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Investigating the environmental Kuznets curve hypothesis in seven regions: The role of renewable energy

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ABSTRACT

The aim of this research is to investigate how renewable energy consumption effects pollution and whether the relationship between income and pollution formulates the inverted U-shaped relationship which signals the existence of the environmental Kuznets curve (EKC). To realize the aims of this study, non-stationary panel data techniques were utilized to examine the seven selected regions. According to Pedroni and Fisher type cointegration tests, the variables were cointegrated. Moreover, the dynamic ordinary least square (DOLS) and the vector error correction model Granger causality revealed that renewable energy consumption has a significant negative effect on pollution in Central and Eastern Europe, Western Europe, East Asia and the Pacific, South Asia, and the Americas. However, the tests revealed that renewable energy consumption has no significant effect on pollution in the Middle East and North Africa and Sub-Saharan Africa. In addition, the results in general indicated that the existence of the EKC hypothesis is determined by the significance of the renewable energy consumption. Therefore, the EKC hypothesis was only found in the regions where their renewable energy has a significant correlation with pollution in both the short run and the long run. Furthermore, a number of policy recommendations were provided for the investigated regions.

1. Introduction

It is well known that the fluctuation in fossil fuels energy prices and the increasing environmental pressure that the world is witnessing represent a major dilemma for the lives of the poor in developing countries as well as put the world's foundations of energy security, economic growth, and development at risk. Therefore, many countries are encouraged to implement strategies to reduce their dependency on the imported fossil fuels and to decrease the environmental pressure. Increasing the role of renewable energy sources is a fundamental strategy in decreasing the environmental pressure. These sources of energy can be a key solution in increasing energy security by reducing the countries' dependency on imported fossil fuels. Furthermore, such sources of energy can decrease the environmental damage because renewables represent a clean source of energy. Therefore, the world had witnessed a substantial boost in renewable energy production. During the period of 1980–2012, the world renewable electricity production increased more than 50% (GIMD, 2014). Thus, the boost in renewable energy production indicates that the task of this source of energy in meeting the world energy needs is increasing. Moreover, the boost in renewable energy can increase this type of energy's role as a solution for reducing greenhouse gas emissions. Therefore, this study is set out to examine whether renewable energy consumption has reached a point where it can reduce the environmental pollution as well as whether renewable energy consumption helps to form the inverted U-shaped relationship between income and pollution which resembles the environmental Kuznets Curve (EKC) hypothesis. In this study, seven regions are selected, namely, East Asia and the Pacific, Western Europe, East Europe and Central Asia, the Americas, Middle East and North Africa, South Asia, and Sub Saharan Africa.

The EKC hypothesis explains that during the early stages of economic development, the increase in income will increase the pollution until it reaches to a certain point where the relationship between income and pollution becomes negative. This phenomenon is represented by an inverted U-shaped relationship. In other words, the inverted U-shaped relationship between income and pollution will take place only when the country reaches

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a certain level of economic development where technologies that enhance energy efficiency and renewable energy are available.

The validity of EKC has been examined by a number of studies, which have utilized different econometrics methods and focused on the different regions. The literature can be divided based on the methods, countries or region being studied, the number of variables included in the model and the data span. In this paper, the literature is structured according to the number of countries in each of the studies. The first fold of the literature examines the EKC hypothesis for individual countries. The second strand of the literature examines the EKC hypothesis for multi-country studies. We also try to highlight the particular type of indicator that has been used as a proxy for energy sector in order to show that many studies have focused on using aggregate energy consumption and the use of renewable energy consumption has been very limited.

Starting with the studies that have concentrated on individual countries, Shahbaz et al. (2013a) examined the relationship in CO_2 emission, GDP, GDP square, and energy consumption in Romania for the period, 1980–2010. Using the ARDL bounds testing of Pesaran et al. (2001), the results provided support for EKC hypothesis. Using a similar approach, Ahmed and Long (2012) established the existence of EKC in Pakistan. Yavuz (2014) utilized the data of Turkey to examine the relationship in CO_2 emission, GDP, GDP square and energy consumption. The author used the Johansen and Juselius (1990) cointegration test, and fully modified OLS of Phillips and Hansen (1990) to establish the existence of EKC in Turkey. Ozturk and Al-Mulali (2015) probed the existence of EKC in Cambodia for the 1996–2012 period. Using the Generalized Method of Moments (GMM) of Arellano and Bover (1995) and the two-stage least squares (TSLS), the study fails to observe EKC in the country.

Jalil and Mahmud (2009) employed the data of China to examine the relationship between CO_2 emission, GDP, GDP square, energy consumption and trade openness for the 1975–2005 period. Using the ARDL bounds testing of Pesaran et al. (2001) and the standard Granger causality test, the result provide support for EKC hypothesis and unilateral causality from GDP to emission. While Ang (2007) and Shahbaz et al. (2012) reached the same conclusion for France and Pakistan; Lau et al. (2014) and Saboori et al. (2012) provided similar results for Malaysia. Tan et al. (2014) examined the presence of EKC and the possible causal relationship between the CO_2 emission, energy consumption, GDP, and GDP square in Singapore for the period, 1975–2011. Using the Johansen and Juselius (1990) cointegration test, the results provide evidence for no EKC in the country. However, the causal analysis reveals that there is unidirectional causality from CO_2 emission to GDP, but no causality between CO_2 emission and energy consumption.

Shahbaz et al. (2014a) used the data of Tunisia to examine the existence of EKC in 1971–2010. Using the ARDL bounds testing of Pesaran et al. (2001) and also performing causality tests on variables that include CO_2 emission, GDP, GDP square, energy consumption, and trade openness; the authors observe the presence of EKC and unidirectional causality from GDP to emission. The results further show that there is bidirectional causality between energy consumption and emission. Using similar approach in Tunisia and South Africa, Farhani et al. (2014) and Kohler (2013) provide evidence for EKC and also similar pattern of causality. Ozturk and Acaravci (2013) employed the data of Turkey to probe the relationship in CO_2 emission, GDP, GDP square, energy consumption, trade openness and financial development. The empirical outcome unveils the presence of EKC in addition to unilateral causality flowing from both GDP and energy consumption to emission. Shahbaz et al. (2013b) and Tang and Tan (2015) provide support for EKC and bidirectional causality between GDP and emission; and bidirectional causality between energy consumption and emission in Malaysia and Vietnam, respectively. On the contrary, Pao et al. (2011) failed to find evidence of EKC in Russia but bidirectional causality in GDP and emission; and between energy consumption and emission. Halicioglu (2009) used the data of Turkey to examine the relationship between CO_2 emission, GDP, GDP square, energy consumption and trade openness in Turkey, for the 1960–2005 period. The empirical output unveils support for inverted U-shaped curve in the country as well as bidirectional causality between emission and GDP, but causality from energy consumption to emission. Pao and Tsai (2011a) observed the same pattern of result in a study that involves the dataset of Brazil for the 1980–2007 period.

There are individual country studies that have adopted either sectoral or provincial datasets in their analyses. For instance, Hamit-Haggar (2012) probed the relationship in CO_2 emission, GDP, GDP square and energy consumption in industrial sector in Canada for the 1990–2007 period. The authors adopted the Pedroni (1999, 2004) tests and the standard causality test, the author found support for EKC and the existence of unidirectional causality from both energy consumption and GDP to emission. Haisheng et al. (2005), Guangyue and Deyong (2011) and Llorca and Meunié (2009) employed the dataset of many provinces in China to examine the existence of EKC in the country. While the outputs in the works of Haisheng et al. (2005) and Guangyue and Deyong (2011) show support for EKC, the results in Llorca and Meunié (2009) suggested that EKC does not exist in the country. In the same vein, Wang et al. (2011) used dataset of 28 provinces in China to investigate the existence of EKC and also the pattern of causality in the country. The findings provide evidence for EKC, unidirectional causality from GDP to emission as well as bidirectional causality between energy consumption and emission.

The foregoing individual-country papers have used energy consumption to represent the energy sector. However, there are individual-country studies that have considered other variables beyond energy consumption to proxy the energy sector. For instance, Al-Mulali et al. (2015a) used both fossil fuels energy consumption and renewable energy consumption as indicators of energy sector in Vietnam for the period, 1981–2011. Using the Pesaran et al. (2001) approach to cointegration, the authors were unable to find evidence for EKC. Whilst using similar approach, Al-Mulali et al. (2016) provided evidence for EKC in Kenya. Shahbaz et al. (2014b) investigated the relationship in CO_2 emission, electricity consumption, GDP, and GDP square, urbanization, and exports in United Arab Emirates for the 1975–2011 period. The results support the existence of EKC in the country as well as unilateral causality from GDP to emission and bidirectional causality between energy consumption to emission. Similarly, Shahbaz et al. (2013c) and Tiwari et al. (2013) used coal consumption as proxy for energy sector and found evidence for EKC hypothesis in South Africa and India. In a more detailed study, which includes total energy consumption, coal consumption, gas consumption, electricity consumption, oil consumption as proxy for the energy sector in Malaysia, Saboori and Sulaiman (2013a) established evidence for EKC in addition to bidirectional causality between GDP and emission; and between different energy indicators and emission.

The second part of our literature review focusses on multi-country studies and the first segment of these papers have used energy consumption as a proxy for the energy sector and also utilized time series techniques largely because the number of countries in their sample is finite. The findings provide support for EKC in Indonesia Malaysia and Thailand. Jayanthakumaran et al. (2010) examined the relationship in CO_2 emission, GDP, GDP square, energy consumption, and trade openness in China and India for the period, 1971–2007. Using the Pesaran et al. (2001) approach to cointegration, the results provide evidence for EKC in both countries. In the same vein, Onafowora and Owoye (2014), Lapinskienė et al. (2014), Baek (2015) and Saboori and Sulaiman (2013b) focused on mixed, European, Artic and ASEAN countries, respectively. The results provided mixed evidence for EKC