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ABSTRACT

A great majority of the EKC literature use CO_2 emissions to proxy for environmental degradation. However, this is an important shortage in application of the EKC concept because environmental degradation cannot be captured by CO_2 emissions only. By using a broader proxy, ecological footprint, this study aims to investigate the presence of Environmental Kuznets Curve hypothesis for the EU countries. The annual data from 1980 to 2013 is examined with second generation panel data methodologies which take into account the cross-sectional dependence among countries. The results show that there is U-shaped relationship between the real income and ecological footprint. In addition, non-renewable energy increases the environmental degradation while renewable energy and trade openness decrease the environmental degradation in the EU countries. Policy implications are further discussed.

Keywords: Ecological footprint; Environmental Kuznets Curve; European countries

1.Introduction

The Environmental Kuznets Curve (EKC) hypothesis claims that there is an inverted U-shaped relationship between environmental degradation and economic growth. This relationship implies that initial stage of economic growth and development make environmental quality worse, and after per capita income reaches a threshold economic growth and development enhance environmental quality (Grossman & Krueger, 1991; Grossman & Krueger, 1995). It, hence, implies that environmental degradation first rises and later falls with increasing development. According to Grossman & Krueger (1995), there are three contributing causes behind the shape of the EKC. First one is *scale effect* which is first stage of the curve that the environment gradually deteriorates since economic growth needs more resource and sparks off more waste and pollution. As economy grows, however, its' structure starts to change from energy intensive industry to services and technology intensive industries. Besides, as technology advances, it reverses polluting production process which also uses more resource and obsolete technologies are replaced by upgraded new and cleaner technology. These probable positive effects of economic growth on environmental quality are named *composition* and *technique effects* respectively. The composition and technique effects are also supported by individual preferences (Selden & Song, 1995; McConnell, 1997). These preferences crop out with the environmental awareness. This awareness leads people to increase their demand for eco-friendly goods and services. Thereby people can achieve a higher standard of living and can care more about the quality of environment they live in (Dinda, 2004). Additionally, one argument claims that the income elasticity of the environment is greater than one. This means that the demand for clean environment will increase by more than 1 percent as income rises by one percent (Baldwin, 1994). As a natural consequence of these arguments, main policy recommendation for a decent environment is to increase the economic growth and to become rich as stated by Beckerman (1992). If this mechanism really works, policy makers should not be concerned that economic growth is driving force of environmental improvements. From this point of view, a large number of studies have been carried out to test the EKC hypothesis for different countries and country groups, and a large part of these studies verify the existence of the EKC hypothesis (Apergis & Ozturk 2015; Hao et al. 2016;Wang et al. 2016;Bilgili et al. 2016; Charfeddine & Mrabet 2017; Mrabet & Alsamara 2017; Pablo-Romero et al. 2017; Álvarez-Herránz et al., 2018; Shahbaz et al., 2017; El Montasser et al., 2018; Balsalobre-Lorente et al., 2018; Sinha and Shahbaz, 2018; Aslan et al., 2018).

The most important question thus is not whether the analysis of the EKC hypothesis is necessary– to that it seems there is an overall consensus in society-but "What should be used to proxy for environmental pollution?" A great majority of the EKC literature use CO_2 emissions to represent environmental degradation. Indeed, this is an important shortage in application of the EKC concept because environmental degradation cannot be captured by CO_2 emissions only. There are also other parts of the environmental degradation such as degradation in soil stock, forestry stock, mining stock, oil stock and so forth. Additionally, CO_2 emissions may really decrease owing to technological innovations or stringent environmental regulations made by governments while aggregate waste and pollution level increases (Stern, 2014). Hence, the inverted-U relationship might be valid for emissions of pollutants, but might not be valid for resource stocks (Arrow et al. 1995). So, results may be misleading policy makers when CO_2 emissions is solely used to proxy for environmental degradation. Therefore, researchers should use an inclusive environmental variable to obtain more dependable results.

Ecological footprint developed by Wachernagel & Rees (1996) can potentially be more appropriate representative for the environment. It is the sum of six subcomponents (Cropland, Grazing Land, Fishing Grounds, Forest Land, Built-up Land and Carbon Footprint (see Lin et al. 2016 for details) and includes in any case CO_2 emissions within the carbon footprint. The ecological footprint answers the question of how much of the regenerative biological capacity of the planet is demanded by a given human activities like resources consumption, goods and services production (Kitzes & Wackernagel, 2009). It also helps highlighting direct and indirect impacts of production and consumption activities on the environment (McDonald & Patterson, 2004). Conceptually, it can be described as the pressure of human activities on the nature (Bartelmus, 2008). According to Costanza (2000) it has been widely praised and effective heuristic and comprehensible device for considering total resource consumption. It can be used to forecast natural resource consumption limits, international distribution of world resources and sustainability of resource consumption in the World (Borucke et al. 2013). Since it is a mature aggregate indicator for analysis of human demand on the nature, the ecological footprint has been used as a variable of environmental degradation for the EKC analysis (Bagliani et al. 2008; Caviglia-Harris et al. 2009; Wang et al. 2013; Al-Mulali et al. 2015; Hervieux & Darné 2015; Aşıcı & Acar 2016; Ozturk et al. 2016; Charfeddine & Mrabet 2017; Mrabet & Alsamara 2017; Ulucak & Bilgili, 2018).

The motivation of this paper is to investigate the EKC hypothesis for the EU countries by using the ecological footprint. To the best of our knowledge, this is the first study that analyzes the EKC hypothesis by the ecological footprint for the EU countries. We preferred EU countries because the European Union (EU) is considered by some to have the most extensive environmental laws of any international organisation (Jordan and Adelle, 2012). Its environmental policy is significantly intertwined with other international and national environmental policies. The environmental legislation of the European Union also has significant effects on those of its member states. The EEA (European Environment Agency) provides environmental information to policymakers and the public. According to EEA, the ecological footprint is already developed and produced by the Global Footprint Network and has matured significantly over its 20 years of existence, both with regards to data sources and methodology. It is of high policy relevance because it indicates the overall resource demand of European societies compared to resource availability in Europe. It is a powerful tool for reaching and communicating with a wide range of audiences to promote an understanding of how people's activities have an impact on the environment, and to support people in making choices to reduce this impact (EEA, 2018). Based on these reasons, analyzing ecological footprint of EU countries are preferred in this study to make practicable policy implications. Furthermore, this paper includes trade openness, renewable and non-renewable energy as control variables to observe their effects on the environment. The rest of the paper is organized as follows: section 2 summarizes the EKC literature made for European countries. Later, data and methodologies are introduced in section 3 and empirical results are presented in section 4. Finally, the paper is completed with conclusion and policy implications in section 5.

2.Literature review

The EKC hypothesis has been tested for either EU member or European countries using different econometric techniques and variables by many studies so far. However, it is difficult to say that there is a consensus about that economic growth helps to ameliorate environmental quality as claimed by the EKC hypothesis. Some verifies the EKC relationship for the EU or European countries (e.g. Markandya et al. 2006; Vehmas et al. 2007; Coondoo & Dinda 2008; Lee et al. 2010; Donfouet et al. 2013; Rafaj, et al. 2014; López-Menéndez et al. 2014; Arbulú et al. 2015; Kasman & Duman 2015; Al-Mulali et al. 2016; Dogan & Seker 2016; Ahmed et al. 2016; Pablo-Romero et al. 2017) and some does not (e.g. Mazzanti, 2008; Mazzanti & Zoboli 2009; Marrero, 2010; Acaravci & Ozturk 2010; Lapinskienė et al. 2014; Bölük & Mert 2014; Abid, 2017). These studies may differ from each other in terms of environmental variable as well as methodology and data set and control variables. In their analyses air pollutants, e.g. CO_2, SO_2, NO_x GHG, water pollution, solid wastes, oil, gas, coal and other specific environmental indicators are used to represent the environment. CO_2 is the most common used one among these variables as it is in many EKC studies made for different country or groups. Table 1 briefly summarizes the studies made for EU and European countries by author, period, country, method, environmental variable used in the analysis and result.

[INSERT TABLE 1 HERE]

As seen from Table 1, each environmental variable used for the EKC analysis represents only a small portion of total environmental damage. We could not reach any paper that directly analyzes the EKC using the ecological footprint for the EU or European countries. However, Holm & Englund (2009) examines the discrepancy between the potential decrease of use of natural resources for the USA and six West European countries comparatively. They analyze *IPAT* equation that can be commented as a basis for a description of human impact on the ecosystems and mention that the existence of an environmental Kuznets curve is not verified. The *IPAT* is the form of an equation combining environmental impact *(I)* with population size *(P)*, affluence (*A*, per capita consumption or production), and technology (*T*) known as *I =PAT* (Fan et al. 2006).

Contrary to most of the aforementioned studies that use CO_2, SO_2, NO_x, waste or any specific and limited variable for environmental degradation, there is a growing body of research utilizing the ecological footprint as an indicator of environmental degradation. Table 2 exhibits the limited number of studies in the relevant literature following the ecological footprint as an environmental indicator for estimating the EKC hypothesis. Aşıcı & Acar (2016), Charfeddine & Mrabet (2017), Mrabet & Alsamara (2017), Ulucak & Bilgili (2018) find evidence for the EKC while Bagliani et al. (2008), Caviglia-Harris et al. (2009), Wang et al. (2013), Hervieux & Darné (2015) and Al-Mulali et al. (2016) couldn't find evidence for the EKC. The other two studies find similar results. Their results confirm the EKC for upper-middle and high income countries but disconfirm it for low and lower-middle income countries. Brief details for these studies are presented in table 2.

[INSERT TABLE 2 HERE]

3.Data and methodology

In order to investigate the validity of EKC hypothesis for the ecological footprint and compare relative performances of renewable and non-renewable energy consumption on environmental pollution, the annual data of 1980-2013 is examined for the 15 EU countries: Austria, Belgium, Bulgaria, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden and the UK. The other EU countries couldn't be included into our analyses since they have not data for the period of 1980-2013. The panel version of empirical model constructed as follows:

$$lnEF_{it} = \gamma_0 + \gamma_1 lnY_{it} + \gamma_2 lnY_{it}^2 + \gamma_3 lnRC_{it} + \gamma_4 lnNC_{it} + \gamma_5 lnTR_{it} + \mu_{it} \quad (1)$$

where t, i and μ_{it} refer to time period, cross-section and residual term respectively. In addition, $lnEF_{it}$is natural log of the ecological footprint per capita, lnY_{it} (lnY_{it}^2) is natural log of real GDP per capita (natural log of the square of real GDP per capita), $lnRC_{it}$ is natural log of renewable energy consumption per capita, $lnNC_{it}$ is natural log of non-renewable energy consumption per capita and $lnTR_{it}$ is trade openness. The ecological footprint is measured in the sum of cropland, grazing land, fishing grounds, forestland, carbon and built-up land footprints, the real GDP is measured in 2010 constant US dollar, renewable and non-renewable energy consumption are measured in Kwh and the trade openness in measured in the total trade share in GDP. The data of real GDP and trade openness is obtained from World Development Indicators, the data of renewable energy and non-renewable energy use is retrieved from US Energy Information Administration and the data of the ecological footprint is downloaded from Global Footprint Network.

Panel data methodologies which ignore the cross-sectional dependence may lead to unreliable results due to high integration throughout the world. Therefore, we first test the existence of cross-sectional dependence among EU countries. Breusch and Pagan (1980) developed Lagrange Multipler (LM hereafter) test on the purpose of examining the cross-sectional dependence. LM test is examined with the use of the following equation;

$$y_{it} = a_i + \beta_i x_{it} + \varepsilon_{it} \quad \text{for } i = 1...,N \text{ and } t = 1...,T, \tag{2}$$

where i and t state respectively the cross-section dimension and the time period. While the null hypothesis of $H_0: Cov(\varepsilon_{it}, \varepsilon_{jt}) = 0$ states that there is not any dependency between the cross-sections, the alternative hypothesis of $H_1: Cov(\varepsilon_{it}, \varepsilon_{jt}) \neq 0$ indicates the dependency between at least one pair of cross-sections. And the computation of the LM test is as follows;

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \sim \chi^2_{N(N-1)/2} \tag{3}$$

where $\hat{\rho}_{ij}$ is the sample of the pair-wise correlation of the residuals from ordinary least squares estimation of Eq.2 for each cross section. While the LM test is suitable for panels providing the condition of small N and sufficiently large T, for situations where $T \rightarrow \infty$ and $N \rightarrow \infty$, the Lagrange multiplier statistic for cross-sectional dependence (CD_{LM} hereafter) version developed by Pesaran (2004) is as follows;

$$CD_{LM} = \left(\frac{1}{N(N-1)}\right)^{1/2} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T\hat{\rho}_{ij}^2 - 1\right) \sim N(0,1) \tag{4}$$

Due to CD_{LM} test tends to dimension failures in case of large N and small T, Pesaran (2004) developed a more comprehensible test. The calculation of the new cross-sectional dependence test (CD hereafter) is as follows;

$$CD = \sqrt{\left(\frac{2T}{N(N-1)}\right)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(\hat{\rho}_{ij} - 1\right) \sim N(0,1) \tag{5}$$

However the CD test will lack power in certain situations that the population average pair-wise correlations are zero. Therefore, Pesaran et al. (2008), suggest a bias-adjusted test which is a modified version of the LM test. The bias-adjusted LM test (LM_{adj} hereafter) is;

$$LM_{adj} = \sqrt{\left(\frac{2}{N(N-1)}\right)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \frac{(T-k)\hat{\rho}_{ij}^2 - \mu_{Tij}}{\sqrt{\nu_{Tij}^2}} \sim N(0,1) \tag{6}$$

where k, μ_{Tij} and ν_{Tij}^2 are the number of regressors, exact mean and variance of $(T-k)\hat{\rho}_{ij}^2$ (Pesaran et al., 2008).

In order to take into account the cross-sectional dependence, we use well-known and frequently used unit root test developed by Pesaran (2007). The computation of the cross-sectional ADF (*CADF*) regression is as following:

$$\Delta y_{it} = a_i + \rho_i y_{it-1} + \beta_i \bar{y}_{t-1} + \sum_{j=0}^{k} \gamma_{ij} \Delta \bar{y}_{it-1} + \sum_{j=0}^{k} \delta_{ij} y_{it-1} + \varepsilon_{it} \quad (7)$$

where a_i is deterministic term, k is the lag order, $\bar{y}_t$ is the cross-sectional mean of time t. Following above equation, t-statistics are obtained with the computation of individual *ADF* statistics. Furthermore, *CIPS* is retrieved from the average of *CADF* statistic for each i as follows;

$$CIPS = \left(\frac{1}{N}\right) \sum_{i=1}^{N} t_i \,(N,T) \quad (8)$$

The critical values of *CIPS* for different deterministic terms are given by Pesaran (2007).

To test the validity of the long-run relationship between real income, the square of real income, renewable energy consumption, non-renewable energy consumption, trade openness and ecological footprint, we utilize error correction based cointegration method proposed by Westerlund (2007). In testing procedure, there is four statistics (G_t,G_α,P_t,P_α) to test the null hypothesis of no cointegration. The test can be performed by testing the significance of the error correction term in the constrained panel error correction model. The main error correction model of the test can be written as follows:

$$\Delta Y_{it} = \delta_i' d_t + a_i Y_{i,t-1} + \lambda_i' X_{i,t-1} + \sum_{j=1}^{p_i} a_{ij} \Delta Y_{i,t-j} + \sum_{j=-q_i}^{p_i} \gamma_{ij} X_{i,t-1} + e_{it} \quad (9)$$

where d_t refers to the deterministic terms; $d_t = 0$ (no deterministic term), $d_t = 1$ (with constant term) and $d_t = (1, t)$ (with constant term and trend). Moreover, a_i determines the speed at which the system returns to the equilibrium, after an unpredictable shock.

4.Empirical results

In the first step of analysis, we examine the presence of cross-sectional dependence among countries. According to the findings from Table 3, the null of cross-sectional independence is rejected for all tests. This means a shock occurred in one of sample country may be spill-over other countries. The validity of cross-sectional dependence implies that we should using second-generation panel tests which allow cross-sectional dependence.

[INSERT TABLE 3 HERE]

In the second step of analysis, we use augmented IPS (CIPS) unit root test of Pesaran (2007) which allows the cross-sectional dependence among countries to determine the degree of integration level of variables. The findings reported in Panel A of Table 4 show that the null hypothesis of unit root process cannot be rejected for the level form of all variables. However, at first differenced form, the null hypothesis is rejected and all series become stationary. The next step should be to investigate whether the ecological footprint, the real income, renewable and non-renewable energy consumption and trade are cointegrated; or, in other words, they have a long-run relationship.

[INSERT TABLE 4 HERE]

Next, we examine the presence of long-run relationship between variables using with three cointegration tests which are illustrated in Panel B of Table 4. First, the results from ADF and PP based statistics of Pedroni (1999) show that the null of there is no cointegration is strongly rejected. Similarly ADF-based statistic of Kao (1999) is also rejected the null hypothesis. Moreover, we utilized with the error correction-based cointegration test of Westerlund (2007) to check the consistency of our findings. At a first glance, it can be seen that the results from Westerlund's test are quite mixed. The findings from G_α and P_α confirm the null hypothesis while G_t and P_t statistics show the evidence of rejection of null hypothesis which implies there is no cointegration. Therefore, it is concluded that real GDP per capita, the square of real GDP per capita, renewable energy use per capita, non-renewable energy use per capita, trade openness and the ecological footprint per capita are cointegrated. Because we find that the analyzed variables have a long-run relationship, we should estimate the impact of each independent indicator on the ecological footprint.

[INSERT TABLE 5 HERE]

In the next step, we examine the effect of selected explanatory variables on the ecological footprint for the whole panel using with the group-mean FMOLS estimator of Pedroni (2000) and the group-mean DOLS estimator of (Pedroni, 2001). In addition, we also utilized with dynamic common correlated effect estimator (DCCE) of Chudik and Pesaran (2015) to consider the cross-sectional dependence among countries. The findings from Table 5 reported that the coefficient of real income on the ecological footprint is negative and the coefficient of the square of real income is positive for both estimators. This result confirms the invalidity of EKC hypothesis. In addition, according to the results of FMOLS estimator, it is concluded that an increase in renewable energy use by 1% will decrease the ecological footprint by 0.109%; an increase in non-renewable use by 1% will increase the ecological footprint by 0.274 % and an increase in trade openness by one percent will decrease the ecological footprint by 0.229 % for the EU countries. Similarly, based on the DOLS results, the coefficient of real income (square of real income) is negative (positive) therefore the U-shaped relationship is found. Dynamic OLS estimator results also show that an increase in renewable energy use and trade openness by 1% will decrease the ecological footprint by 0.093 % and 0.485 %, respectively. In addition, an increase in non-renewable energy use by 1% will increase the ecological footprint by 0.216 % in the EU countries. In case of cross-sectional dependence, obtained findings from DCCE estimation also show that the validity of EKC hypothesis is rejected because the U-shaped relationship exists between real income and ecological footprint. Furthermore, DCCE results indicate that an increase in renewable energy usage and trade openness by 1% will decrease ecological footprint by 0.045 % and

0.181%, respectively. However, an increase in non-renewable energy consumption will increase ecological footprint by 0.162 %.

Finally, country-specific fully modified OLS and dynamic OLS estimator results are reported in Table 6. In case of the findings from the FMOLS, the coefficient of real GDP (square of real GDP) is negative (positive) and statistically significant in Austria, Denmark, Germany, Italy, Netherlands, Portugal, Spain and the UK. Therefore, the U-shaped relationship between real GDP and the ecological footprint is found for these countries. However, the inverted U-shaped EKC hypothesis is found only for Portugal. In addition, the negative and statistically significant coefficient of renewable energy use is found in almost all countries except Austria, Netherlands and Sweden. The coefficient of trade openness is also negative and statistically significant in Denmark, Germany, Italy, Netherlands, Portugal and the UK. Moreover, we found the positive coefficient of non-renewable energy use in Austria, France, Germany, Greece, Ireland, Portugal and the UK. As a seen in Table 6, the dynamic OLS estimation results are highly consistent with the results of fully modified OLS estimation. In case of dynamic OLS estimation, the U-shaped relationship between income and the ecological footprint is confirmed for Austria, Denmark, Finland, Germany, Italy, Netherlands, Spain and the UK while the inverted U-shaped relationship is supported for France and Portugal. Additionally, the negative coefficient of renewable energy use is valid for 10 EU countries.

[INSERT TABLE 6 HERE]

To sum up, based on the mean-group results, it is concluded that the U-shaped relationship exists between economic growth and the ecological footprint. Contrary to EKC hypothesis, these results mean that economic growth sparks off environmental degradation after a threshold although it leads degradation to decrease at earlier process of its trend path till that threshold. In addition, we found that increasing renewable energy consumption (non-renewable energy consumption) decreases (increases) the ecological footprint. Moreover, increasing trade openness reduces environmental degradation in the EU countries.

5.Conclusions and policy implications

The purpose of this study is to examine the validity of environmental Kuznets curve on the ecological footprint and to compare the relative effect of renewable and non-renewable energy consumption on environmental pollution for the period from 1980 to 2013 in the 15 EU countries. For this purpose, the relationship among the real income, the square of real income, renewable energy use, non-renewable energy use, trade openness and the ecological footprint is investigated using with second generation panel data methodologies which take into account the cross-sectional dependence.

The cross-sectional dependence among countries is an expected situation because of globalization and international agreements and empirical findings confirm that the cross-sectional dependence and is valid across the EU countries. According to the mean group estimators, it is concluded that there is U-shaped relationship between real income and the ecological footprint. In addition, we found that renewable energy consumption usage and trade openness decreases the ecological footprint while non-renewable energy consumption increases the environmental pollution. When the findings are evaluated for each cross-section, according to the FMOLS estimation results, it seems U-shaped relationship between real income and the ecological footprint is valid in Denmark, Germany, Italy, Netherlands, Portugal, Spain and the UK while the inverted U-shaped EKC hypothesis is found only for Portugal. the negative and statistically significant coefficient of renewable energy use is found in Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Spain and the UK. Moreover, non-renewable energy consumption usage increases environmental pollution in Austria, France, Germany, Greece, Ireland, Portugal and the UK. In case of the DOLS estimation results, U-shaped relationship between real income and the ecological footprint is valid in Austria, Denmark, Finland, Germany, Italy, Netherlands, Spain and the UK while the inverted U-shaped relationship is supported for France and Portugal.

The message from this research to policy makers is the importance of renewable energy source in reducing environmental degradation. Based on this implication, policy makers should introduce legislations and set regulations that support the production and consumption of renewable energy and discourage the production and consumption of non-renewable energy. It seems that this strategy should supported by subsidies and tax credits.

Overall, we found that the inverted U-shaped EKC hypothesis does not hold in the EU countries and existing environmental regulation standards of the EU countries are inadequate for the purpose of reducing environmental degradation. In addition, based on the empirical finding that renewable energy (non-renewable energy) consumption reduces (increases) the environmental degradation, it is recommended that reducing environmental degradation will be possible by sweeping away from fossil-fuel energy consumption based growth policies in the EU countries.

References

Abid, M. (2017). Does economic, financial and institutional developments matter for environmental quality? A comparative analysis of EU and MEA countries. *Journal of Environmental Management*, *188*, 183–194. https://doi.org/10.1016/j.jenvman.2016.12.007

Acaravci, A., & Ozturk, I. (2010). On the relationship between energy consumption, CO2 emissions and economic growth in Europe. *Energy*, *35*(12), 5412–5420. https://doi.org/10.1016/j.energy.2010.07.009

Ahmed, A., Uddin, G. S., & Sohag, K. (2016). Biomass energy, technological progress and the environmental Kuznets curve: Evidence from selected European countries. *Biomass and Bioenergy*, (90), 202–208. https://doi.org/10.1016/j.biombioe.2016.04.004

Al-mulali, U., Solarin, S. A., Sheau-Ting, L., & Ozturk, I. (2016). Does moving towards renewable energy cause water and land inefficiency? An empirical investigation. Energy Policy, 93, 303–314. https://doi.org/10.1016/J.ENPOL.2016.03.023

Al-Mulali, U., Ozturk, I., & Solarin, S. A. (2016). Investigating the environmental Kuznets curve hypothesis in seven regions: The role of renewable energy. *Ecological Indicators*, *67*, 267–282. https://doi.org/10.1016/j.ecolind.2016.02.059

Al-Mulali, U., Weng-Wai, C., Sheau-Ting, L., & Mohammed, A. H. (2015). Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. *Ecological Indicators*, *48*, 315–323.

Álvarez-Herránz, Agustín & Balsalobre, Daniel & Cantos, José María & Shahbaz, Muhammad. (2018). Energy Innovations-GHG Emissions Nexus: Fresh Empirical Evidence from OECD Countries. *Energy Policy*, 101, 90-100.

Apergis, N., & Ozturk, I. (2015). Testing Environmental Kuznets Curve hypothesis in Asian countries. *Ecological Indicators*, *52*, 16–22. https://doi.org/10.1016/j.ecolind.2014.11.026

Arbulú, I., Lozano, J., & Rey-Maquieira, J. (2015). Tourism and solid waste generation in Europe: A panel data assessment of the Environmental Kuznets Curve. *Waste Management*, *46*, 628–636. https://doi.org/10.1016/j.wasman.2015.04.014

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., … Pimentel, D. (1995). Economic Growth, Carrying Capacity, and the Environment, 13–15. https://doi.org/10.2307/2269539

Aslan, A., Destek, M. A., & Okumus, I. (2018). Bootstrap rolling window estimation approach to analysis of the Environment Kuznets Curve hypothesis: evidence from the USA. *Environmental Science and Pollution Research*, *25*(3), 2402-2408.

Aşıcı, A. A., & Acar, S. (2016). Does income growth relocate ecological footprint?. *Ecological indicators*, *61*, 707-714.

Bagliani, M., Bravo, G., & Dalmazzone, S. (2008). A consumption-based approach to environmental Kuznets curves using the ecological footprint indicator. *Ecological Economics*, *65*(3), 650–661.

Baldwin, R. (1994). Does sustainability require growth? In I. GOLDIN & L. A. WINTERS (Eds.), *The Economics of Sustainable Development* (First, pp. 51–78). Cambridge: Cambridge University Press.

Balsalobre-Lorente, D., Shahbaz, M., Roubaud, D., & Farhani, S. (2018). How economic growth, renewable electricity and natural resources contribute to CO2 emissions?. Energy Policy, 113, 356-367.

Bartelmus, P. (2008). *Quantitative eco-nomics: How sustainable are our economies? Quantitative Eco-nomics: How sustainable are our economies?* Springer Netherlands.

Beckerman, W. (1992). Economic growth and the environment: Whose growth? whose environment? *World Development*, *20*(4), 481–496. https://doi.org/10.1016/0305-750X(92)90038-W

Bilgili, F., Koçak, E., & Bulut, Ü. (2016). The dynamic impact of renewable energy consumption on CO2 emissions: A revisited Environmental Kuznets Curve approach. *Renewable and Sustainable Energy Reviews*, *54*, 838–845. https://doi.org/10.1016/j.rser.2015.10.080

Borucke, M., Moore, D., Cranston, G., Gracey, K., Iha, K., Larson, J., … Galli, A. (2013). Accounting for demand and supply of the biosphere's regenerative capacity: The National Footprint Accounts' underlying methodology and framework. *Ecological Indicators*, *24*, 518–533.

Bölük, G., & Mert, M. (2014). Fossil & renewable energy consumption, GHGs (greenhouse gases) and economic growth: Evidence from a panel of EU (European Union) countries. *Energy*, *74*, 439–446. https://doi.org/10.1016/j.energy.2014.07.008

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies*, *47*(1), 239-253.

Caviglia-Harris, J. L., Chambers, D., & Kahn, J. R. (2009). Taking the 'U' out of Kuznets. A comprehensive analysis of the EKC and environmental degradation. *Ecological Economics*, *68*(4), 1149–1159.

Charfeddine, L., & Mrabet, Z. (2017). The impact of economic development and social-political factors on ecological footprint: A panel data analysis for 15 MENA countries. *Renewable and Sustainable Energy Reviews*, *76*, 138–154. https://doi.org/10.1016/j.rser.2017.03.031

Chudik, A., & Pesaran, M. H. (2015). Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. *Journal of Econometrics*, *188*(2), 393-420.

Coondoo, D., & Dinda, S. (2008). Carbon dioxide emission and income: A temporal analysis of cross-country distributional patterns. *Ecological Economics*, *65*(2), 375–385. https://doi.org/10.1016/j.ecolecon.2007.07.001

Costanza, R. (2000). The dynamics of the ecological footprint concept. *Ecological Economics*, *32*, 341–345. Retrieved from www.elsevier.com/locate/ecolecon

Dinda, S. (2004). Environmental Kuznets Curve Hypothesis: A Survey. *Ecological Economics*, *49*(4), 431–455. https://doi.org/10.1016/j.ecolecon.2004.02.011

Dogan, E., & Seker, F. (2016). Determinants of CO2 emissions in the European Union: The role of renewable and non-renewable energy. *Renewable Energy*, *94*, 429–439. https://doi.org/10.1016/j.renene.2016.03.078

Donfouet, H. P. P., Jeanty, P. W., & Malin, E. (2013). *A spatial dynamic panel analysis of the environmental Kuznets curve in European countries* (No. WP 2013-18). Retrieved from http://crem.univ-rennes1.fr/wp/2013/201318.pdf

El Montasser, G., Ajmi, A. N., & Nguyen, D. K. (2018). Carbon emissions- income relationships with structural breaks: the case of the Middle Eastern and North African countries. Environmental Science and Pollution Research, 1-10.

EU (2018). Environment, https://europa.eu/european-union/topics/environment_en (date accessed 19.03.2018).

Fan, Y., Liu, L.-C., Wu, G., & Wei, Y.-M. (2006). Analyzing impact factors of CO2 emissions using the STIRPAT model. *Environmental Impact Assessment Review*, *26*(4), 377–395. https://doi.org/10.1016/j.eiar.2005.11.007

Grossman, G. M., & Krueger, A. B. (1991). Environmental Impacts of a North American Free Trade Agreement. *National Bureau of Economic Research Working Paper Series*, *No. 3914*(3914), 1–57. https://doi.org/10.3386/w3914

Grossman, G. M., & Krueger, A. B. (1995). Economic Growth and the Environment. *The Quarterly Journal of Economics*, *110*(2), 353–377. https://doi.org/10.2307/2118443

Hao, Y., Liu, Y., Weng, J.-H., & Gao, Y. (2016). Does the Environmental Kuznets Curve for coal consumption in China exist? New evidence from spatial econometric analysis. *Energy*, *114*, 1214–1223. https://doi.org/10.1016/j.energy.2016.08.075

Hervieux, M.-S., & Darné, O. (2015). Environmental Kuznets Curve and ecological footprint: A time series analysis. *Economics Bulletin*, *35*(1), 814–826.

Holm, S.-O., & Englund, G. (2009). Increased ecoefficiency and gross rebound effect: Evidence from USA and six European countries 1960–2002. *Ecological Economics*, *68*(3), 879–887. https://doi.org/10.1016/j.ecolecon.2008.07.006

Jordan, A.J. and C. Adelle (ed.) (2012) Environmental Policy in the European Union: Contexts, Actors and Policy Dynamics (3e). Earthscan: London and Sterling, VA.

Kao C. (1999). Spurious regression and residual-based tests for cointegration in panel data. J Econom. 90:1–44.

Kasman, A., & Duman, Y. S. (2015). CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. *Economic Modelling*, *44*, 97–103. https://doi.org/10.1016/j.econmod.2014.10.022

Khan, S. A. R., Zaman, K., & Zhang, Y. (2016). The relationship between energy-resource depletion, climate change, health resources and the environmental Kuznets curve: Evidence from the panel of selected developed countries. *Renewable and Sustainable Energy Reviews*, *62*, 468–477. https://doi.org/10.1016/j.rser.2016.04.061

Kitzes, J., & Wackernagel, M. (2009). Answers to common questions in Ecological Footprint accounting. *Ecological Indicators*, *9*(4), 812–817.

Lapinskienė, G., Tvaronavičienė, M., & Vaitkus, P. (2014). Greenhouse gases emissions and economic growth – evidence substantiating the presence of environmental Kuznets curve in the EU. *Technological and Economic Development of Economy*, *20*(1), 65–78. https://doi.org/10.3846/20294913.2014.881434

Lee, C.-C., Chiu, Y.-B., & Sun, C.-H. (2010). The environmental Kuznets curve hypothesis for water pollution: Do regions matter? *Energy Policy*, *38*(1), 12–23. https://doi.org/10.1016/j.enpol.2009.05.004.

Lin, D., Hanscom, L., Martindill, J., Borucke, M., Cohen, L., Galli, A., Lazarus, E., Zokai, G., Iha, K., Eaton, D., Wackernagel, M. (2016). Working Guidebook to the National Footprint Accounts: 2016 Edition. Oakland: Global Footprint Network.

López-Menéndez, A. J., Pérez, R., & Moreno, B. (2014). Environmental costs and renewable energy: Re-visiting the Environmental Kuznets Curve. *Journal of Environmental Management*, *145*, 368–373. https://doi.org/10.1016/j.jenvman.2014.07.017

Markandya, A., Golub, A., & Pedroso-Galinato, S. (2006). Empirical Analysis of National Income and SO2 Emissions in Selected European Countries. *Environmental and Resource Economics*, *35*(3), 221–257. https://doi.org/10.1007/s10640-006-9014-2

Marrero, G. A. (2010). Greenhouse gases emissions, growth and the energy mix in Europe. *Energy Economics*, *32*(6), 1356–1363. https://doi.org/10.1016/j.eneco.2010.09.007

Mazzanti, M. (2008). Is waste generation de-linking from economic growth? Empirical evidence for Europe. *Applied Economics Letters*, *15*(4), 287–291. https://doi.org/10.1080/13504850500407640

Mazzanti, M., & Zoboli, R. (2009). Municipal Waste Kuznets Curves: Evidence on Socio-Economic Drivers and Policy Effectiveness from the EU. *Environmental and Resource Economics*, *44*(2), 203–230. https://doi.org/10.1007/s10640-009-9280-x

McConnell, K. E. (1997). Income and the demand for environmental quality. *Environment and development Economics*, *2*(4), 383-399.

McDonald, G. W., & Patterson, M. G. (2004). Ecological Footprints and interdependencies of New Zealand regions. *Ecological Economics*, *50*(1), 49–67. https://doi.org/10.1016/j.ecolecon.2004.02.008

Menegaki, A. N., & Tsagarakis, K. P. (2015). Rich enough to go renewable, but too early to leave fossil energy? *Renewable and Sustainable Energy Reviews*, *41*, 1465–1477. https://doi.org/10.1016/j.rser.2014.09.038

Mrabet, Z., & Alsamara, M. (2017). Testing the Kuznets Curve hypothesis for Qatar: A comparison between carbon dioxide and ecological footprint. *Renewable and Sustainable Energy Reviews*, *70*, 1366–1375. https://doi.org/10.1016/j.rser.2016.12.039

Ozturk, I., Al-Mulali, U., & Saboori, B. (2016). Investigating the environmental Kuznets curve hypothesis: the role of tourism and ecological footprint. *Environmental Science and Pollution Research*, *23*(2), 1916–1928. https://doi.org/10.1007/s11356-015-5447-x

Pablo-Romero, M. del P., & Sánchez-Braza, A. (2017). Residential energy environmental Kuznets curve in the EU-28. *Energy*, *125*, 44–54. Retrieved from http://www.sciencedirect.com/science/article/pii/S0360544217302736

Pablo-Romero, M. P., Cruz, L., & Barata, E. (2017). Testing the transport energy-environmental Kuznets curve hypothesis in the EU27 countries. *Energy Economics*, *62*, 257–269. https://doi.org/10.1016/j.eneco.2017.01.003

Pedroni P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. Oxf Bull Econ Stat. 61:653–70.

Pedroni, P., (2000). Fully modified OLS for heterogeneous cointegrated panels. Adv. Econ. 15, 93–130.

Pedroni, P., (2001). Purchasing power parity tests in cointegrated panels. Rev. Econ. Stat. 83, 727–731

Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels. CESifo Working Paper 1229. IZA Discussion Paper, 1240.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of applied econometrics*, *22*(2), 265-312.

Pesaran, M. H., Ullah, A., & Yamagata, T. (2008). A bias-adjusted LM test of error cross-section independence. *The Econometrics Journal*, *11*(1), 105-127.

Rafaj, P., Amann, M., Siri, J., & Wuester, H. (2014). Changes in European greenhouse gas and air pollutant emissions 1960–2010: decomposition of determining factors. *Climatic Change*, *124*(3), 477–504. https://doi.org/10.1007/s10584-013-0826-0

Selden, T. M., & Song, D. (1995). Neoclassical Growth, the J Curve for Abatement, and the Inverted

U Curve for Pollution. *Journal of Environmental Economics and Management*, *29*(2), 162–168. https://doi.org/10.1006/jeem.1995.1038
Selin, H. & VanDeveer, S. (2015). EU Environmental Policy Making and Implementation: Changing Processes and Mixed Outcomes, EUSA Fourteenth Biennial International Conference, Boston. http://aei.pitt.edu/79664/1/Selin.VAnDeveer.pdf (date accessed 19.03.2018).
Shahbaz, M., Solarin, S. A., Hammoudeh, S., & Shahzad, S. J. H. (2017). Bounds testing approach to analyzing the environment Kuznets curve hypothesis with structural beaks: The role of biomass energy consumption in the United States. *Energy Economics*, *68*, 548-565.
Sinha, A., & Shahbaz, M. (2018). Estimation of Environmental Kuznets Curve for CO2 emission: Role of renewable energy generation in India. Renewable Energy, 119, 703-711.
Stern, D. I. (2014). *The Environmental Kuznets Curve: A Primer* (CCEP Working Paper 1404).
Vehmas, J., Luukkanen, J., & Kaivo-oja, J. (2007). Linking analyses and environmental Kuznets curves for aggregated material flows in the EU. *Journal of Cleaner Production*, *15*(17), 1662–1673. https://doi.org/10.1016/j.jclepro.2006.08.010
Ulucak, R., & Bilgili, F. (2018). A reinvestigation of EKC model by ecological footprint measurement for high, middle and low income countries. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2018.03.191
Wackernagel, M., & Rees, W. (1996). *Our Ecological Footprint: Reducing Human Impact on the Earth*. *The New Catalyst Bioregional Series*. New Society Publishers.
Wang, Y., Han, R., & Kubota, J. (2016). Is there an Environmental Kuznets Curve for SO2 emissions? A semi-parametric panel data analysis for China. *Renewable and Sustainable Energy Reviews*, *54*, 1182–1188. https://doi.org/10.1016/j.rser.2015.10.143
Wang, Y., Kang, L., Wu, X., & Xiao, Y. (2013). Estimating the environmental Kuznets curve for ecological footprint at the global level: A spatial econometric approach. *Ecological Indicators*, *34*, 15–21.
Westerlund J. (2007). Testing for error correction in panel data. Oxf Bull Econ Stat., 69:709–48