian manufacturing sector. Ecological Economics, 90, 140-149.
- Say, N. P., & Yücel, M. (2006). Energy consumption and CO2 emissions in Türkiye: Empirical analysis and future projection based on an economic growth. Energy policy, 34(18), 3870-3876.
- Sevüktekin, M., & Çınar, M. (2017). Ekonometrik zaman serileri analizi: EViews uygulamalı. Fifth Edition, Dora Publishing.
- Siebert, H. (1977). Environmental quality and the gains from trade. Kyklos, 30(4), 657-673.
- Singhania, M., & Saini, N. (2021). Demystifying pollution haven hypothesis: Role of FDI. Journal of Business Research, 123, 516-528.
- Tayyar, A. E. (2022). Testing Pollution Haven and Pollution Halo Hypotheses for the Energy Sector: Evidence from Türkiye. Business and Economics Research Journal, 13(3), 367-383.
- Terzi, H., & PATA, U. (2020). Is the pollution haven hypothesis (PHH) valid for Türkiye?. Panoeconomicus, 67(1).
- Toda, H.Y. & Yamamoto (1995) Statistical inference in Vector Autoregressions with possibly integrated processes. Journal of Econometrics, 66, 225-250.
- Turkish Electricity Transmission Corporation (TEİAŞ) (2021). Türkiye Electricity Generation-Transmission Statistics for the Year 2021, https://www.teias.gov.tr/turkiye-elektrik-uretim-iletim-istatistikleri, Access Date: 16.05.2023
- Wang, H., Dong, C., & Liu, Y. (2019). Beijing direct investment to its neighbors: A pollution haven or pollution halo effect?. Journal of Cleaner Production, 239, 118062.
- Zarsky, L. (1999). Havens, halos and spaghetti: untangling the evidence about foreign direct investment and the environment. Foreign direct Investment and the Environment, 13(8), 47-74.