CHAPTER 4

Single-Country Versus Multiple-Country Studies

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The number of studies on the validity of the environmental Kuznets curve (EKC) hypothesis seems to have increased significantly in recent years. The results of the studies vary according to the differences in the models used, the types of pollution used, the periods covered, and the countries involved. The studies using time-series methods (single-country) in the literature related to the EKC are reported in Section A of Tables 4.1 and 4.2, whereas the studies using panel methods (panel-country) in the literature are reported in Section B of Tables 4.1 and 4.2. It is worth to note that the number of studies that support the validity of hypothesis is more than that that support the invalidity of EKC hypothesis for both single-country and panel-country studies.

SINGLE-COUNTRY STUDIES

This chapter starts by discussing single-country studies. Roca, Padilla, Farre, and Galletto (2001) examined the relationship between economic growth and atmospheric pollution by using Spain's indicators data period from 1980 to 1996. This study that applied Seemingly Unrelated Regression (SUR) technique has proved that the EKC hypothesis is invalid for other pollution indicators (CO_2, NO_x, CH_4, N_2O, and NMVOC) outside SO_2. Similar results obtained by Kunnas and Myllyntaus (2007), which is a similar study that applied according to the subelements. The paper revealed that EKC hypothesis is valid for only SO_2 emissions in Finland for the period from 1800 to 2003. Lindmark (2002) investigated the nexus between CO_2 emissions, technology, fuel prices, and growth in Sweden for historic data period 1870–1997, using structural time series models and reached that the EKC hypothesis is valid only for the period 1920–60. Başar and Temurlenk (2007) tested the hypothesis for Turkey 1950–2000 data period. This research that used carbon emissions as a pollution indicator implied that the EKC hypothesis is invalid in Turkey. Soytaş, Sari, and Ewing (2007) investigated the relationship between energy consumption, income, and carbon emissions for United States 1960–2004 data period, using Toda-Yamamoto causality test. They found that income is not cause carbon emissions in the long run, energy consumption does. Contrary to the inverted U-shaped relationship on which the EKC hypothesis is based, Ang (2008) found a positive relationship between pollution and income in Malaysia. Thus, Ang (2008) implied that the EKC hypothesis is invalid as a result of Johansen cointegration test and Error Correction Model (ECM)-based causality analysis. Another study that argues that the EKC hypothesis is not valid belongs to Akbostancı, Türüt-Aşık, and Tunç (2009). They reached this finding, using Johansen cointegration test with Turkey's 1968–2003 data. He and Richard (2010) tested the same relationship by using 1948–2004 data and found that there is a little evidence in favor of the EKC.

Esteve and Tamarit (2012a,b) studied on the EKC hypothesis for Spain during the period 1857–2007. According to their results based on Stock-Watson-Shin and Arai-Kurozumi-Kejriwal cointegration tests, there is not inverted U-shaped relationship between per capita CO_2 and per capita income. Whereas in another study, they used the same country and same period data but changed the method of analysis (threshold cointegration test) and reached the conclusion that the EKC is valid that mean inverted U-shaped relationship between per capita CO_2 and per capita income. In more recent studies, Autoregressive Distributed Lag (ARDL) analysis has been extensively used to test the EKC hypothesis because of the advantages it provides methodically. One of the studies that applied ARDL analysis and showed that EKC is invalid belongs to Saboori, Sulaiman, and Mohd (2012a,b). They examined the relationship between carbon emissions and economic growth in Indonesia data period

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TABLE 4.1
Single-Country and Multiple-Country Studies on the Validity of the Environmental Kuznets Curve Hypothesis.

Study	Country	Period	Method
SINGLE-COUNTRY STUDIES			
Lindmark (2002)	Sweden	1870–1997	STRM
Kunnas and Myllyntaus (2007)	Finland	1800–2003	Regression
Jalil and Mahmud (2009)	China	1975–2005	ARDL
Fodha and Zaghdoud (2010)	Tunisia	1961–2004	Johansen cointegration test
Iwata et al. (2010)	France	1960–2003	ARDL
Nasir and Rehman (2011)	Pakistan	1972–2008	Johansen cointegration test
Esteve and Tamarit (2012a,b)	Spain	1857–2007	Threshold cointegration test
Fosten et al. (2012)	UK	1830–1998	Nonlinear threshold cointegration test and error correction model
Franklin and Ruth (2012)	USA	1800–2000	OLS, Prais-Winsten regression
Saboori et al. (2012a,b)	Malaysia	1980–2009	ARDL
Shahbaz et al. (2012)	Pakistan	1971–2009	ARDL, Gregory-Hansen cointegration test, Granger causality test
Ahmed and Qazi (2013)	Mongolia	1980–2010	Johansen cointegration test
Saboori and Sulaiman (2013)	Malaysia	1980–2009	ARDL, Johansen-Juselius maximum likelihood approach
Shahbaz, Mutascu et al. (2013), Shahbaz, Ozturk et al. (2013)	Romania	1980–2010	ARDL
Shahbaz, Mutascu et al. (2013), Shahbaz, Ozturk et al. (2013)	Turkey	1970–2010	VECM Granger causality
Tiwari et al. (2013)	India	1966–2011	ARDL, VECM Granger causality
Lau et al. (2014)	Malaysia	1970–2008	ARDL, Granger causality
Onafowora and Owoye (2014)	8 countries	1970–2010	ARDL
Shahbaz et al. (2014)	Tunisia	1971–2010	ARDL, VECM Granger causality test
Balaguer and Cantavella (2015)	Spain	1874–2011	ARDL
Bozkurt and Okumus (2015)	Turkey	1966–2011	Hatemi-J cointegration test
Boluk and Mert (2015)	Turkey	1961–2010	ARDL
Al-Mulali et al. (2015a)	Kenya	1980–2012	ARDL
Tutulmaz (2015)	Turkey	1968–2007	Johansen and Engle-Granger cointegration tests
Abdulrazag and Alrajhi (2016)	Saudi Arabia	1971–2013	ARDL, VECM Granger causality
Alam et al. (2016)	Brazil, China, India, Indonesia	1970–2012	ARDL
Ali et al. (2016)	Malaysia	1971–2012	ARDL, DOLS, Granger causality test
Aslan and Gözbaşı (2016)	China	1977–2013	FMOLS, pairwise Granger causality test
Javid and Sharif (2016)	Pakistan	1972–2013	ARDL, VECM cointegration test

TABLE 4.1
Single-Country and Multiple-Country Studies on the Validity of the Environmental Kuznets Curve Hypothesis.—cont'd

Study	Country	Period	Method
Kılıç and Akalın (2016)	Turkey	1960–2011	ARDL
Lebe (2016)	Turkey	1960–2010	ARDL, Granger causality test
Sugiawan and Managi (2016)	Indonesia	1971–2010	ARDL
Waluyo and Terawaki (2016)	Indonesia	1962–2007	ARDL
Zambrano-Monserrate et al. (2016b)	Brazil	1971–2011	ARDL, Granger causality test
Zambrano-Monserrate et al. (2016c)	Iceland	1960–2010	ARDL
Zambrano-Monserrate et al. (2016a)	Ecuador	1971–2011	ARDL, Granger causality test
Rafindadi (2016)	Japan	1961–2012	ARDL
Vita et al. (2016)	Turkey	1960–2009	DOLS
Ahmad et al. (2017)	Croatia	1992Q1 –2011Q1	ARDL, VECM Granger causality, DOLS, FMOLS
Ali et al. (2017)	Pakistan	1960–90	Johansen cointegration test
Och (2017)	Mongolia	1981–2012	ARDL, VECM Granger causality test
Aslan et al. (2018)	USA	1966–2013	Bootstrap rolling window estimation method
Balaguer and Cantavella (2018)	Australia	1950–2014	ARDL
Ravanoğlu et al. (2018)	Kyrgyzstan	1990–2013	ARDL
PANEL-COUNTRY STUDIES			
Markandya et al. (2006)	EU	1870–2001	Panel FE, panel RE
Apergis and Payne (2009)	Central America countries	1971–2004	Pedroni cointegration, FMOLS
Atici (2009)	Central and Eastern Europe	1980–2002	OLS with FE and RE
Lean and Smyth (2010)	ASEAN	1980–2006	Johansen cointegration, panel DOLS
Pao and Tsai (2011)	BRIC countries	1992–2007	OLS
Arouri et al. (2012)	MENA	1981–2005	LM cointegration, mean-group estimation
Donfouet et al. (2013)	EU	19611–2009	Panel GMM and spatial panel
Farhani and Shahbaz (2014)	MENA	1980–2009	Pedroni cointegration, FMOLS, DOLS
Shafiei and Salim (2014)	OECD countries	1980–2011	Johansen cointegration, Westerlund cointegration, GMM, AMG
Heidari, Katircioglu, and Saeidpour (2015)	ASEAN	1980–2008	PSTR model
Al-Mulali, Weng-Wai, Sheau-Ting, and Mohammed (2015c)	Panel of higher-income countries	1980–2008	OLS with FE, GMM
Kasman and Duman (2015)	EU countries	1992–2010	Pedroni cointegration, FMOLS

Continued

TABLE 4.1
Single-Country and Multiple-Country Studies on the Validity of the Environmental Kuznets Curve Hypothesis.—cont'd

Study	Country	Period	Method
Jebli et al. (2016)	OECD countries	1980–2010	Pedroni cointegration, panel FMOLS, panel DOLS
Dogan and Seker (2016)	EU	1980–2012	Panel DOLS
Bilgili et al. (2016)	OECD countries	1977–2010	Pedroni cointegration, FMOLS, DOLS
Al-Mulali and Ozturk (2016)	Panel of 27 advanced countries	1990–2012	Kao cointegration, Johansen cointegration, FMOLS
Ahmad et al. (2016)	EU	1980–2010	Panel ARDL
Charfeddine and Mrabet (2017)	MENA	1995–2007	Panel DOLS and panel FMOLS
Pablo-Romero et al. (2017)	EU	1995–2009	OLS with RE
Rauf et al. (2018)	Belt and Road Initiative countries	1981–2016	Mean-group estimator
Dong et al. (2018)	Asia-Pacific countries	1970–2016	Panel FMOLS and mean-group estimator
Ulucak and Bilgili (2018)	45 countries	1961–2013	CUP-FM, CUP-BC
Hu et al. (2018)	Developing countries	1996–2012	Panel DOLS and panel FMOLS

AMG, augmented mean group estimation; *ARDL*, autoregressive ditributed lag; *CUP-BC*, Countinuously Updated Bias Corrected; *CUP-FM*, Countinuously Updated Fully Modified; *DOLS*, dynamic ordinary least squares; *GMM*, generalized method of moments; *MENA*, middle east and north africa; *OLS*, ordinary least squares; *PSTR*, panel smooth transition regression model; *STRM*, structural time series model; *VECM*, vector error correction model.

from 1971 to 2007, including energy consumption and foreign trade. Using the same method, they obtained an opposite result for the EKC from their analysis with the Malaysia' 1980–2009 data. But unlike the analysis done for Indonesia in this study, energy consumption and foreign trade data were excluded from the econometric model. In addition, a causality test performed using the vector error correction model following the boundary test. Saboori and Sulaiman (2013) examined the nexus between environmental degradation, economic growth, and energy consumption for Malaysia and proved that the validity of the EKC depends on energy consumption. They suggested that decreasing energy consumption appears to be an effective way to control carbon emissions but simultaneously hinder economic growth. Koçak (2014) is another study that tests the EKC hypothesis with ARDL approach and proved that this hypothesis is invalid in Turkey for data period from 1960 to 2010.

Robalino-Lopez, Garcia-Ramos, Golpe, and Mena-Nieto (2014) analyzed whether the EKC hypothesis is held within the period 1980–2025 in Ecuador, using cointegration tests based on Stock and Watson (2010) and reached that the hypothesis is invalid. Boopen and Vinesh (2015) investigated the relationship among GDP and CO_2 in Mauritania for 1975–2009 data period. They used Johansen cointegration test, and they were unable to prove the existence of a reasonable turning point and thus no EKC inverted-U shape was obtained. The same relation was investigated by Erdoğan, Türköz, and Görüş (2015) for Turkey. There was no evidence of validity of the EKC in the study covering the 1975–2010 periods, using ARDL boundary test and Toda-Yamamoto causality analysis. Jebli and Youssef (2015) preferred the vector error correction model for causality test despite applied ARDL analysis in their study for Tunisia. Their analysis included that economic growth and carbon emissions as well as trade, renewable, and nonrenewable energy consumption variables. Their results suggested that the inverted U-shaped EKC hypothesis is not supported graphically and analytically in the long run. Robalino-Lopez, Mena-Nieto, Garcia-Ramos, and Golpe (2015) studied in detail how changes in the driving forces of the economy affect carbon emissions for Venezuela 1980 2025 data period. Their analysis results based on SUR method implied that Venezuela does not fulfill the EKC hypothesis, but the country could be on the way

TABLE 4.2
Single-Country and Multiple-Country Studies on the Invalidity of the Environmental Kuznets Curve Hypothesis.

Study	Country	Period	Method
SINGLE-COUNTRY STUDIES			
Roca et al. (2001)	Spain	1980–96	SUR
Başar and Temurlenk (2007)	Turkey	1950–2000	Regression
Soytaş et al. (2007)	USA	1960–2004	Toda-Yamamoto causality test
Ang (2008)	Malaysia	1971–99	Johansen cointegration, ECM-based causality test
Akbostancı et al. (2009)	Turkey	1968–2003	Johansen cointegration test
He and Richard (2010)	Canada	1948–2004	PLR model and Hamilton's model
Esteve and Tamarit (2012a,b)	Spain	1857–2007	Stock-Watson-Shin and Arai-Kurozumi-Kejriwal cointegration test
Saboori et al. (2012a,b)	Indonesia	1971–2007	ARDL
Koçak (2014)	Turkey	1960–2010	ARDL
Robalino-Lopez et al. (2014)	Ecuador	1980–2025	Cointegration test
Boopen and Vinesh (2015)	Mauritania	1975–2009	Johansen cointegration test, VAR, OLS
Erdoğan et al. (2015)	Turkey	1975–2010	ARDL, Toda-Yamamoto Granger causality
Al-Mulali et al. (2015b)	Vietnam	1981–2011	ARDL
Ozturk and Al-Mulali (2015)	Cambodia	1996–2012	GMM, 2SLS
Robalino-Lopez et al. (2015)	Venezuela	1980–2025	SUR
Jebli and Youssef (2015)	Tunisia	1980–2009	ARDL, VECM Granger causality test
Erdoğan et al. (2015)	Turkey	1975–2010	ARDL, Toda-Yamamoto Granger causality
Al-Mulali et al. (2015b)	Vietnam	1981–2011	ARDL
Ozturk and Al-Mulali (2015)	Cambodia	1996–2012	GMM, 2SLS
Robalino-Lopez et al. (2015)	Venezuela	1980–2025	SUR
PANEL-COUNTRY STUDIES			
Ozcan (2013)	Middle East countries	1990–2008	Westerlund cointegration, Panel FMOLS
Boluk and Mert (2014)	EU countries	1990–2008	OLS with FE
Lopez-Menendez, Perez, and Moreno (2014)	EU countries	1996–2010	OLS with FE and RE
Ajmi, Hammoudeh, Nguyen, and Sato (2015)	G7 countries	1960–2010	Ng-Perron unit root, causality test
Al-Mulali et al. (2016)	58 countries	1980–2009	Panel FE and panel GMM
Dogan et al. (2017)	OECD	1995–2010	LM cointegration, DOLS
Abid (2017)	EU	1990–2011	Panel GMM

PLR, Partially Linear Regression.

to achieve environmental stabilization in the medium run. Al-Mulali, Saboori, and Ozturk (2015b) reached the findings that the EKC is invalid for the case of Vietnam, using ARDL analysis. Although they used the same data period and the same method, they found the opposite result when they study for Kenya. Ozturk

and Al-Mulali (2015) investigated whether better governess and corruption control help to form the inverted U-shaped relationship between income and pollution in Cambodia for the period of 1996–2012. The results from Generalized Method of Moments (GMM) and the Two-Stage Least Squares (2SLS) revealed that GDP, urbanization, energy consumption, and trade openness increase CO_2 emission, whereas the control of corruption and governess reduces carbon emission and ultimately showed that the EKC hypothesis is invalid for Cambodia. Yurttagüler and Kutlu (2017) tested the EKC hypothesis in Turkey, using the data for 1960–2011. Their results indicated that there is an N-shaped relationship between income and carbon emission.

Although there are numerous time-series studies advocating that this hypothesis is invalid in studies conducted to test the EKC hypothesis, a relatively large number of studies have proved that this hypothesis is valid. Jalil and Mahmud (2009) examined the long-run relationship between carbon emissions, energy consumption, income, and foreign trade in the case of China by using time-series data of 1975–2005. They aimed testing the EKC hypothesis for CO_2 emission and per capita real GDP by using ARDL method and Granger causality analysis. Nasir and Rehman (2011) also researched for Pakistan using the same indicators, and the results again confirmed the validity of EKC hypothesis for the period 1972–2008. The analysis results indicated that the EKC hypothesis is valid; in addition, carbon emissions are mainly determined by income and energy consumption. Another study that analyzes for Pakistan using carbon emissions, energy consumption, growth, and trade indicators is the research of Shahbaz, Lean, and Shabbir (2012). Their analyses that are based on ARDL, Gredory-Hansen cointegration, and Granger causality tests proved that existence of EKC hypothesis for the period from 1971 to 2009. Shahbaz, Mutascu, and Azim (2013), Shahbaz, Ozturk, Afza, and Ali (2013) tested the EKC hypothesis for Romania this time, not including of trade variable in analysis. In this study, they applied ARDL boundary test and revealed that the EKC is valid for the period of 1980–2010. They analyzed this relationship in the same year for Turkey and confirmed the presence of the EKC hypothesis. Ahmed and Qazi (2013) tested the EKC hypothesis for CO_2 in Mongolia data period from 1980 to 2010, using Johansen cointegration test with major explanatory variables as energy consumption, economic growth, and trade openness. Their results confirmed the existence EKC hypothesis among the variables both in long run and short run except trade openness. Tiwari, Shahbaz, and Hye (2013) also examined the case of India with the same indicators, using ARDL analysis and Vector Error Coreection Model (VECM) Granger causality test. They revealed that existence of the EKC hypothesis, and coal consumption and trade openness contributes to CO_2 emission.

Fodha and Zaghdoud (2010) investigated this hypothesis for Tunisia data period from 1961 to 2004 by using Johansen cointegration test. They used CO_2 and SO_2 emissions as the environmental pollution indicators and the GDP as an economic indicator. Their results proved that there is an inverted U-shaped relationship between SO_2 emissions and GDP, with income turning point approximately equals to $1200 but was found monotonically a relationship between CO_2 and GDP. Another study using the variables of carbon emission and sulfur dioxide emission as pollution indicators belongs to Fosten et al. (2012). They investigated whether the EKC hypothesis is valid for the United Kingdom by using nonlinear threshold cointegration test and error correction model and reached that there is an inverted U-shaped relationship between per capita CO_2 and SO_2 emissions and per capita GDP. Och (2017) used nitrous oxide (NO_x) emissions as an indicator of environmental pollution and analyzed the EKC hypothesis in Mongolia for the 1981–2012 period, using ARDL and VECM Granger causality tests. A highly significant and robust long-run U-shaped relationship between NO_x emissions and income was found, meaning that the existence of the EKC hypothesis.

Iwata, Okada, and Samreth (2010) studied for France by considering the role of nuclear energy, and their ARDL estimation results provided evidence supporting the EKC hypothesis for the 1960–2003 data period. Franklin and Ruth (2012) conducted a regression analysis using the 1800–2000 period data from the United States and found the inverted U-shaped relationship between pollution and growth. Lau, Choong, and Eng (2014) provided a different contribution to the literature by including foreign direct investment in analysis for Malaysia. They attempted to examine the EKC hypothesis for Malaysia in the presence of foreign direct investment and trade openness both in the short and long run for the period from 1970 to 2008. Their analysis results indicated the inverted U-shaped relationship between economic growth and CO_2 emission. Ali, Abdullah, and Azam (2016) investigated the impact of foreign direct investment as well as financial development, energy consumption, and trade openness on carbon emission for Malaysia, using ARDL boundary test, DOLS method, and Granger causality analysis; they

reached same results with Lau et al. (2014). Javid and Sharif (2016) analyzed the effects of financial development, income, energy consumption, and trade openness on CO_2 emissions in Pakistan for the period from 1972 to 2013. In this study, where ARDL analysis was the basic research methodology, the validity of the hypothesis was revealed. Lebe (2016) achieved the same result for Turkey, using same indicators and same analysis technique.

Onafowora and Owoye (2014) investigated the EKC hypothesis for each of eight different countries (Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea, and South Africa) with ARDL analysis, using economic growth, energy consumption, population density, trade openness, and CO_2 emission indicators. The estimate results showed that the inverted U-shaped EKC hypothesis holds in Japan and South Korea. Bozkurt and Okumus (2015) considered energy consumption, population density, and trade openness in testing the hypothesis such as Onafowora and Owoye (2014). In this study that applied Hatemi-J cointegration test with 1966–2011 data is proved the validity of the hypothesis for Turkey. A study to test the EKC hypothesis with same indicators was also conducted by Abdulrazag and Alrajhi (2016) for Saudi Arabia. Results of ARDL analysis and VECM causality test with 1971–2013 data revealed the validity of the hypothesis. Alam, Murad, Noman, and Ozturk (2016) examined the impacts of income, energy consumption, and population growth on CO_2 emissions in Brazil, China, India, and Indonesia for the 1970–2012 data period. Their results suggested that the EKC hypothesis is valid only in Brazil, China, and Indonesia.

Shahbaz, Khraief, Uddin, and Ozturk (2014) investigated the existence of the EKC hypothesis in Tunisia for the period of 1971–2010. They applied ARDL boundary test and causality analysis based on VECM and proved the presence of this hypothesis. Balaguer and Cantavella (2015) included fuel oil prices in analysis while testing the EKC hypothesis for Spain. ARDL test results supported the hypothesis. Boluk and Mert (2015) tried to demonstrate the reducing effect of renewable energy sources on greenhouse gas emission, using ARDL approach for Turkey; their results suggested an inverted U-shaped relationship between per capita green gas emission and income. Tutulmaz (2015) using Johansen and Engle-Granger cointegration tests reached the first phases of an inverted U-shaped EKC relationship in his study for Turkey data period from 1968 to 2007. Aslan and Gözbaşı (2016) investigated the validity of the EKC hypothesis for the period among 1977 and 2013 by using the subelements of CO_2 emissions in China. Fully Modified Ordinary Least Squares (FMOLS), Pairwise Granger causality test results suggested that the EKC hypothesis is valid for CO_2 emissions from gaseous fuel consumption, liquid fuel consumption, solid fuel consumption, and transportation but invalid for aggregate CO_2 emissions: CO_2 emissions from residential buildings and commercial and public services, from electricity and heat production, and from manufacturing industries and constructions. Kılıç and Akalın (2016, pp. 49–60) used per capita CO_2 emission as the indicator of environmental pollution and per capita income as the indicator of economic growth. Their results obtained from ARDL boundary analysis show that there is an inverted U-shaped relationship between the variables for 1960–2011 periods.

Sugiawan and Managi (2016) explored the existence of EKC hypothesis in Indonesia by using the analysis and reached that the EKC hypothesis is valid (turning point is 7729 USD per capita). Waluyo and Terawaki (2016) also made an ARDL analysis for Indonesia but also considered deforestation. Test results supported the long-run inverted-U relationship, thus, while the deforestation rate increases at the initial stage of economic growth, it declined after a threshold point (990.4 USD). Zambrano-Monserrate, Garcia-Alban, and Henk-Vera (2016) conducted different studies for Brazil, Iceland, and Ecuador and applied ARDL analysis in each study. The results of three studies revealed the validity of the EKC hypothesis. Rafindadi (2016) used ARDL analysis to test the presence of EKC in Japan for the period from 1961 to 2012. This analysis of the period covering energy disaster and deteriorating income proved that the EKC is valid despite deteriorating income. Vita, Katircioglu, Altinay, Fethi, and Mercan (2016) while testing the EKC hypothesis for Turkey took the subject from a different perspective in the context of tourism development. They found that tourist arrivals, growth, and energy consumption exert a positive and statistically significant impact on CO_2 emissions in the long run. In addition, empirical results supported the existence of EKC hypothesis. Ahmad et al. (2017) analyzed the relationship between CO_2 emissions and economic growth in Croatia for the 1992–2011 periods, using ARDL analysis, VECM Granger causality test, Dynamic Ordinary Least Squares (DOLS), and FMOLS estimation methods. Their results confirmed the EKC hypothesis. Aslan, Destek, and Okumus (2018) investigated the hypothesis in the United States for the period from 1966 to 2013. They applied bootstrap rolling window estimation method and reached that the hypothesis is valid. Balaguer and

Cantavella (2018) examined the role of education on EKC in Australia. According to this study, the EKC hypothesis is valid; in addition, the effect of education is positive on the U-shaped relationship. Ravanoğlu et al. (2018) investigated the validity of EKC hypothesis in Kyrgyzstan, using ARDL analysis. They findings suggested that the EKC hypothesis is valid in the long run. Finally, a different study conducted by Ali, Ashraf, Bashir, and Cui (2017) explored the EKC hypothesis in relation to Green Revolution in Pakistan, applying Johansen cointegration test. They reached that the EKC hypothesis in relation to the Green Revolution is not valid.

MULTIPLE-COUNTRY STUDIES

Panel-country studies are henceforth discussed. Lean and Smyth (2010) analyzed the relationship between CO_2 emissions and economic growth for the panel of Association of Southeast Asian Nations (ASEAN) countries for the 1980–2006 periods, using the Johansen cointegration test and DOLS. Their results confirmed the EKC hypothesis. Moreover, Heidari, Katircioğlu, and Saeidpour (2015) also supported the validity of the EKC hypothesis for the ASEAN countries. Kasman and Duman (2015) investigated the effects of energy consumption, the real income, trade, and urbanization on the level of emissions for the EU countries over the period 1992–2010 by using the FMOLS. They reached that the EKC hypothesis is valid. The existence of the EKC hypothesis was supported for Central American countries in the study of Apergis and Payne (2009). Jebli, Youssef, and Ozturk (2016) suggested that the EKC hypothesis is valid for the Organization for Economic Cooperation and Development (OECD) countries by applying the FMOLS and the DOLS on renewable energy, nonrenewable energy consumption, economic growth, trade, and CO_2 emissions for 1980–2010 periods. Bilgili, Kocak, and Bulut (2016) and Shafiei and Salim (2014) reached the same conclusion for OECD members. On the contrary, Dogan, Seker, and Bulbul (2017) found the evidence of invalidity of the EKC hypothesis for OECD countries by using the DOLS for 1995–2010 periods.

Boluk and Mert (2014) studied on EKC hypothesis for the European Union (EU) members during the period 1990–2008. According to their results based on the Ordinary Least Squares (OLS) with Random Effects (RE), there is not inverted U-shaped relationship between CO_2 emissions and income. In a similar study, Lopez-Menendez, Perez, and Moreno (2014) also reported the invalidity of the EKC hypothesis for the EU countries by using the data on CO_2 emissions, income, the square of income, the cube of income, and renewable energy for the period of 1996–2010, whereas in another study, Dogan and Seker (2016) used the same country but different period data (1980–2012) and different method of analysis (the panel DOLS). They reached the conclusion that EKC is valid; in another mean, an inverted U-shaped relationship between CO_2 and income. In a more recent study by Pablo-Romero (2017), which applied the OLS with RE on the data from 1995 to 2009 showed that EKC is valid for the EU countries.

There are very recent studies that cover different panel of countries use different methodologies. Rauf et al. (2018) analyzed the effects of income per capita, square of income per capita, population growth, and energy consumption on environmental degradation measures (deforestation, water quality, and air pollution) for the Belt and Initiative countries over the period 1981–2016 by using the Westerlund cointegration test and mean group estimators. Results showed the validity of the EKC hypothesis. Dong, Sun, Li, and Liao (2018) examined the energy-growth-environment nexus by focusing on relationship between natural gas consumption, CO_2 emissions and GDP per capita for a panel of 14 Asia-Pacific economies for the years 1970–2016. Empirical results revealed that natural gas consumption increased the environmental degradation, and the reverted U-shaped relationship is found between carbon emissions and income per capita, implying the validity of the EKC hypothesis. Referring to Hu, Xie, Fang, and Zhang (2018), the EKC was verified in a panel of 25 major developing countries for the years 1996–2012 by using the FMOLS and the DOLS estimators.

As a summary of a review of the EKC hypothesis for panel-country studies, the presence of EKC hypothesis is confirmed for the EU countries in Markandya et al. (2006), Donfuet et al. (2013), Kasman and Duman (2015), Dogan and Seker (2016), Ahmad et al. (2016), and Pablo-Romero et al. (2017); for the OECD countries in Shafiei and Salim (2014), Jebli et al. (2016), Bilgili et al. (2016), and Dogan et al. (2017); for the Middle East and North Africa (MENA) economies in Arouri, Youssef, M'henni, and Rault (2012), Farhani and Shahbaz (2014), and Charfeddine and Mrabet (2017); for the ASEAN countries in Lean and Smyth (2010) and Heidari et al. (2015); for some other panel of countries in Apergis and Payne (2009), Pao and Tsai (2011), Al-Mulali, Solarin, and Ozturk (2015a), Al-Mulali and Ozturk (2016), Rauf et al. (2018), and Ulucak and Bilgili (2018).

CONCLUSION

In the late 1990s, there was an explosion in the empirical literature investigating the relationship between economic growth and environmental degradation. Much of these studies' main purpose is to test the EKC hypothesis, which is based on the idea that there is a positive relationship between the two variables in the early stages of economic development and that it is transformed into a negative relationship in the later stages of development. This chapter has focused on the empirical literature on the EKC hypothesis. The studies in the literature are divided into two groups as single-country analysis and panel-country analysis. In addition, all studies are classified according to the results obtained in terms of whether EKC hypothesis is valid or not.

As a result of this research, firstly, it is worth to note that the number of studies that support the validity of hypothesis is more than that that support the invalidity of EKC hypothesis for both single-country and panel-country studies. Another result is that the number of single-country studies is greater than that of panel-country studies. This result can be explained by the fact that the determination of the EKC relationship and the threshold income level in a single country makes it easier to direct national policies.

The research has shown that the literature on the EKC hypothesis is still up to date although it has a very old history. In particular, econometric developments have allowed this hypothesis to be tested by different methods. Furthermore, developments in economic science require the continuous updating of the models used to test this hypothesis. This dynamic process explains the popularity of the literature on the EKC hypothesis and the differences in the results achieved. Different results from the empirical studies have shown that there is no consensus on the validity of the hypothesis. Therefore, the literature on the hypothesis has been extensively examined, and a contribution has been made to determine the starting point of future studies.

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