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Tuba Yildiz, Ünal Arslan, Yıldız Sağlam Çeliköz

Hatay Mustafa Kemal University
Turkey

THE RELATIONSHIP BETWEEN HUMAN CAPITAL AND ENVIRONMENTAL DESTRUCTION: THE CASE OF EUROPEAN COUNTRIES

Purpose. *This study aims to examine the relationship between human capital and environmental destruction.*

Methodology / approach. *The analysis includes 56 years between 1961 and 2017 for 14 selected European countries. In the model established for the variables, the ecological footprint is used as the dependent variable, human capital and real national income per capita are used as independent variables. To select the appropriate test method in the analysis, we used the CADF panel unit root test, which considers the cross-sectional dependence. The Pooled Mean Group was used for model estimation.*

Results. *In the study, it is emphasized that human capital has an important contribution to reducing the ecological footprint as an indicator of environmental pollution. According to the results of the PMG co-integration analysis, the increase in human capital reduces the ecological footprint in European countries. Since the European countries are developed ones, the availability of a good educational infrastructure is an important factor. It increases human capital. In addition, the high level of education and welfare in European countries is effective in increasing the number of environmentally sensitive individuals. This increases the environmental quality and therefore is an important factor in reducing the ecological footprint.*

Originality / scientific novelty. *There are no studies in the literature examining the relationship between human capital and the ecological footprint of European countries. Therefore, this study closes a gap in the literature and takes its originality from the relationship between human capital and ecological footprint in European countries.*

Practical value / implications. *The practical value of the results is that human capital reduces the ecological footprint by protecting natural resources, exhibiting a more environmentally friendly behavior, and realizing production that will minimize the damage to the environment.*

Key words: *ecological footprint, environment, human capital, economic growth, European countries.*

Introduction and review of the literature. The traditional production system changed with the industrial revolution, which began in the middle of the 19th century. With the industrial revolution, the marketing techniques used in connection with increase in production carried the consumption to larger dimensions. This increase in production is expressed as "economic growth", and consumption has caused more significant environmental damage than expected. The excessive use of natural resources in the regions due to the industrialization caused by the industrial revolution intensified and brought natural destruction (Kayan, 2018). On the other side, with the globalization that started in the 1980s, many economies desired to achieve economic growth at the expense of the deterioration of the environment.

Naturally, the competition between economies intensified. In the face of increasing competition, all countries have used their natural resources to achieve a higher growth rate. The increasingly competitive environment with globalization has led all economies to use natural resources more for more growth and profit without seeing the environmental destruction. However, this excessive use of natural resources has led to environmental pollution, including soil, water, and air (Majeed & Mazhar, 2020; Saleem et al., 2019). According to Shahzadi et al. (2019), globalization contributes to development undoubtedly, and it creates negative externalities through environmental degradation and ecological contamination. Therefore, the world has faced a sizeable environmental degradation problem, one of the greatest dangers that countries worldwide are currently facing (Al-Mulali et al., 2014; El Alaoui, 2017).

Environmental degradation and climate change are among the most significant challenges facing all living things on earth today (Rafique et al., 2021). The effects of climate change or environmental degradation on the world can be listed as follows: melting glaciers, increasing air and ocean temperatures, increasing sea levels, decreasing agricultural production, wildlife extinction, unpredictable precipitation and changing climates, and workforce degradation (Danish et al., 2019). Recently, there has been a reasonably large research literature on climate change or environmental degradation, that utilized different proxies in analyses. Greenhouse gas emissions (GHGs) have central importance among these different proxies (Rafique et al., 2021). However, in the literature, most carbon dioxide (CO_2) emissions have been used as a representative of environmental degradation since carbon dioxide emissions have the highest share in GHG emissions (Zafar et al., 2019). Carbon dioxide emissions mainly were used to test the Environmental Kuznets Curve (EKC) (Saleem et al., 2019), which indicates that in the early stages income growth increases pollution, but after reaching a threshold level, income growth reduces pollution (Mahmood et al., 2019).

However, using only carbon dioxide emissions as a single polluting factor to test the EKC hypothesis may give misleading results to get the overall environmental degradation (Saleem et al., 2019) because the relationship expressed with EKC does not take into account the direct effects of environmental degradation on the existing human capital stock (Sapci & Shogren, 2018). For example, the EKC may apply to pollute emissions but not to resource stocks such as soil stock, forestry stock, mineral stock, and oil stock (Ulucak & Lin, 2017). On the other hand, the ecological footprint is a comprehensive and reliable environmental indicator that can be compared on a country-by-country basis. Since it can reveal the impact of human activities on the ecosystem in terms of soil, air, and water, it can be said that the ecological footprint is preferred over carbon dioxide emissions in recent academic studies (Ahmed & Wang, 2019).

According to Folloni and Vittadini (2010), the first one who tried to define the concept of human capital was W. Petty, who lived in the 1623–1687 period. Petty (1690) described labor as the “father of wealth” and argued that it was as important as land and population in determining a nation’s wealth. Therefore, he stated that the value of labor should not be overlooked when estimating national wealth (Folloni & Vittadini, 2010). This thought led Petty to place a monetary value on laborers (Kiker, 1966). After Petty, Cantillon (1680–1734) evaluated the human capital as the cost of maintaining the slave and his offspring instead of the earnings that the slave created. Smith (1723–1790), instead of being interested in determining the value of human capital, was interested in the differences of wages in different fields of work and tried to explain these differences by human capital term (Hofflander, 1966). As a result, A. Smith never used the concept of "human capital" but instead he used the concept of the 'value' of acquired skills and abilities in the concept of capital (Folloni & Vittadini, 2010). Farr (1853) devised the method used to find the capital or money value in 1853. This method is considered to be the first accurate scientific procedure many economists use (Kiker, 1966). Engel (1883) considers investment expenditures for human beings as productive factors. He was mainly concerned with the cost of food invested in growing a child. Whereas Nicholson (1891) looked at the expense of education, not feeding the child, as the most significant investment in human productivity (Machlup, 1982). However, Mill (1848) stated that man could not be defined as capital. He has questioned whether there is a market for acquired talents and skills to determine their value and argued that since acquired skills are costly and make people more productive, they should be treated as capital. Thus, he took a position similar to that of A. Smith (Folloni & Vittadini, 2010). By separating "personal" capital from "material" capital, A. Marshall argued that personal capital is primarily generated through investment by parents who pay for their children's education and care (Machlup, 1982).

In short, the concept of human capital was introduced into the literature by economists such as Petty (1690), Smith (1776/1937), Farr (1853), and Engel (1883). These economists defined human capital as the abilities acquired by individuals and claimed that it was equal to traditional assets such as land and fixed capital, and an essential element of national wealth (Liu & Fraumeni, 2016). The subject of human capital was discussed and developed in detail by economists such as Schultz (1961), Becker (1964), and Mincer (1974), who were members of the Chicago School in the mid-20th century (Kucharčíkova, 2011; Alika & Aibieyi, 2014). The concept of human capital was largely forgotten until it was elaborated on in the mid-20th century by economists of the Chicago School, such as Schultz (1961), Becker (1964), and Mincer (1974) (Laroche et al., 1999). However, with the work of these economists, the concept of human capital was re-accepted in the 1960s, and since then, its importance in economic growth has been emphasized (Liu & Fraumeni, 2016).

OECD (2001) defined human capital as "the knowledge, skills, competencies, and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being". As can be seen, OECD, while emphasizing the economic dimension in the definition of human capital, also included personal and social concepts.

The ecological footprint concept was first used in economics by economists W. Rees & M. Wackernagel in the 1990s. It was introduced and conceptualized to measure the total pressure of human consumption on the inhabited areas of the earth (Zafar et al., 2019; Ahmed & Wang, 2019).

An ecological footprint is a tool used to measure human demand on nature (Meena & Yadav, 2019) or to represent the fertile land area that may be needed to regenerate the resources consumed by the human population (Sonu et al., 2011). Alternatively, in the words of Kitzes et al. (2007), the ecological footprint is a resource accounting tool that measures how much bio-efficient land and the sea is on earth and how much of this area is allocated for human use.

As seen in the literature, there is more than one definition of the ecological footprint (Majeed & Mazhar, 2020). These definitions were summarized in four items: 1. It demonstrates the total carrying capacity of the world; 2. It follows the world's regenerative capacity demand; 3. It provides an assessment of the demand for available natural resources; 4. It monitors the pressure of human activities on environmental services.

Based on the classification of the economists in the literature (Ahmed et al., 2020b; Ahmed et al., 2019; Wackernagel et al., 2002; Sonu et al., 2011) seven types of land areas that bring together the consumption types are selected to be used in the calculation of the ecological footprint:

1. Croplands: areas where food, animal feed, fiber, oil, and rubber can be grown (Wackernagel et al., 2002);

2. Grazing lands: land is required for meat, leather, wool, and milk (Wackernagel et al., 2002). In short, the required land for livestock (Ahmed et al., 2019);

3. Forests: a required area for paper and wood production (Ahmed et al., 2019) excluding firewood (Sonu et al., 2011);

4. Forests: area is required for fuelwood (Sonu et al., 2011);

5. Forests: the land area required to absorb carbon dioxide emissions from fossil fuel use (Sonu et al., 2011) is called a Carbon footprint (Ahmed et al., 2020b);

6. Build uplands: area needed for infrastructure and housing (Ahmed et al., 2019). It is called an infrastructure footprint (Ahmed et al., 2020b);

7. Fishing grounds: area for seafood production and freshwater fishing (Wackernagel et al., 2002).

Although the factors affecting the ecological footprint have been addressed in recent empirical studies, human capital has received little attention among these factors. Human capital is based on education and the return rate of education. Since most environmental problems are caused by humans, it can be said that human capital can reduce its ecological footprint (Ahmed & Wang, 2019).

However, human capital has an impact on the environment and its sustainability. For example, human capital can help economies conserve energy, conserve natural resources, and reduce the amount of waste in landfills by promoting the use of renewable energy products and recycling. It also encourages people to comply with environmental rules and regulations, thus improving environmental quality (Majeed & Mazhar, 2020).

In the literature, human capital is generally classified into three types general, firm-specific, and task-specific human capital (Bano et al., 2018). General human capital is the general knowledge and skill obtained from general education and working experience and it is transferable between firms, jobs, and industries. Firm-specific human capital is acquired through firm-related education, knowledge, and skills. Task-specific human capital is also acquired through task-related education, experience, skills, and knowledge.

Improvement in human capital reduces the use of fossil fuels and improves environmental quality by controlling the high carbon emissions that will take place in the production process without affecting economic growth in any way (Saleem et al., 2019). It is believed that human capital can provide the potential to be sensitive to environmental pollution and thus increase people's ability to work efficiently. It is also stated that human capital can play an essential role in reducing carbon emissions by increasing energy efficiency (Bano et al., 2018).

Table 1 indicates the empirical studies which examined the relationship between human capital (HC) and ecological footprint (ECO) in the literature.

Table 1

Studies examining human capital and ecological footprint

Author(s), Date	Country	Sample Period	Method	Results
1	2	3	4	5
Chen et al., 2021	40 high income, 34 middle income, 36 low income, 27 large-sized population, 55 medium-sized population, 28 small-sized population	1990–2016	Panel cointegration	HC affects negatively ECO in high-income countries and no significant relationship between HC and ECO in middle-income countries. HC affects positively ECO in low-income countries and large-sized populations. HC negatively affects ECO after a certain level in medium-sized and small-sized populations
Langnel et al., 2021	ECOWAS member countries	1984–2016	Panel cointegration	HC negatively impacts ECO in Burkina Faso and The Gambia. Nevertheless, there is no relationship between HC and ECO in other countries
Nathaniel, 2021	G7 countries	1980–2016	Panel cointegration	HC negatively affects the ECO in the long run. While HC contributes to reducing environmental degradation in the USA, Japan, Germany, and Canada, it has a meaningless effect in France and the United Kingdom. There is a bidirectional causality relationship between ECO and HC
Nathaniel et al., 2021a	South Africa	1970–2016	ARDL, Toda-Yamamoto causality	HC negatively affects the ECO. There is a unidirectional relationship from HC to ECO

Continuation of Table 1

1	2	3	4	5
Nathaniel et al., 2021b	BRICS	1992–2016	Panel cointegration	HC reduces ECO in all BRICS countries except China. There is a bidirectional causality relationship between ECO and HC
Zia et al., 2021	China	1985–2018	Dynamic simulated ARDL model	HC positively affects the ECO in China
Ahmed et al., 2020a	China	1970–2016	Bayer-Hanch cointegration ARDL, Bootstrap causality	HC negatively affects ECO in China. There is no causal relationship between HC and ECO in China
Ahmed et al., 2020b	G7 countries	1971–2014	Panel cointegration Panel causality	There is a negative relationship between HC and ECO, and HC reduces the ECO. There is a causal relationship between HC and ECO
Ahmed & Wang, 2019	India	1971–2014	Bayer-Hanch cointegration ARDL, Granger causality	HC negatively affects ECO footprint. There is a unidirectional relationship from HC to ECO in the long and short run
Danish et al., 2019	Pakistan	1971–2014	Bayer-Hanch cointegration ARDL, Granger causality	There is no long-term relationship between HC and ECO, and HC positively affects ECO in the short run, and a bidirectional causality relation-ship exists between ECO and HC
Majeed & Mazhar, 2020	20 upper-income 36 middle-income and 20 low-income countries	1961–2018	Panel cointegration	Results show that HC negatively and significantly affects ECO in all countries irrespective of their development levels
Shujah-ur-Rahman et al., 2019	CEECs (Central and Eastern European Countries)	1991–2014	Panel cointegration Panel causality	HC has a negative and statistically significant impact on ECO. There is a bidirectional causality relationship between ECO and HC
Saleem et al., 2019	BRICS	1991–2014	Panel cointegration Panel causality	HC hurts ECO in BRICS countries. A two-way association exists between ECO and HC
Zafar et al., 2019	USA	1970–2015	ARDL, Granger causality	HC negatively affects the ECO. A bidirectional causal relationship exists between HC and ECO in the USA

Source: formed by the authors based on a literature review.

As can be seen from the Table, HC affects ECO negatively and significantly. However, in the studies conducted by Zia et al. (2021) for the Chinese economy, Danish et al. (2019) for Pakistan, and Chen et al. (2021) for low-income and high-population countries, a positive and significant relationship was found.

Also, a bidirectional causality relationship is found between HC and ECO in the studies of Danish et al. (2019), Nathaniel et al. (2021b), Shujah-ur-Rahman et al. (2019), Ahmed et al. (2020b), Saleem et al. (2019), Zafar et al. (2019). There is a unidirectional relationship from HC to the ECO in the studies of Nathaniel et al. (2021a); Ahmed & Wang (2019). There is no causal relationship between HC and ECO in the study of Ahmed et al. (2020a). At the same time, in the literature known to us, there are no studies that would examine the relationship between human capital and the ecological footprint of European countries.

The purpose of the article. This study aims to examine the relationship between human capital and environmental destruction.

Methodology and data. This study analyzed the relationship between HC and ECO using annual data from 14 European countries[1] between 1961 and 2017. Data representing ecological footprint (ECO) and real gross domestic product (real GDP – RGDP) were obtained from world Penn Tables as seen in our study. As can be seen, our study includes a large number of observations (T) and a large number of groups (N). Therefore, panel data models will be used in our analysis. In the model established for the variables, the ecological footprint is used as the dependent variable, human capital and real national income per capita are used as independent variables.

To obtain reliable results in panel data analysis, as in time series analysis, it is necessary to test whether the data are stationary or not (Yalçınkaya & Kaya, 2017). While testing whether the series are stationary and choosing the appropriate model to be used, it is necessary to determine whether there is a cross-sectional dependence between the units. If there is a cross-sectional dependence between the units, using “second generation panel unit root tests” in stationarity tests will yield more accurate results (Erkişi & Ceyhan, 2020).

Results and discussion. Today, environmental problems appear as follows: Depletion of the ozone layer, air pollution, change of seasons, melting of glaciers, pollution of seas and lakes, in addition to many other problems. Naturally, these environmental problems endanger the living space of human beings. For this reason, the UN Framework Convention on Climate Change (UNFCCC) was adopted in 1992 and entered into force in 1994. According to this contract, the parties to the contract would reduce their greenhouse gas emissions. With the Kyoto Protocol, which was signed in 1997 and entered into force in 2005, a distinction was made between developed and developing countries. It was aimed for developed countries to reduce the greenhouse gas emitted into the atmosphere to 5 %. On the other hand, the Paris Agreement, which was signed in 2015 and entered into force in 2016, was aimed to reduce global warming. As can be understood from the agreements concluded on environmental issues, the environmental problem has been expanding in scope day by

[1] Austria, Belgium, Germany, Denmark, Spain, France, United Kingdom, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Romania.

day. So, this section presents the results of an empirical study of the relationship between human capital and ecological footprint for 14 selected European Union countries.

Cross-Sectional Dependency. Different tests are used in the literature depending on the time (T) and cross-section (N) dimensions of the series in determining the cross-sectional dependence. The first of these is the Breusch & Pagan (1980) Lagrange Multiplier (LM) test used in case T > N (Çınar, 2011). The LM statistics used to determine the cross-section dependency can be written as follows:

$$LM = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \qquad (1)$$

In the above equation, $\hat{\rho}_{ij}^2$ is the simple correlation coefficient between the residuals obtained from the Least Squares estimation of each equation, and under the null hypothesis, there is no correlation between the residuals. LM shows the X2 distribution for T→α while N is constant (Pesaran, 2004).

Since the LM test is not applicable when Pesaran (2004) developed the Breusch and Pagan test and suggested the CDLM test, which can be applied in cases N = T (Pesaran, 2004).

$$CD_{lm} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T\hat{\rho}_{ij}^2 - 1\right) \qquad (2)$$

However, in cases where N > T, the CDLM test shows significant distortions, and the deviations increase as N gets more extensive, which may occur in some empirical studies. Therefore, Pesaran (2004) developed the CD test for cross-section dependence in cases where N > T. This test seen in equation (3) is used when N is more significant than T (N > T). Koçbulut & Barış (2016), Pesaran (2004) test cross-sectional dependency as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left\{\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij}\right\} \qquad (3)$$

However, Pesaran (2004) shows that under a broad class of panel data models, including a heterogeneous dynamic model with multiple breaks in slope coefficients and error variances, the CD statistic has exactly zero mean for constant values of T and N. To eliminate the drawbacks of all the tests mentioned above Pesaran et al. (2008) developed the LMadj (Bias-Adjusted Cross-Sectional Dependency Lagrange Multiplier) test, which can be written as below:

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^2 \frac{(T-k)\hat{\rho}_{ij}^2 - \mu_{Tij}}{\vartheta_{Tij}}, \qquad (4)$$

where k represents the regressors number, while μ_{Tij} represents the average, and ϑ_{Tij} represents the variance. According to the obtained test results, cross-section dependence is accepted if the probability value is less than 0.05.

The cross-sectional dependence results obtained from the three models for the variables used in this study are shown in Table 2. According to the results of the tests, there is a cross-section dependency in the variables and models. Moreover, due to the cross-sectional dependency, it was used the second-generation unit root test, which takes into account the cross-sectional dependence. As it can be seen in the last two rows of Table 2, the delta and adjusted delta, which indicate the slope homogeneity test results, are included in the table. Since the probability values of the homogeneity tests obtained were less than 0.05, the H0 hypothesis claiming that the slope coefficient was homogeneous was firmly rejected. It was concluded that the constant and slope coefficients in the model were heterogeneous.

Table 2

Cross-Sectional Dependency Test

Variables and Models	Breusch and Pagan (1980) LM Test	Pesaran (2004) CDLM Test	Pesaran et al. (2008) LMadj	Result Cross-Sectional Dependency
ECO	1753 (0.001)	36.15 (0.001)	5222 (0.001)	Accepted
HC	1641 (0.001)	17.83 (0.001)	486.8 (0.001)	Accepted
RGDP	2320 (0.001)	39.66 (0.001)	700.7 (0.001)	Accepted
Model	1386 (0.001)	31.47 (0.001)	393.6 (0.001)	Accepted
Model				
$\tilde{N}$		35.020 (0.000)		
$\tilde{N}_{adj}$		36.317 (0.000		

Note. The values in parentheses show the probability value (*p*-value).
Source: authors' calculations.

Homogeneity Test. This study determined whether the slope of the panel data models is homogeneous or not by Pesaran & Yamagata (2008) Delta test. Pesaran & Yamagata's (2008) Delta test is an improved version of the homogeneity test used by Swamy (1970) when estimating the regression equation with cross-sectional time series. The Delta test can be written as follows:

$$\tilde{N} = \sqrt{N}\left(\frac{N^{-1}\,\tilde{S} - k}{\sqrt{2k}}\right) \qquad (5)$$

$$\tilde{N}_{adj} = \sqrt{N}\left(\frac{N^{-1}\,\tilde{S} - E(\tilde{Z}_{iT})}{\sqrt{Var}(\tilde{Z}_{iT})}\right) \qquad (6)$$

Panel Unit Root Test. Since the panel data used in the study included cross-section dependence, Pesaran's (2007) Cross-Sectionally Augmented Dickey-Fuller (CADF) test, which is one of the second generation unit root tests, was used. With this test, the "Panel contains unit root H0 hypothesis" is tested against the "alternative Ha hypothesis that the panel is stationary" (Erkişi & Ceyhan, 2020). In this test, CADF test statistics values are calculated for all units that make up the panel. Then, by taking the arithmetic average of these tests, the statistical values of the CIPS (Cross-Sectionally Augmented IPS) test are calculated for the panel in general. However, while the results of the CADF test make a stationarity analysis for each country that makes up the panel, the results of the CIPS test make a stationarity analysis for the panel in general (Yalçınkaya & Kaya, 2017).

$$\Delta y_{it} = a_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + e_{it} \quad (7)$$

CADF test statistics are calculated as follows:

$$t_i(N,T) = \frac{\Delta Y_i' \bar{M}_W Y_{i,-1}}{\hat{\sigma}_i (Y_{i,-1}' \bar{M}_W Y_{i,-1})^{\frac{1}{2}}} \quad (8)$$

The CIPS statistic can be expressed as follows:

$$CIPS(N,T) = N^{-1} \sum_{i=1}^{N} t_i(N,T) \quad (9)$$

A stability test was performed by comparing the CIPS statistics calculated for 14 developed countries in the study with Pesaran's (2007) critical table values. The obtained results are presented in Table 3.

Table 3

CADF Panel Unit Root Test Results

Variable	CIPS STATISTICS		
	Test Statistics	P-Value	Result
ECO	-1.593	0.777	I(1)
d(ECO)	-5.495***	0.000	I(0)
HC	-2.427***	0.004	I(0)
RGDP	-1.146	0.995	I(1)
d(RGDP)	-3.606***	0.000	I(0)

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

Source: authors' calculations.

The CIPS statistics obtained from the CADF unit root test are calculated for the entire panel. Pesaran's (2007) CADF unit root test results show that HC is stationary at a level. Nevertheless, ecological footprint and real GDP variables are not stationary at the level. When the first difference in the environmental footprint and real GDP variable is taken, they become stationary.

PMG Estimations. The HC and ECO relationship has been tested using PMG (pooled-mean group) and MG (mean group) estimators. PMG is non-stationary dynamic panel estimators where intergroup parameters are heterogeneous. In this framework, the model created to investigate the long-term relationship is as follows:

$$ECO_{it} = \alpha_0 + \alpha_1 HC_{it} + \alpha_2 RGDP + \epsilon_{it} \quad (10)$$

Among the variables included in the model, ECO indicates ecological footprint, HC – human capital, RGDP equals real GDP, and ϵ_{it} denotes the error term. The model examines the cointegration relationship between HC and ECO. This model includes variables of human capital and real GDP. The long and short-term coefficients obtained from the estimation of the model are presented in Table 4.

In the results obtained from the model in which the cointegration relationship between HC and ECO was tested, a negative and statistically significant coefficient was found in the long run. In other words, it can be said that there is a long-term cointegration relationship between ecological footprint and human capital. On the other hand, the error correction term estimated for the model is negative and statistically significant, which means that the error correction mechanism is working. Besides, it will come to balance again when a deviation from the long-term balance occurs, which means increased human capital reduces environmental pollution. It can be mentioned here that developments in technology raise ecological awareness. In the past, growth based on industrialization polluted the environment, but now human capital and technology development is the driving force of economic growth.

Table 4

PMG Estimations Results

Dependent Variable	
Long-run coefficients	
HC	-1.280625 (0.036)
RGDP	-4.51 (0.345)
Short-run coefficients	
HC	-5.5 (0.015)
RGDP	0.0000251 (0.112)
Cons	1.088 (0.000)
ECT	-0.117 (0.00)
Statistics	
Number of observations	784

Notes. The values in parentheses show the probability value (*p*-value).
*** indicate significance at the 1 % level.
Source: authors' calculations.

On the other hand, there is a short-term relationship between HC and ECO, and HC negatively affects the environmental footprint in the short run. As a result, it can be said that there is both a long-term and a short-term cointegration relationship between human capital and the environment. In both cases, it could be concluded that the increase in human capital reduces environmental pollution. These results obtained from the PMG test confirm the studies conducted by Chen et al. (2021), Langnel et al. (2021), Nathaniel (2021), Nathaniel et al. (2021a), Nathaniel et al. (2021b), Ahmed et al. (2020a), Ahmed et al. (2020b), Ahmed & Wang (2019), Majeed & Mazhar (2020); Rahman et al. (2019), Saleem et al. (2019), Zafar et al. (2019).

So, according to the results of the analysis and the studies supporting them, the impact of HC on the environment and therefore on the ECO cannot be ignored. According to Engel (1883), Nicholson (1891), Petty (1690), Smith (1776/1937), Farr (1853), and Marshall, HC is the investment made to raise more educated and productive individuals. Therefore, as more educated people behave more sensitivity to the environment, ECO decreases. Raising more productive individuals enables more production to be realized with less natural resources. This prevents the reduction of natural resources and reduces ECO.

According to the theoretical explanations and the empirical analysis results that confirms them, the effect of human capital on the ecological footprint is great.

Therefore, it is important to train an educated workforce in society, to protect natural resources and develop production methods that will minimize the damage to the environment. At the same time, increasing human capital can improve environmental quality by encouraging the use of cleaner production resources. For this, individuals in society can be informed about environmental awareness. Individuals in the working sector can be directed to use production resources that will cause the least harm to the environment. Providing education seminars for children and young people at the age of education on the protection of natural resources and ecosystems can be beneficial in those environmentally sensitive individuals. The use of renewable energy sources, which are less harmful to the environment, can be effective in reducing the ecological footprint by reducing the amount of carbon dioxide emitted into the air.

Conclusions. The changing production system with the industrial revolution has also changed the consumption habits of human beings. More importantly, however, the advertising and marketing techniques used by new production technologies to increase consumption drove consumption to high levels, and excess production translated into economic growth. The increase in both production and consumption has increased the intervention of human beings in nature. As a human intervention in nature increased, existing natural resources began to be used in a disproportionate and unbalanced way. The unbalanced use of natural resources by companies acting with the profit motive and consumers trying to maximize benefit has brought many environmental problems, especially environmental pollution.

This study examined the relationship between HC and ECO for 14 selected European countries. The analysis covers 56 years between 1961 and 2017. In the first part of the study, the concepts of HC and ECO are evaluated in terms of the historical process. Then the empirical part of the study has been carried out. According to the PMG results, ECO and HC are cointegrated. Long-term coefficient results show that HC hurts ECO. Negative signs and statistically significant error correction coefficient ECT show a long-term relationship between dependent and independent variables. Even if it deviates from the equilibrium, it converges to the balance again. The long-run relationship between the dependent and independent variables in the equation has been proven with this coefficient. According to the results of PMG analysis, human capital negatively affects the ecological footprint in the short and long term. Increases in human capital in European Union countries reduce the ecological footprint.

Therefore, to increase the impact of human capital on the ecological footprint, it is important to increase the studies that will further strengthen the education infrastructure, to improve the environmental quality. To achieve this, training seminars can be given in schools and work areas. It is possible to obtain more output by using fewer inputs by accelerating technological development by increasing R&D activities. In this way, natural resources used as inputs can be protected. The use of renewable energy sources, which are less harmful to the environment, can be effective in reducing the ecological footprint by reducing the amount of carbon dioxide emitted into the air. Using renewable energy sources and obtaining government support in this regard can reduce the ecological footprint.

Further research could be instrumental in determining the impact of human capital on the ecological footprint. Human capital is an effective factor in the development of technology by increasing R&D studies. Technological development enables more production to be realized by using fewer production resources. Therefore, it can provide positive developments in terms of protecting natural resources and reducing environmental pollution. For this reason, as a new research direction, the theoretical explanations and empirical analyzes in this study can be examined and R&D activities can be included in the analysis.

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