Bootstrap Rolling Window Estimation Approach to Analysis of the Environment Kuznets Curve Hypothesis: Evidence from the United States

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17 March 2017

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ABSTRACT

This study aims to examine the validity of inverted U-shaped Environmental Kuznets Curve by investigating the relationship between economic growth and environmental pollution for the period from 1966 to 2013 in the United States. Previous studies based on the assumption of parameter stability and obtained parameters do not change over the full sample. This study uses bootstrap rolling window estimation method to detect the possible changes in causal relations and also obtain the parameters for sub-sample periods. The results show that the parameter of economic growth has increasing trend in 1982-1996 sub-sample periods and it has decreasing trend in 1996-2013 sub-sample periods. Therefore, the existence of inverted U-shaped Environmental Kuznets Curve is confirmed in the United States.

Keywords: Environmental pollution; Economic growth; Rolling window causality; EKC hypothesis; USA

1.Introduction

In recent years, as a result of increasing economic activities, the scale of the greenhouse gas emissions has reached serious levels. Therefore, the linkage between economic development and environmental degradation has become one of the most attractive topics because of the some environmental concerns (global warming, climate change etc.). Income-pollution nexus is mostly explained with the Environmental Kuznets Curve (EKC) hypothesis which argues that environmental degradation is increased with the first stages of economic growth to a certain point, and after turning point, the economic development leads to environmental improvements. Based on the EKC hypothesis, the effect of economic development on environment quality is explained with three channels; the scale, composition and technique effects. The scale effect of economic activities is shown at the first stage of economic development which increases environmental degradation by increasing input usage. On the other hand, the composition effect of the economic development exists when economic activities tend to cleaner activities by the means of structural changes. In addition, when an economy reach to high income levels, as a result of the increasing R&D investments, cleaner and eco-friendly technology becomes more affordable. This situation is called as the technique effects of economic development. Based on these channels, it is mostly argued that there is inverted U-shaped relationship between economic growth and environmental degradation.

Most of the studies examine the validity of EKC hypothesis by using non-linear empirical model that includes CO2 emission as a dependent variable and real GDP and the square of the real GDP as an explanatory variable. This approach is based on some assumptions. First, it is assumed that if there is inverted U-shaped relation between economic growth and environmental pollution, the parameter of real GDP (square of real GDP) will be positive (negative). Second and the more uncertain assumption is that obtained parameters have stable properties and reflect whole sample. Based on these reasons, this study aims to examine the relationship between economic growth and environmental pollution for the period from 1966 to 2013 in the United States using with bootstrap rolling window estimation approach. Using this methodology gives us a chance to determine the effects of economic growth on the environmental pollution in sub-sample periods. Therefore, the validity of inverted U-shaped EKC hypothesis can be tested more reliably through the obtained parameters of each sub-sample period.

[INSERT FIGURE 1 HERE]

There is some reasons to chosen the United States as the observation country. Firstly, the United States is responsible for 21.78 % of global CO2 emissions and has 24.23 % of total world's wealth for the period from 1966 to 2013. In addition, it is well known fact that increasing global CO2 emission is largely based on increased energy consumption (WDI, 2016). In this regard, according to the U.S. Energy Information Administration (EIA), energy consumption of the U.S. is 98.301 quadrillion btu that constitutes 18 % of global energy consumption in 2014. On the other hand, the renewable energy sector investments of United States have been increased to improve environmental quality in recent years. After 2005, total investments in renewable energy sector of the U.S. are 374.3 billion U.S. dollars which constitutes 16.5 % share of global renewable energy investments. Moreover, the United States is still the leader country in the world in terms of total capacity of biopower generation and geothermal power capacity (REN21, 2016). As a shown in Fig.1, total CO2 emissions of the U.S. have generally increased from 1980 to 2007 but it has decreasing trend after 2007. However, it is not a certain situation that reduced CO2 emission is sourced from whether increasing renewable energy use or financial crisis.

This study offers multiple advantages. First, this is the first study to examine the relationship between economic growth and environmental pollution using with rolling window procedure. Second, using rolling window causality method leads to determine the possible changes in causality between environmental pollution and economic growth. Third, the effects of economic growth on environmental pollution can be observed for each sub-sample period. Fourth, used bootstrapping technique minimizes the distortions sourced from small samples therefore obtained findings will be reliable for policy implications.

2.Literature review

The relationship between income and environmental quality is one of the most controversial issues in many fields of science because of climate change and global warming problems. Especially in economics, there has been rapidly growing literature on this subject for last decades. Grossman and Krueger (1991) firstly found the inverted-U shaped relationship between income and pollution suggesting that economic growth can improve environmental quality. In addition, Shafik and Bandyopadhyay (1992) examined income-environmental degredation nexus for 149 countries for the period 1960-1990. They used 10 environmental degradation indicators for analysis and outcomes of analysis showed that the EKC hypothesis is valid in only two air pollutants-income relationships. Panayotou (1993) looked into the validity of the EKC hypothesis using 4 different environmental indicators with nominal GDP for 30 developed and developing countries covering the period 1982-1994. The empirical results supported the EKC hypothesis. After these pioneering studies about the EKC hypothesis, there have been plenty amount of empirical papers which are applied different econometrics techniques and different countries or country groups.

Jalil and Mahmud (2009) utilized the ARDL bound test to probe income-pollution nexus for China for the time period 1975-2005 and the results show that the EKC hypothesis is valid. Akbostancı et al. (2009) aimed to examine whether the inverted-U shaped relationship between economic growth and environmental degradation exist or not for Turkey and its provinces by applying both time series and panel data series methods. According to empirical outcomes of these methods, the EKC hypothesis is not valid for Turkey and its provinces. He and Richard (2010) explored the link between GDP per capita and carbon dioxide emissions for Canada for 57 years period from 1948 to 2004. The analysis reveals that the EKC hypothesis does not exist and there is monotonically increasing relationship between income and pollution in Canada. Iwata et al. (2010) employed the ARDL bound test to analyze the presence of the EKC hypothesis for France spanning period 1960-2003. This study provides evidence for inverted-U shaped relationship between GDP per capita and CO_2 emissions in France.

Shahbaz et al. (2013) utilized the ARDL bound test to conduct a study to determine the relationship between income and environmental degradation for Romania for the period 1980-2010. According to results, the inverted-U shaped relationship exists between income and pollution. Tiwari et al. (2013) investigated the dynamic relationship between economic growth and carbon dioxide emissions using annual time series data for India covering the period 1966-2009. The empirical evidence of ARDL bound test show that the EKC hypothesis exists in India. Shahbaz et al. (2014) probed the economic growth-CO_2 emissions relationship for Tunisia for 1971-2010 periods. ARDL bound test results show that the EKC hypothesis is valid. Ahmed (2013) examined the impacts of economic growth on environmental quality for Mongolia for the period 1980-2010. The EKC hypothesis is supported for Mongolia. Onafowora and Owoye (2014) applied the ARDL bound test to investigate the existence of EKC hypothesis for Brazil, China, Egypt, Japan, South Korea, Mexico, Nigeria and South Africa covering the period 31 years from 1970 to 2010. According to empirical results, the EKC hypothesis is confirmed for only Japan and South Korea. Lapinskiene et al. (2014) investigated the presence of EKC hypothesis for 29 EU countries in the period of 1995-2010. Farhani et al. (2014) aimed to explain the income-pollution relationship for 10 MENA countries over the period of 1990-2010 using panel data methods in the context of EKC hypothesis. The empirical results reveal that there is an inverted-U shaped relationship between economic growth and CO_2 emissions for these countries. Lau et al. (2014) aimed to explore the income-pollution relationship for Malaysia spanning period 1970-2008 using ARDL method. The validity of EKC hypothesis is confirmed.

Al-Mulali et al. (2015) examined the effects of economic growth on CO_2 emissions in Vietnam from 1981 to 2011 applying the Autoregressive Distributed Lag (ARDL) methodology. The results reveal that EKC hypothesis is not valid. Ozturk and Al-Mulali (2015) tested the existence of EKC hypothesis in Cambodia for 1996-2012 periods applying TSLS and GMM method and the EKC hypothesis is not valid. Baek (2015) examined the impacts of economic growth on CO_2 emissions for Arctic countries (Canada, Denmark, Finland, Iceland, Norway, Sweden, U.S.) using annual time series data for each countries spanning periods 1960-2010. According to ARDL bound test results, the EKC hypothesis is not valid for U.S. Shahbaz et al. (2015) probed the inverted-U shaped relationship between economic development and environmental degradation for Portugal for the period 1971-2008. The ARDL bound test results supported the existence of EKC hypothesis for Portugal. Apergis and Ozturk (2015) investigated the economic growth-environmental degradation relationship for 14 Asian countries during

period 1990-2011. It is utilized GMM panel data method and results confirmed the existence of EKC hypothesis for these countries. Al-Mulali et al. (2015) tested the validity of EKC hypothesis positing the inverted-U shaped relation between economic growth and pollution for Kenya covering the period 1980-2012 by using ARDL bound test. According to this study, the existence of EKC hypothesis is supported for Kenya.

Apergis (2016) searched the validity of EKC hypothesis in 15 countries for the period of 1960-2013 using with second generation panel data methods and found the evidence that the inverted U-shaped relationship between real income and CO_2 emission is supported. Saboori et al. (2016) analyzed the effects of economic growth on environmental pollution for Malaysia spanning period 1980-2008 by utilizing ARDL bound test. The existence of the EKC hypothesis is proved. Alam et al. (2016) employed the ARDL bound test to clarify the relationship between economic growth and carbon dioxide emissions for Brazil, China, India and Indonesia by using time series data during the period 1970-2012. The results suggest that the EKC hypothesis is confirmed in some countries. Shahbaz et al. (2016) aimed to probe the validity of EKC hypothesis implying the inverted-U shaped relation between GDP growth and environmental pollution for 19 African countries for the time period 1971-2012. The ARDL bound test results suggest that the EKC exists in Africa, Algeria, Cameroon, Congo Republic, Morocco, Tunisia and Zambia. Li et al. (2016) applied panel data method to examine the relationship between income and pollution indicators (CO_2, waste water and waste solid emissions) for 28 provinces of China during period 1996-2012. EKC hypothesis is confirmed for these relationships. Osabuohien et al. (2016) used the panel data method to explore the reality of EKC hypothesis for 50 African countries for the period 1995-2010. The results show that the EKC hypothesis is valid for African countries. Al-Mulali and Ozturk (2016) purposed to search the relationship between economic development and environmental degradation in the context of the EKC hypothesis for 27 developed countries for the period 1990-2012 by applying panel data methods. The empirical results prove the inverted-U shaped relation between income and pollution which shows the presence of the EKC hypothesis. Ozokcu and Ozdemir (2017) tested the validity of the EKC hypothesis for separately 26 OECD countries and 52 emerging countries covering period 1980-2010. According to panel data methods, the hypothesis is not supported for these two sample countries.

3.Data and methodology

The data used in this study consists of annual observations from 1966 to 2013 for the United States. The real gross domestic product per capita (GDP) is measured in constant 2010 US dollars and CO2 emission per capita (CO) is measured in metric tons per capita. Both the GDP and CO data are retrieved from World Development Indicators. All variables are used in natural logarithmic form in empirical analyses.

In order to determine the validity of Environmental Kuznets Curve hypothesis, we first utilized with full sample bootstrap causality of Hacker and Hatemi-J (2006) which is generally used in empirical analysis to investigate the relationship between economic growth and CO2 emissions. The full sample bootstrap causality method is a modified version of causality method of Toda and Yamamoto (1995) which allows to investigating the causal relationship between variables whether the variables are cointegrated or non-cointegrated. In addition, the critical values of test are obtained from bootstrap testing procedure of Efron (1979). In the first step of this methodology, consider the vector autoregressive process as follows;

$$y_t = \varphi_0 + \varphi_1 y_{t-1} + \cdots + \varphi_p y_{t-p} + \varepsilon_t, \quad t = 1,2,\dots,T \tag{1}$$

where p is the lag order, $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ is zero mean white noise process with covariance matrix Σ. y_t is splited in two vectors; CO (y_{1t}) and GDP (y_{2t}) and finally obtain;

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \varphi_{10} \\ \varphi_{20} \end{bmatrix} + \begin{bmatrix} \varphi_{11}(L) & \varphi_{12}(L) \\ \varphi_{21}(L) & \varphi_{22}(L) \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{2}$$

where $\varphi_{ij}(L) = \sum_{k-1}^{p} \varphi_{ij,k} L^k$, $i, j = 1,2$ and L is the lag operator. The null hypothesis of real GDP (GDP) does not Granger-cause environmental pollution (CO) can be examined by imposing zero restrictions $\varphi_{12,i} = 0$ for $i = 1,2,\dots,p$ and the null of environmental pollution (CO) does not Granger-cause real GDP (GDP) can be computed by imposing zero restrictions $\varphi_{21,i} = 0$ for $i = 1,2,\dots,p$.

In empirical analysis, researchers call different methods (splitting the sample into pieces, using dummy variables etc.) to determine the structural changes. This study uses rolling window causality method of Balcilar et al. (2010) to consider the changes of causal relationship between economic growth and environmental pollution for sub-sample periods. Balcilar et al. (2010) utilized above methodology of Hacker and Hatemi-J (2006) and developed a causality method to investigate the bootstrap causality in rolling window sub-samples for $t = \tau - 1 + l, \tau - 1, \dots, \tau, \tau = l, l + 1, \dots, T$, where l is the rolling window. Possible changes in the causal connections between growth and CO2 emissions are determined with computing the bootstrap *p*-values of LR-statistic rolling through T-1 sub-samples. Furthermore, the effect of economic growth on environmental pollution is calculated as $B^{-1} \sum_{k-1}^{P} \hat{\varphi}_{21,k}^{*}$ with $\hat{\varphi}_{21,k}^{*}$ obtained from bootstrap estimation of vector autoregressive (VAR) model by Eq.2 and B is the bootstrap repetition number. Similarly, the effect of environmental pollution on economic growth is computed as $B^{-1} \sum_{k-1}^{P} \hat{\varphi}_{12,k}^{*}$ where $\hat{\varphi}_{12,k}^{*}$ is obtained from bootstrap estimation of VAR model by Eq.2 and B refers to bootstrap repetition number.

4. Empirical results

To investigate the relationship between economic growth and environmental pollution, we first test the stationary properties of economic growth and CO2 emission series using with unit root test developed by Carrion-i-Silvestre et al. (2009). The results of unit root test are shown in Table 1. According to the results, the null of unit root is not rejected in the level form of variables while all series become stationary in first differenced form. Table 1 also presents that the break dates of both economic growth and CO2 emissions are 1973, 1979 and 2007 which indicates the two oil crises and financial crisis, respectively.

[INSERT TABLE 1 HERE]

We also examine the stationary properties of variables with non-linearity assumption using with the non-linear unit root test (KSS unit root test) developed by Kapetanios et al. (2003). Table 2 presents that the null hypothesis of unit root process is not rejected however the null hypothesis can rejected and both variables have become stationary for the level form of the variables. It can be said that real income and carbon dioxide emission are integrated of order one for both linear and non-linear assumption.

[INSERT TABLE 2 HERE]

After determining the integration level of variables, we used full sample bootstrap causality method to examine the causal relationship between economic growth and environmental pollution. The results are illustrated in Table 3. According to the findings, the null of economic growth does not Granger-cause environmental pollution is not rejected while the null of environmental pollution does not Granger-cause is rejected. Therefore, we concluded from full sample bootstrap causality test, economic growth has predictive power on environmental pollution.

[INSERT TABLE 3 HERE]

[INSERT TABLE 4 HERE]

The previous studies are based on full sample relationship between economic growth and environmental pollution with the assumption of stable parameters. We used LC test of Hansen (1992) to examine the stability properties of long-run parameters of cointegrated VAR model and also utilized with Sup-LR, Exp-LR and Mean-LR tests of Andrews (1993) and Andrews and Ploberger (1994) to investigate the stability properties of short-run parameters. The results of stability tests are shown in Table 4. Sup-LR, Exp-LR and Mean-LR tests show that the short-run parameters confirm the short-run parameter stability while the null of long-run parameter stability is rejected based on the results of L_C test. Overall, the findings of previous studies which assume the long-run parameter stability may not be reliable because estimated parameters of cointegrated VAR model are not stable and obtained parameters do not reflect full sample.

Based on above reasons, the main aim of this study is to examine the causal relationship between economic growth and environmental pollution in sub-sample periods and investigating the validity of Environmental Kuznets Curve hypothesis by rolling sample coefficients. The bootstrap *p*-values of observed LR statistics are computed rolling through all sample period from 1966 to 2013. For this, the model in Eq. 2 is estimated for a time span of 15 years.

The results of rolling window estimation are shown in Figure 2. In Panel a of Fig. 2, it can be seen that economic growth causes CO2 emission in 1982-1987, 1996, 2004 and 2009 sub-sample periods. In addition, the results from Panel b of Fig.2 shows that CO2 emission causes economic growth in 1984-1987, 1994, 1996 and 2009 sub-sample periods. The results of the Panel c of Fig.2 show that the effect of economic growth on environmental pollution is negative in 1982-1991 sub-sample periods. After this period, the coefficient of economic growth on environmental pollution is positive in 1993-2004 sub-sample periods and it becomes negative in 2006-2013 sub-sample periods. When the effect of economic growth on environmental pollution is evaluated in terms of trend, we can see that it has an increasing trend from 1982 to 1996. After the peak, the effect of economic growth on CO2 emission has decreasing trend. These findings indicate that there is an inverted U-shaped relationship between economic growth and environmental pollution. It is also concluded from Figure 2, the impact of CO2 emission on economic growth is negative for most of the sub-sample periods.

[INSERT FIGURE 2 HERE]

5. Conclusions and policy implications

This study examines the existence of inverted U-shaped EKC hypothesis for the period from 1966 to 2013 in the US. In doing so, the relationship between GDP per capita and CO2 emission per capita using with bootstrap full sample and sub-sample causality methods. The unit root test of Carrion-i-Silvestre et al. (2009) is used to determine the order of integration of the variables under multiple structural breaks. To take into account the possible non-linearity of the series, the unit root of Kapetanios et al. (2003) is employed. In addition, the parameter stability tests are utilized to examine the constancy of both short-run and long-run parameters constancy.

First, the findings from unit root test show that the variables are stationary at first differenced form and the breaks are found in 1973, 1979 and 2007 which indicates two oil crises and global financial crisis, respectively. According to the results of the full sample bootstrap approach, we found unidirectional causality from GDP to CO2 emissions. However, the result of parameter stability tests confirms the long-run parameter instability of the estimated VAR models and it is concluded that the results of full sample causality method will not give reliable information about the nexus. Finally, the results of the bootstrap sub-sample causality method show that GDP causes CO2 emissions in 1982-1987, 1996, 2004 and 2009 sub-sample periods. The environmental degradation causes economic growth in 1984-1987, 1994, 1996 and 2009 sub-sample periods. Based on the main aim of this study, when the coefficients of GDP on CO2 emissions are evaluated, it seems the effect of economic growth on environmental degradation

has increasing trend in 1982-1996 period, and has decreasing trend in 1996-2013 period. Therefore, the inverted U-shaped EKC hypothesis is confirmed.

Our empirical results implied that the US government seems to have achieved environmental pollution reduction policies along with economic growth. Based on this situation, existing environmental regulatory policies need to be maintained. In addition, it is necessary to adapt the increasing national income to environmentally friendly technologies and to allocate resources to investments especially in the renewable energy sector.

References

Ahmed, K. (2014). Environmental Kuznets curve for CO2 emission in Mongolia: an empirical analysis. *Management of Environmental Quality: An International Journal*, *25*(4), 505-516.

Akbostancı, E., Türüt-Aşık, S., & Tunç, G. I. (2009). The relationship between income and environment in Turkey: Is there an environmental Kuznets curve?. *Energy Policy*, *37*(3), 861-867.

Alam, M. M., Murad, M. W., Noman, A. H. M., & Ozturk, I. (2016). Relationships among carbon emissions, economic growth, energy consumption and population growth: Testing Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia. *Ecological Indicators*, *70*, 466-479.

Al-Mulali, U., & Ozturk, I. (2016). The investigation of environmental Kuznets curve hypothesis in the advanced economies: The role of energy prices. *Renewable and Sustainable Energy Reviews*, *54*, 1622-1631.

Al-Mulali, U., Saboori, B., & Ozturk, I. (2015). Investigating the environmental Kuznets curve hypothesis in Vietnam. *Energy Policy*, *76*, 123-131.

Al-Mulali, U., Solarin, S. A., & Ozturk, I. (2016). Investigating the presence of the environmental Kuznets curve (EKC) hypothesis in Kenya: an autoregressive distributed lag (ARDL) approach. *Natural Hazards*, *80*(3), 1729-1747.

Andrews, D.W.K., (1993). Tests for parameter instability and structural change with unknown change point. Econometrica 61, 821–856.

Andrews, D.W.K., Ploberger, W., (1994). Optimal tests when a nuisance parameter is present only under the alternative. Econometrica 62, 1383–1414

Apergis, N., & Ozturk, I. (2015). Testing environmental Kuznets curve hypothesis in Asian countries. *Ecological Indicators*, *52*, 16-22.

Apergis, N. (2016). Environmental Kuznets curves: new evidence on both panel and country-level CO 2 emissions. *Energy Economics*, *54*, 263-271.

Baek, J. (2015). Environmental Kuznets curve for CO 2 emissions: the case of Arctic countries. *Energy Economics*, *50*, 13-17.

Balcilar, M., Ozdemir, Z. A., Arslanturk, Y., (2010). Economic growth and energy consumption causal nexus viewed through a bootstrap rolling window. Energy Economics, *32*(6), 1398-1410.

Carrion-i-Silvestre, J. L., Kim, D., & Perron, P. (2009). GLS-based unit root tests with multiple structural breaks under both the null and the alternative hypotheses. *Econometric theory*, *25*(06), 1754-1792.

EIA (2016).U.S. Energy Information Administration database.

Efron, B., (1979). Bootstrap methods: another look at the jackknife. Annals of Statistics 7,1–26.

Farhani, S., Mrizak, S., Chaibi, A., & Rault, C. (2014). The environmental Kuznets curve and sustainability: A panel data analysis. *Energy Policy*, *71*, 189-198.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement (No. w3914). National Bureau of Economic Research.

Hacker, R.S., Hatemi-J, A., (2006). Tests for causality between integrated variables using asymptotic and bootstrap distributions: theory and application. Applied Economics 38, 1489–1500.

Hansen, B.E., (1992). Tests for parameter instability in regressions with I(1) processes. Journal of Business and Economic Statistics 10, 321–336.

He, J., & Richard, P. (2010). Environmental Kuznets curve for CO 2 in Canada. *Ecological Economics*, *69*(5), 1083-1093.

Iwata, H., Okada, K., & Samreth, S. (2010). Empirical study on the environmental Kuznets curve for CO 2 in France: the role of nuclear energy. *Energy Policy*, *38*(8), 4057-4063.

Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve for CO 2 emissions: a cointegration analysis for China. *Energy Policy*, *37*(12), 5167-5172.

Kapetanios, G., Shin, Y., & Snell, A. (2003). Testing for a unit root in the nonlinear STAR framework. *Journal of econometrics*, *112*(2), 359-379.

Lau, L. S., Choong, C. K., & Eng, Y. K. (2014). Investigation of the environmental Kuznets curve for carbon emissions in Malaysia: Do foreign direct investment and trade matter?. *Energy Policy*, *68*, 490-497.

Li, T., Wang, Y., & Zhao, D. (2016). Environmental Kuznets Curve in China: New evidence from dynamic panel analysis. *Energy Policy*, *91*, 138-147.

Onafowora, O. A., & Owoye, O. (2014). Bounds testing approach to analysis of the environment Kuznets curve hypothesis. *Energy Economics*, *44*, 47-62.

Osabuohien, E. S., Efobi, U. R., & Gitau, C. M. W. (2014). Beyond the environmental Kuznets curve in Africa: evidence from panel cointegration. *Journal of Environmental Policy & Planning*, *16*(4), 517-538.

Ozturk, I., & Al-Mulali, U. (2015). Investigating the validity of the environmental Kuznets curve hypothesis in Cambodia. *Ecological Indicators*, *57*, 324-330.

Ozokcu, S., & Ozdemir, O. (2017). Economic growth, energy, and environmental Kuznets curve. *Renewable and Sustainable Energy Reviews*, *72*, 639-647.

Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development (No. 992927783402676). International Labour Organization.

REN21 (2016). Renewables 2016 Global Status Report.

Saboori, B., Sulaiman, J., & Mohd, S. (2016). Environmental Kuznets curve and energy consumption in Malaysia: A cointegration approach. *Energy Sources, Part B: Economics, Planning, and Policy*, *11*(9), 861-867.

Shahbaz, M., Dube, S., Ozturk, I., & Jalil, A. (2015). Testing the environmental Kuznets curve hypothesis in Portugal. *International Journal of Energy Economics and Policy*, *5*(2).

Shahbaz, M., Khraief, N., Uddin, G. S., & Ozturk, I. (2014). Environmental Kuznets curve in an open economy: A bounds testing and causality analysis for Tunisia. *Renewable and Sustainable Energy Reviews*, *34*, 325-336.

Shahbaz, M., Mutascu, M., & Azim, P. (2013). Environmental Kuznets curve in Romania and the role of energy consumption. *Renewable and Sustainable Energy Reviews*, *18*, 165-173.

Shahbaz, M., Solarin, S. A., & Ozturk, I. (2016). Environmental Kuznets Curve hypothesis and the role of globalization in selected African countries. *Ecological Indicators*, *67*, 623-636.

Shafik, N., & Bandyopadhyay, S. (1992). Economic growth and environmental quality: time-series and cross-country evidence (Vol. 904). World Bank Publications.

Tiwari, A. K., Shahbaz, M., & Hye, Q. M. A. (2013). The environmental Kuznets curve and the role of coal consumption in India: cointegration and causality analysis in an open economy. *Renewable and Sustainable Energy Reviews*, *18*, 519-527.

Toda, H.Y.,Yamamoto, T., (1995), Statistical inference in vector autoregression with possibly integrated processes. Journal of Econometrics 66, 225–250

WDI (2016). World Development Indicators database, World Bank.