International Journal of Economy, Energy and Environment
2023; 8(1): 1-11
http://www.sciencepublishinggroup.com/j/ijeee
doi: 10.11648/j.ijeee.20230801.11
ISSN: 2575-5013 (Print); ISSN: 2575-5021 (Online)

Revisiting Environmental Kuznets Curves for NO_2, SO_2 and CO: Evidence from OECD Countries

Asma Sghaier[1], Zouhayer Mighri[2, *]

[1]Department of Accounting and Finance, Faculty of Economics and Business Administration, Sousse University, Sousse, Tunisia

[2]Department of Accounting and Finance, Higher Institute of Computer Science and Management of Kairouan (ISIGK-Tunisia, LARTIGE, FSEG Sfax), Kairouan University, Kairouan, Tunisia

Email address:

asma_sghaier1983@yahoo.fr (Asma Sghaier), mighrizouhair@gmail.com (Zouhayer Mighri)

[*]Corresponding author

To cite this article:

Asma Sghaier, Zouhayer Mighri. Revisiting Environmental Kuznets Curves for NO_2, SO_2 and CO: Evidence from OECD Countries. *International Journal of Economy, Energy and Environment*. Vol. 8, No. 1, 2023, pp. 1-11. doi: 10.11648/j.ijeee.20230801.11

Received: July 18, 2022; **Accepted**: August 29, 2022; **Published**: February 27, 2023

Abstract: This study investigates the position of the environmental Kuznets curve in 25 OECD countries for three pollutants (SO_2, NO_2 and CO) and analyses the impacts of Environmental Policy Stringency and energy consumption per capita on the environmental quality. Therefore, the originality of this paper lies in the attempt to better understand theoretically and empirically the specificities of the concept related to the environmental Kuznets curve. The study used a dynamic panel model with the system Generalized Method of Moments (GMM) estimator and an autoregressive distributed lag (ARDL) model with alternative panel estimators. We consider that the results of this paper are very interesting. The found results confirm that: i) firstly, the Environmental Kuznets Curve (EKC) hypothesis is well supported for all three major pollutant emissions in OECD. ii) Secondly, the positive effects of energy consumption on various pollutant emissions are confirmed. iii) Finally section analyses the Environmental Policy Stringency negatively effects the pollutant emissions. We consider that the results of this paper are very interesting, The policy instruments will help in realizing a balanced environment. Public authorities are encouraged to implement more and more of the regulatory instruments to protect the environmental quality.

Keywords: Environment Kuznets Curve, Envir1aonmental Policy Stringency, Energyj 7. Iik Consumption, ARDL, GMM, OECD, Dynamic Panel Model

1. Introduction

The concern given to environmental problems (global warming, deforestation, loss of biodiversity, soil salinization, etc.) is increasingly important, and occupies a very important media space. Indeed, global warming, due to the accumulation of Greenhouse Gas (GHG), is the main threat to humanity, and could cost the global economy up to 550 billion dollars if governments do not take drastic measures. An important strand of literature searches for relationships between several pollutants and gross domestic product (GDP), energy consumption growth, or both variables simultaneously. Indeed, most empirical studies seek to verify the environmental Kuznets curve hypothesis: the relationship between the pollutant and the income level takes the inverted U-shaped. This relationship suggests that emissions of pollutants increase with the GDP per capita in the first stages of economic development up to a turning point, after which emissions begin to decline.

The analysis of the environmental Kuznets curve seems to check whether the wealth accumulation stimulates the environmental degradation, or on the contrary it contributes to improving the environmental quality [55]. According to the theory, if GDP per capita is less than the level of the turning point, the wealth accumulation stimulates the environmental degradation; on the contrary, if GDP per capita is higher, it improves the environmental quality. The ambiguity of the conclusions of earlier studies lies in the value of the turning points, as highlighted [34]. In fact, several studies have concludes that the estimated turning points are beyond the sample income levels: the increasing in the income stimulates the environmental degradation [2, 47, 59]. In the others studies, the authors have concludes that the turning points calculated are lower than the sample income levels and the increasing income improves the environmental quality [25, 47, 69].

In more the two factors incorporated in the standard form of the environmental Kuznets curve (per capita income and pollutant emissions), several empirical studies have introduced other factors that may affect the quality of the environment in order to mitigate the omitted variables bias in previous studies EKC. In this perspective, energy consumption, international trade and urbanization illustrate some frequent variables that researchers introduce into the EKC study [32, 47, 49].

Work on the relationship between economic growth and CO_2 emissions has become increasingly abundant in recent years. Indeed. the increased interest granted by researchers to this problem is explained by their desire to change the growth models that dominated at length and which, finally, showed their limits and failures on several aspects: in distributive terms [44-46], in terms of social costs and in terms of the degradation of the quality of the environment measured by greenhouse gas emissions [16].

However, the technfiques and models used have not, until then, answered many questions that are still unclear. For example, the study of the causality that is established between growth and CO_2 emissions, although it can give us an idea of its nature (total absence of causality. unidirectional or bidirectional causality), it cannot answer so many important questions: is causality, if it exists, immediate, or it exists a delay or a phase advance recorded by one of the variables on the other (GDP in advance compared to CO_2? or the opposite)? What is the nature of causality (linear or non-linear. strong or weak)?

This paper contributes to the literature on the EKC studies in three points. Firstly, we introduce three pollutants (SO_2, NOx, CO) other than CO_2 emissions frequently used in the majority of anterior work. Secondly, we introduce the Environmental Policy Stringency index to check the hypothesis of environmental Kuznets curve which predicts that substitution and income effects in response to the Environmental Policy Stringency changes exert a major influence on the relationship between GDP and CO_2 emissions. Finally, we used the ARDL modeling for analyzed the dynamic of the variables. In this regard, the study of the specification lagged dependent variable dynamic EKC has been largely unexplored in the literature. Gold, the quality of the environment changes cumulatively over time: the quality of the environment today is likely to be linked to that of yesterday, making it appropriate to consider a dynamic specification that EKC has shifted dependent variable.

Our paper is organized in the following manner: Section 2 reviews the literature on the EKC hypothesis; Section 3 presents the data employed and econometric methodology; Section 4 introduces the econometric results and some further discussion; finally, Section 5 summarizes thei paper's conclusions and its main policy implications.

2. A Summary of Theoretical Literature

The EKC concept was introduced and popularized in the early 1990s with [38] work on the potential environmental impacts of NAFTA, and the 1992 World Bank Report. However, the idea that economic growth is necessary in order for environmental quality to be maintained or improved is an essential part of the sustainable development argument promulgated by the World Commission on Environment and Development (1987).

Many recent studies studied the various position of the Environmental Kuznets Curve (EKC) on different countries, applying different methods of investigations and amidst varying economic circumstance. So, the U-shaped inversed of Kuznets curve is not prouved for several authors [2, 3, 35, 41]. In this perspective, Yang et al (80) have rejected the environmental Kuznets curve hypothesis in the China country by examining the revisited relationship between economic performance and emission related indicators such as CO_2 emission, SO_2 emission, industrial waste etc. however, several studies have used the cross-section analyses to check the (EKC) relationship; we can mention for example, the studies by Lean and Smyth for the ASEAM countries, Georgiev, E., & Mihaylov, E. in OECD, Wang [36, 61] for 138 developed and developing countries. Also by uses of time series, several authors have about is to conclude the existence of the environmental Kuznets curve for many countries we can mention for example the study of Mongelli and al. in Italy; Ang in France; Jalil and Mahmoud, Shiyi and Dhakal in China; Halicioglu in Turkey; Alam and al. in Bengladech; Fodha and Zaghdoud in Tunisia; Shahbaz and al. in Romania; Kanjilal and Ghosh in India [4, 34, 39, 48, 56, 65, 71, 72].

In addition to that, the position of EKC hypothesis was found to be a well-established concept that is common in the developed nation's and emerging market economies. This assertion can be traced in the studies of Ozturk and Acaravci, Cho et al., Farhani et al., Al-mulali et al. and Ozturk and Al-Mulali [72, 20, 31, 5, 72]. To support their results, several authors used different indicators and ecological footprint ranging from CO_2 emission, SO_2 emission, NO_x emission, and have introduced different variable that have a relationship with the environmental degradation which mainly: trade (Suri and Chapman, 1998), financial development [11], for investigate the EKC in their studies.

Based on the data of the Organization for Economic Cooperation and Development (OECD), Georgiev and Mihaylov [36] tested the hypothesis of Environmental Kuznets Curve, with income and air pollutants. Their results confirm the existence of environmental Kuznets Curve and inverted U- shaped relationship between income and pollutant is confirmed. The verifying of the existence of an inverted U-shaped curve is also confirmed by Duarte and al. [26] who have analyzed the shape of the relationship between the income and water usage by using regression approach. Also, in the same perspective, Kanjilal and Ghosh [55] used the annual data of carbon emissions, energy consumption, economic and commercial activity in the opening during the period 1971 – 2008 in China for tested the existence of Environmental Kuznets Curve and the relationship between macro level environmental variables and economic performance. The authors concluded the existence of Environmental Kuznets Curve in India for the relationship between carbon emission and per capita income.

Kris Aaron Beck [57] have re-evaluated whether the EKC exists for CO_2 emissions in OECD, non-OECD, Latin America, Asia, and Africa countries. They used the econometric technique of Arellano-Bover/Blundell-Bond Generalized Methods of Moments (GMM) estimator. In this study, authors used five groups for compare and determine how various factors like economic growth, population, trade, urbanization, and energy use influence CO_2 emissions. The results confirm that the OECD countries have an N-shaped curve with income growth whereas the regions of Asia and Africa experience an income-based EKC pattern. The results further reveal that population growth has a mixed impact on CO_2 emissions, increased trade and urbanization contribute to CO_2 emissions for most areas, and increased energy use actually helps to decrease CO_2 emissions.

Jebli MB and al. [50, 53] analyzed the causal relationships between per capita CO_2 emissions, gross domestic product (GDP), renewable and non-renewable energy consumption, and international trade for a panel of 25 OECD countries over the period 1980–2010. The results of the Short-run indicate bidirectional causality between: renewable energy consumption and imports, renewable and non-renewable energy consumption, non-renewable energy and trade (exports or imports); and unidirectional causality running from: exports to renewable energy, trade to CO_2 emissions, output to renewable energy. In the long-run, the causality is bidirectional between all our considered variables. The authors concluded also that the inverted U-shaped environmental Kuznets curve (EKC) hypothesis is verified for this sample of OECD countries. Karp LS, Liu X., and al. [56] examined the environmental Kuznets curve in the panel of selected developed countries, over the period of 2000–2013. The authors used panel Generalized Method of Moments (GMM) estimate for robust inferences and have conclude the existence of EKC hypothesis in the energy-resource depletion model; the relationship between energy-resource depletion and GDP per capita take an inverted U-shaped.

Despite the relative abundance, noted in the last decades, concerning the frequency of the studies on the relationship between CO_2 and economic growth, no consensus had been reached. Indeed, the exam of literature review linked to this relation leads to four groups of results (see table 1).

The first group, support the idea stipulating the existence of unidirectional causality from CO_2 to economic growth or from economic growth to CO_2. [1, 6, 7, 17-19, 27-30, 72]

The second group had found a bidirectional relation between the two variables as proved by the following set of papers [18, 27-30, 49].

The third group had negated the positive correlation between CO_2 and economic growth as showed by Bai et al. [15] who converged to the result that economic growth had negative effects on CO_2. This result, while its strangest, can draw a novel condition and transformation of the relation between the two variables and will lead to an ewer a in which the wealth of nations will be invested to reduce a pollutants and to edify a green world.

The fourth set of work shad tried to combine the couple of variables (CO_2, economic growth) with other variables and to determine the effects. The results are mitigating. [15, 23, 27, 28, 34, 74]

Table 1. *Literature review.*

First Group

Author	**Data**	**Model**	**Variables**	**Results**
First Group				
Kraft & Kraft (1978)	1947-1974	Log-distribution regression	GEI, GNP	Unidirectional causality follow from GNP to GEI
Coondoo & Dinda (2002)	America, Europe, Africa and Asia countries	Cross countries panel data Granger-causality	CO_2, GDP	Unidirectional causality between GDP and CO_2, from America and western Europe
Ang (2007)	France 1960-2000	VECM	CO_2, EC, GDP	GDP exerts a causal influence CO_2 Unidirectional causal from GDP to CO_2
Apergis & Payne (2010)	Commonwealth of independent states 1992-2004	Panel VECM	CO_2, EC, GDP	Unidirectional causality EC, GDP to CO2
Dogan & Seker (2016b)	40 courtiers 1985-2011	FMOLS, DOLS	FDI, EC, CO_2, GDP, REC	Variables cointegreated and have a long-run relationship
Asongu et al. (2016)	24 African countries	Pmg-ARDL	EC, CO_2, GDP	Unidirectional causal from (CO_2 to GDP) and (CO_2 to EC)
Jebli (2016); Jebli & Belloumi (2017)	Tunisia 1980-2011 1990-2011	ARDL	CO_2, GDP, CR	Unidirectional causal from GDP to CO_2 GDP contribute to decrease CO_2
Odhiambo (2011, 2017)	Sub sahara Africa South Africa	Dynamic panel data ECM ARDL	CO_2, GDP	Unidirectional causal flow from GDP to CO_2
Ben Mbarek et al.	18 countries	VECM	NE, CO_2, RE,	Unidirectional relationship running GDP to CO_2

Author	Data	Model	Variables	Results
(2018)	1990-2013		GDP	
Ben Jebli & Hadhri (2018)	10 tourism destination 1995-2013	VECM	CO_2, Tour, GDP	Unidirectional causality running from CO_2 to GDP Economic growth leads to the increase of CO_2

Second Group

Author	Data	Model	Variables	Results
Second Group				
Coondoo & Dinda (2002)	America, Europe, Africa and Asia countries	Cross countries panel data Granger-causality	CO_2, GDP	Bidirectional causality between GDP and CO_2 from Asia and Africa countries
Wang et al. (2011)	28 china provinces 1995-2007	Panel VECM	CO_2, EC, GDP	Bidirectional causal from (CO_2 to EC) and (EC to GDP) In long run: EC and GDP cause CO_2 CO_2 will not decrease in a long period of time
Shahbaz, Hye, et al. (2013)	Indonesia 1975Q1-2011Q4	ARDL, VECM	GDP, EC, FinDev, Tr, CO_2	GDP increases CO_2 Bidirectional causal from GDP to CO_2
J.-H. Chen & Huang (2013)	N-11 1981-2009	FMOLS, DOLS	EC, CO_2, GDP	Bidirectional causality between CO_2 electric consumption Positive long-run relationship among CO_2, energy consumption and GDP
Zeb et al. (2014)	SAARC countries 1975-2010	Panel data FMOLS	RE, CO_2, GDP	Bidirectional Granger-causality from CO_2 and GDP Increase in energy production leads to decrease in CO_2 emission
Ben Jebli et al. (2015)	24 sub-Saharan Africa 1980-2010	Panel cointégration technic	GDP, CO_2	Bidirectional Granger-causality from CO_2 and GDP
Jammazi & Aloui (2015)	GCC countries 1980–2013	Maximal Overlap Discrete Wavelet Transform	CO_2, GDP, EC	-directional lead/ CO_2' emissions, EC, and GDP
Dogan & Turkekul (2016)	USA 1960-2010		CO_2, EC, GDT, Tr, Urb, FinDev	Not support the validity of EKC hypothesis GDP increase the level of CO_2 Bidirectional causal from CO_2 to GDP
Wang et al. (2018)	170 countries 1980-2011	VECM	GDP, Pop, EC, CO_2	Bidirectional causal from GDP to CO_2

Third Group

Author	Data	Model	Variables	Results
Third Group				
Richmond & Kaufmann (2006)	OCDE 1978-1997	Panel data	EC, CO_2, GDP	Increase in income probably will not reduce energy use and CO_2 emission
Akbostancı et al.(2009)	Turkey 1968-2003 1992-2001	Time Series Panel data	CO_2, GDP, PM, SO	Monotonically increasing relationship CO_2/GDP in the long run Not support the EKC hypothesis
He&Richard (2010)	Canada 1948-2004	Cubic parametric model Hamilton's model	GDP, CO_2	No evidence of an EKC Relationship monotonically increasing Positive correlation between CO_2, GDP
Shahbaz, Ti wari,&Nasir (2013)	South Africa 1965-2008	ARDL ECM	FinDev, GDP, CC, Tr, CO_2	Relationship among variables GDP increases CO_2
Leitão (2013)	18 countries 1990-2010	GMM-sys	CO_2, GDP, EC, Glob	According EKC hypothesis Relationship between GDP and CO_2 has increased Inverted U-Shaped relationship between GDP and CO_2
Y. Chenetal. (2019)	China 1980-2014	ARDL, VECM	CO_2, GDP, NRE, RE, Tr	Does not have the EKC of CO_2 emission under GDP GDP increase CO_2 CO_2 have a negative correlation with GDP

Fourth Group

Author	Data	Model	Variables	Results
Fourth Group				
Selden & Song (1994)	30 countries 1973-1984	Panel data (RE, FE, CS)	Sulfur, oxid, carbon, gdp	Emission decreases in the long run
Galeotti et al. (2009)	OCDE 1960-2002	Panel data	SO_2, CO_2, GDP	The EKC hypothesis remain a fragile concept
Diao et al. (2009)	China (diaxing city) 1995-2005	Linear, quadratic, cubic functions	GDP, EQ	The relation GDP/EQ is more complex The pollutants will gradually decrease with further economy development
Tiwari et al. (2013)	India	ARDL	CC, GDP, Tr, CO_2	Presence of EKC in long-run Feedback hypothesis between GDP and CO_2 Granger causes GDP, CO_2
Dogan & Seker (2016a)	EU 1980-2012	DOLS	GDP, CO_2	EKC hypothesis is supported Unidirectional causality running from GDP to CO_2
Dogan & Aslan	EU	FMOLS, DOLS	GDP, CO_2	Low-way causality between CO_2 and GDP

Author	Data	Model	Variables	Results
Fourth Group				
(2017)	1995-2011			
Salahuddin et al. (2018)	Kuwait 1980-2913	ARDL	GDP, CO_2, EC, FDI, FinDev	GDP stimulate CO_2 GDP strongly Granger-causality CO_2
Zhang et al. (2017)	Pakistan 1970-2012	ARDL, VECM	RE, NRE, EC, CO_2	Presence of EKC hypothesis
Pao & chen (2019)	G-20 1991-2016	VECM	GDP, CO_2, FF, Ren, Hyd, Nuc	Relationship between CO_2, GDP
Bai et al. (2019)	China (64 cites) 2006-2013	2SLS	Pop, GDP, Urb, CO_2	GDP negative effects on CO_2
Churchill et al. (2019)	90 countries 2001-2010	OLS, 2SLS, IV, ME	GDP, Ethnic, CO_2	Ethnic reduce GDP/ CO_2
Kahouli (2017)	6South Mediterranean countries (1995 – 2015)	Bound tests for cointegration, ARDL approach and VECM method		In the long run: EC ↔GDP In the short run: EC → GDP: except Egypt.
Ahmad and Du (2017)	Iran (1971 –2011)	ARDL approach		In the long run: GDP → CO_2 EC → GDP
Appiah (2018)	Ghana (1965 – 2015)	Toda-Yamamoto and Granger causality tests		In the long run: GDP → CO_2 EC → GDP EC → CO_2
Sekrafi and Sghaier (2016)	MENA Countries (1984 –2012)	Static and dynamic panel data		In the long run: COR→ GDP COR→CO_2 COR→ EC
Nurunnabi. M & Sghaier. A (2018),	1979 - 2015 the determinants of terrorism in Tunisia	Co integration method; (ARDL)	TI, GTD, GDP / P, HPI, FDI, GER	Poverty affects positively the phenomenon of terrorism
Ben Jabeur. S & Sghaier. A (2018),	1996–2012 16 MENA countries	PLS-SEM.	CO_2; GDP COR; TAX; EC	Results from PLS-SEM show a positive relationship between economic growth and pollution.
Sekrafi & Sghaier (2018)	1974-2014 Tunisia	co-integration, ARDL model and Granger Causality Tests	CO_2, GDP, corruption	The results indicate that tourism has a direct impact and statistically significant effect on the consumption of energy for the future of the Tunisian economy.
Sekrafi & Sghaier (2018)	1984 - 2012 Tunisia	autoregressive distributed lag (ARDL)	CO_2, GDP, corruption	(1) a positively and significant relationship between control of corruption and economic growth (2) a negatively and significant relationship between control of corruption and environmental quality (CO_2) (3) a negatively and significant relationship between control of corruption and energy consumption

Notes: EC→GDP means that the causality runs from energy consumption to growth. GDP→ EC means that the causality runs from growth to energy consumption. GDP→CO_2 means that the causality runs from economic growth to pollution. EC↔GDP means that bidirectional causality exists between energy consumption and growth. CO_2↔GDP means that bidirectional causality exists between pollution and economic growth. COR↔GDP means that the causality runs from corruption to economic growth. COR→EC means that the causality runs from energy consumption to corruption. COR→CO_2 means that the causality runs from corruption to pollution.

3. Research Methodology

3.1. Data Collection and Processing

This paper employs data for 25 OECD countries (Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States) for the period 1990-2018. The variables are (CO) carbon monoxide emissions per capita (Kilograms per capita), (NO_2) Nitrogen oxides emissions per capita (Kilograms per capita), Sulphur oxides (SOx) emissions per capita (Kilograms per capita), GDP per capita (current US$), the GDP per capita squared, (EPS) Environmental Policy Stringency and energy consumption per capita. Data are extracted respectively from the OECD statistics and World Bank database.

3.2. Methodology

The EKC hypothesis is the old and gold theory which is related with the work of Kuznets (1955) who presented the novel relationship between GDP per capita & income inequality and found the inverted U-shaped relationship between the variables. The author has identified different forms of the relationship between income inequality and per capita GDP i.e., (i) inverted U-shaped relationship, (ii) U-shaped relationship, (iii) no relationship between the variables, (iv) monotonic increasing function, and (v) monotonic decreasing function. The form of EKC is deducted in the after years to analysis of the relationship between CO_2 emissions per capita and GDP per capita [47]. The reduced form of EKC is presented in Eq (1):

$$\ln(\text{polluant})_{it} = \beta_0 + \beta_1 \ln(\text{GDP})_{it} + \beta_2 \ln(\text{GDP})_{it}{}^2 + \beta_4 Z_{it} + \varepsilon_{it} \quad (1)$$

Where, pollutant is the per-capita pollution indicator, represented alternatively by (CO) carbon monoxide emissions per capita, (NO_2) Nitrogen oxides emissions per capita, (SO_x) Sulphur oxides emissions per capita, GDP captures the level of per capita income and Z is a vector that contains the variables which have an effect on the quality of the environment represented by (EPS) Environmental Policy Stringency and (EC) energy consumption per capita.

Under the specification in Eq. (1), the EKC hypothesis is supported if β1>0 and β2<0. to capture the short-run contemporaneous effects of various variables on environmental quality, the Eq(1) is estimated in the first step through the employ the GMM approach put forth by Hansen [39] and later refined into the difference GMM estimator by Arellano and Bond [8]. Indeed, Arellano and Bover and Blundell and Bond [9] argued that the weak instrumental variable problem may be unavoidable for difference GMM and further proposed the system GMM estimator, which builds a system containing both the original level equation and the transformed difference equation.

In addition to estimating the short-run relationship between various variables, we estimate the dynamic EKC specification in Eq. (1). We study another specification that allows us to estimate the long-run EKC relationship. To this end, we recast (1) into the general autoregressive distributed lag (ARDL) (p, q) model:

$$\Delta \ln(\text{polluant})_{it} = \gamma_i + \sum_{j=1}^{p} \lambda_{i,j} \ln(\text{polluant})_{i,t-j} + \sum_{j=0}^{q} \delta_{i,j} X_{i,t-j} + \varepsilon_{it} \quad (2)$$

Where $X_{i,t} = (\ln(\text{GDP})_{i,t}, \ln(\text{GDP})^2_{i,t}, \ln(\text{EC})_{i,t}, \text{EPS})$

We estimate Eq. (2) by employing the Pooled Mean Group (PMG) estimator proposed by Pesaran et al. [79]. The PMG estimator is used also, by Martínez-Zarzoso and Bengochea-Morancho [63] to confirm the long-term EKC relationship for CO_2 emissions in a panel of 22 countries in the OECD.

4. The Estimation Results and Discussion

Table 2. *Unit root test.*

	LLC				IPS			
	in level		in diference		in level		in diference	
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
EPS	1.84404	0.9674	-8.25210	0.0000***	5.74226	1.0000	-9.92820	0.0000***
LnEC	-1.20823	0.1135	-4.14330	0.0000***	0.72403	0.7655	-7.61235	0.0000***
LnGDP	-5.44906	0.0000***	-7.06722	0.0000***	0.76673	0.7784	-7.59284	0.0000***
lnGDP2	-5.11592	0.0000***	-7.20253	0.0000***	0.98679	0.8381	-7.69219	0.0000***
$\ln NO_2$	4.27971	1.0000	-6.22178	0.0000***	6.84532	1.0000	-7.47809	0.0000***
$\ln SO_2$	0.22453	0.5888	-4.67189	0.0000***	4.64277	1.0000	-7.17050	0.0000***
LnCO	-0.61681	0.2687	-4.91767	0.0000***	4.27943	1.0000	-8.18001	0.0000***

***Significant level for 1%.

Table 1 shows the results of unit root test of the variables. We can notice that the LLC test indicates that all variables are non-stationary in level with the exception of GDP and by GDP2 against the results of the IPS test indicates that all variables are non-stationary in level. However, in the case of small sample, the results of the IPS test are less robust. Thus, we can conclude that the stationarity hypothesis is rejected for all variables. In level, we notice that the two tests confirm the stationarity of all variables. The conclusion drawn is that all variables are integrated I (1). After to verify the stationarity of the variables in level, we verify the cointegration relationship between the variables.

Table 3. *Pedroni Residual Cointegration Test.*

	F(LNCO/ LNGDP LNGDP2 LNEC EPS)		F($LNNO_2$/ LNGDP LNGDP2 LNEC EPS)		F($LNSO_2$/ LNGDP LNGDP2 LNEC EPS)	
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	1.970801	0.0244**	2.198521	0.0140**	2.109749	0.0174**
Panel rho-Statistic	0.236728	0.5936	0.054608	0.5218	0.136543	0.5543
Panel PP-Statistic	-4.876241	0.0000***	-3.789241	0.0001***	-4.179355	0.0000***
Panel ADF-Statistic	-4.023523	0.0000***	-4.224669	0.0000***	-4.804509	0.0000***
Group rho-Statistic	1.778861	0.9624	1.642786	0.9498	2.170317	0.9850
Group PP-Statistic	-6.474245	0.0000***	-4.351725	0.0000***	-4.153636	0.0000***
Group ADF-Statistic	-4.735695	0.0000***	-5.875992	0.0000***	-5.087224	0.0000***

Significant level for 5%.,*Significant level for 1%.

Table 3 shows the results of Pedroni co-integration test. In this perspective, Pedroni [75, 78] proposed various tests to understand the null hypothesis of no intra-individual co-integration for both homogeneous and heterogeneous panels.

The critical values in this work is related to the presence of a single regressor in the cointegrating relationships, Pedroni [62, 63] proposes an extension if the cointegration relationships include more than two variables. In fact, the Pedroni tests take into account the heterogeneity of parameters that may differ between individuals. Thus, under the alternative hypothesis, there is a cointegration relationship for each individual, and the parameters of this relationship are not necessarily the same for each individual panel. In our analysis, we can notice that four of seven statistics are statistically significant at the 5% level, which confirming the existence of at least one co-integrating relationship between the variables.

In the after step, we estimate the dynamic short-run relationship between the variables to using the GMM and the long-run relationship to using the ARDL modeling.

Table 4. *The GMM estimations of dynamic EKC for per-capita NO_2, CO and SO_2 emissions.*

	F(LNNO$_2$/lngdp, lngdp2, lnec, EPS)			**F(LNSO$_2$/lngdp, lngdp2, lnec, EPS)**			**F(LNCO/lngdp, lngdp2, lnec, EPS)**		
	Coef.	**z**	**P>z**	**Coef.**	**z**	**P>z**	**Coef. Std.**	**z**	**P>z**
Pollutant (-1)	.9713436	50.17	0.000***	1.000131	47.47	0.000***	.9505198	69.98	0.000***
lngdp	1.682379	6.38	0.000***	1.36953	1.96	0.050**	1.775743	4.89	0.000***
lngdp2	-.0879844	-6.47	0.000***	-.0717878	-1.97	0.049**	-.0923584	-4.95	0.000***
lnec	.076691	2.11	0.035**	.2433129	1.98	0.048**	.0891173	2.16	0.031**
EPS	-.0091801	-2.06	0.039**	-.0025019	-0.21	0.832	-.0062379	-0.96	0.338
_cons	-8.520045	-6.56	0.000***	-8.554764	-2.35	0.019**	-9.020968	-4.88	0.000***
turning point		14195,303			13887,407			14962,868	
AR(1)		-7.97		-8.45			-9.69		
Pr >z		0.000***		0.000***			0.000***		
AR(2)		-1.39		-0.99			1,77		
Pr >z		0.166		0.323			0,161		
Hansen test		19.32		20.80			22.68		
Chi2		[0.200]		[0.409]			[0.305]		
Difference in Hansen test		13.89		18.75			18.15		
Chi2		[0.239]		[0.226]			[0.255]		

The p-value of the serial correlation tests in Arellano and Bond (1991) and the p-value of the Hansen tests of over-identification are reported in square brackets. **Significant level for 5%.,***Significant level for 1%.

The table 4 gives the results of our regression for three pollutants. Firstly, we note that the coefficients of the lagged dependent variable (pollutant (-1)) are positive and highly significant in all regressions. Indeed, we can conclude that a dynamic EKC specification in our study is justified and the pollutants emissions are positively serially correlated. Also, we note that the correlation test and the over-identification test do not reject the validity hypothesis of lagged variables in level and difference as instruments. On the other hand, the autocorrelation test does not reject the hypothesis of no autocorrelation of second order [81].

Secondly, the coefficient of ln (gdp) is positive and the coefficient of (ln(gdp))2 negative, both of which are significant at 1% level, consistently across all estimations. These results thus confirm the existence of an inverted U-shaped EKC for emissions in OECD countries. thus, we can conclude that the NO2 emissions (respectively SO_2 and CO) initially increase and then decrease after reaching with a turning point which is equal to 14195,303 (13887,407, 14962,868) in economic development. The comparing the value of the turning point and the average level of GDP in our sample shows that the countries of the panel reached a turning and are in the third phase of the curve. However, the comparison with GDP levels in each country shows that some countries are still in their first phase of the curve.

Furthermore, we can notice that the coefficients associated with energy consumption are significantly positive for the three pollutants. The 1% increase in energy consumption is increasing respectively; the NO_2 emissions of 0.0766%, SO_2 emissions of 0.243% and CO emissions of 0.089%. Energy consumption is a major degradation source of environmental as is already checked in earlier work [6, 7, 10, 69]. Finally, we note that the coefficient associated the variable (.) is positive for all three pollutants, which confirms that any policy of control and requirement causes improved environmental quality. Public authorities are encouraged to impose more regulation on environment.

After checking the existence of the environmental Kuznets curve in short-run, we next study the validity of long-run EKC relationship using a panel ARDL model. Specifically, we apply PMG estimators to estimate Eq. (2) in order to deduce the long-run relationship among different pollutant (SO_2, NO_2, CO), per-capita output, energy consumption and Environmental Policy Stringency. The estimation results are reported in Table 5.

Table 5. *The PMG estimations of EKC in ARDL model for NO_2, SO_2 and CO emissions.*

Variable	**Selected Model: ARDL (2, 3, 3, 3, 3)**		**Selected Model: ARDL (1, 3, 3, 3, 3)**		**Selected Model: ARDL (1, 3, 3, 3, 3)**	
	Coefficient	**t-Statistic**	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
Adjust coef	-0.185663	-1.982284**	-0.198600	-2.787537***	-0.143912	-3.183149***
	Long Run Equation					
LNGDP	4.015307	8.680416***	-47.82415	-19.04951***	4.427924	2.699860***
LNGDP2	-0.253941	-10.76647***	2.018564	17.55653***	-0.342187	-4.129442***

Variable	Selected Model: ARDL (2, 3, 3, 3, 3)		Selected Model: ARDL (1, 3, 3, 3, 3)		Selected Model: ARDL (1, 3, 3, 3, 3)	
	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
LNEC	1.160320	27.57809***	4.839023	21.17775***	1.401769	5.171076***
EPS	-0.040265	-5.129250***	-0.247379	-15.76859***	-0.195657	-7.014104***
	Short Run Equation					
D(LNNO$_2$(-1))	-0.151761	-1.558428				
D(LNGDP)	32.98630	1.908179*	-126.5339	-2.481625**	1.780406	0.086363
D(LNGDP(-1))	-10.13803	-0.432256	-37.26745	-0.859848	12.13661	0.694967
D(LNGDP(-2))	29.36518	2.099243**	-62.93047	-1.653439*	-6.866804	-0.467152
D(LNGDP2)	-1.577706	-1.894434**	6.327837	2.518806**	-0.073581	-0.073817
D(LNGDP2(-1))	0.531968	0.473549	1.738296	0.828686	-0.555826	-0.670090
D(LNGDP2(-2))	-1.433137	-2.109025**	3.031827	1.664163	0.387048	0.539697
D(LNEC)	0.545885	2.346818**	-0.025498	-0.071917	0.404557	3.367093***
D(LNEC(-1))	-0.027176	-0.138982	-0.243735	-0.700345	-0.058753	-0.509775
D(LNEC(-2))	0.087155	0.394138	-0.267842	-0.854772	-0.134042	-1.213500
D(EPS)	0.008097	0.429335	-0.010562	-0.187457	-0.037272	-1.754959*
D(EPS(-1))	0.007840	0.501394	-0.029274	-0.625185	-0.005621	-0.374968
D(EPS(-2))	0.012494	0.694836	-0.030068	-0.545031	0.012581	0.625972
C	-3.977557	-2.020754**	47.78262	2.786690***	-2.667999	-3.141872***
Akaike info criterion		-3.879798	-1.966224		-3.186829	
Schwarz criterion		-1.009700	0.714554		-0.506052	

*Significant level for 10%,**Significant level for 5%.,***Significant level for 1%.

Table 3 presents the estimation results of Eq (2). We notice that the estimated adjustment coefficient is negative and significant in all regressions, indicating that the economic dynamics converge to a long-run equilibrium relationship between the different pollutant and its determinants. Following the confirmation of the existence of a long-term relationship between the variables, we determine later the shape of the relationship between different pollutants and economic growth. We remark that the coefficient of ln (gdp) is positive and the coefficient of (ln (gdp)) 2 negative and both of which are highly significant at 1% level in all estimations. We conclude there exists a long-run, inverted U-shaped EKC between the variables. For the coefficient associated with energy consumption, we can notice that it persists and remains significantly positive in the long-run. In addition, the comparison of the short-run values obtained by the GMM (table 3) and long-run values obtained through the ARDL model (table 4), we can conclude that the negative effect of energy on the environmental quality is increasingly growing over time. For the environmental policy stringency (EPS), we remark that the associate's coefficients to this variable are significantly negative. At one point increase in the environmental requirement degree reduces the pollutant emissions of 0.04 point for NO_2, 0247 for SO_2 and 0.19 point for CO. in fact; the OECD countries are engaged in various environmental protection strategies including mainly the historic decision taken by the Council of OECD in 1972 about the "polluter-pays principle" Completed by the "user-pays principle".

5. Conclusions and Implications

This paper investigates the validity of Environmental Kuznets Curve (EKC) hypothesis for SO_2, NO_2 and CO emissions using a panel of 25 OECD countries over the period 1990– 2018. The current paper empirically estimated the dynamic relationship between pollutant emissions and economic development, while controlling for the impacts of energy consumption and environmental policy stringency. our results from estimating a dynamic panel model by the GMM estimator, well as estimating the ARDL model by the PMG estimators,, have all supported EKC hypothesis for the three major pollutants in the short and long run.

The short-run outcomes identified by the GMM method indicate that energy consumption positively and significantly affects the environmental quality; energy consumption strengthens environmental degradation. However, regulations policies have a negative and not significant impact in the short term. The policy makers are encouraged to pressure on energy consumption and stimulate the energy conservation strategy and alternative energy sources.

In the long term, the results of ARDL model indicate that the effect of energy consumption persists and becomes more important. The associated coefficient with the environmental policy stringency variable becomes significantly negative. Thus, we can deduce the following implication: an awareness policy on energy efficiency is not sufficient and the authorities are encouraged to implement regulatory policies to protect the environment (taxes, emission permits, quotas can be introduced as an example).

References

[1] Asongu, S., El Montasser, G., & Toumi, H. (2016)."Testing the relationships between energy consumption, CO_2 emissions, and economic growth in 24 African countries: a panel ardl approach. Environmental Science and Pollution Research, 23 (7), 6563–6573.

[2] Agras, J., Chapman, D., (1999). A dynamic approach to the Environmental Kuznets Curve hypothesis. Ecological Economics 28, 267–277.

[3] Akbostancı E, Turut-Asik S, Tunc GI, (2009). The relationship between income and environment in Turkey: is there an environmental Kuznets curve? Energy Policy; 378: 861-7.

[4] Alam, MJ, Begum IA, Buysse J, Huylenbroeck GV. (2012). Energy consumption, carbon emissions and economic growth nexus in Bangladesh: cointégration and dynamic causality analysis. Energy Policy; 45: 217–25.

[5] 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. Ecol. Indic. 48, 315–323.

[6] Ang J., (2007). CO_2 emissions, energy consumption, and output in France. Energy Policy; 35: 4772–8.

[7] Ang, J., (2009). CO_2 emissions, research and technology transfer in China. Ecol. Econ. 68 (10), 2658–2665.

[8] Arellano, M., Bond, S., (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev. Econ. Stud. 58 (2), 277–297.

[9] Arellano, M., Bover, O., (1995). Another look at the instrumental variables estimation of error-components models. J. Econ. 68 (1), 29–51.

[10] Baek, J., Gweisah, G., (2013). Does income inequality harm the environment? Empirical evidence from the United States. Energy Policy 62, 1434–1437.

[11] Bhattarai, M., Hammig, M., (2001). Institutions and the environmental Kuznets curve for deforestation: a cross country analysis for Latin America, Africa and Asia. World Dev. 29 (6), 995–1010.

[12] Bai, Y., Deng, X., Gibson, J., Zhao, Z., &Xu, H. (2019). How does urbanization affect residential CO_2 emissions? Analysis on urban agglomerations of china. Journal of Cleaner Production, 209, 876–885.

[13] Belloumi, M. (2009). "Energy consumption and GDP in Tunisia: cointegration and causality analysis." Energy policy, 37 (7), 2745 –2753.

[14] Ben Jebli, M., Ben Youssef, S., & Ozturk, I."(2015). "The role of renewable energy consumption and trade: Environmental kuznets curve analysis for sub-Saharan Africa countries". African Development Review, 27 (3), 288–300.

[15] Ben Jebli, M., & Hadhri, W. (2018). "The dynamic causal links between CO_2 emissions from transport, real gdp, energy use and international tourism". International Journal of Sustainable Development & World Ecology, 1–10.

[16] Ben Mbarek, M., Saidi, K., & Amamri, M. (2018). The relationship between pollutant emissions, renewable energy, nuclear energy and gdp: empirical evidence from 18 developed and developing countries. International Journal of Sustainable Energy, 37 (6), 597–615.

[17] Cho, C. H., Chu, Y. P., Yang, H. Y., (2014). An environment Kuznets curve for GHG emissions: a panel cointégration analysis. Energy Sources PartB: Econ. Plan. Policy 9, 120–129.

[18] Churchill, S. A., Ivanovski, K., & Bhattacharya, M. (2019). "The role of ethnic diversity in sustainable environmental growth: new evidence across different income regions". Applied Economics, 51 (4), 398–408.

[19] Dijkgraaf, E., Vollebergh, H. R. J., (2001). A Note on Testing for Environmental Kuznets Curves with Panel Data. Available from: http:/www.feem.it/web/activ/_activ. html.

[20] Duarte, R., Pinilla, V., & Serrano, A. (2013). Is there an environmental Kuznets curve for water use? A panel smooth transition regression approach. Economic Modelling, 38, 518-527. http://dx.doi.org/10.1016/j.econmod.2012.12.010

[21] Dogan, E., & Aslan, A. (2017). "Exploring the relationship among CO_2 emissions, real gdp, energy consumption and tourism in the EU and candidate countries: Evidence from panel models robust to heterogeneity and cross-sectional dependence". Renewable and Sustainable Energy Reviews, 77, 239–245.

[22] Dogan, E., & Seker, F. (2016a). "Determinants of CO_2 emissions in the European Union: Therole of renewable and non-renewable energy". Renewable Energy, 94, 429–439.

[23] Dogan, E., & Seker, F. (2016b). "The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries". Renewable and Sustainable Energy Reviews, 60, 1074–1085.

[24] Dogan, E., & Turkekul, B. (2016). "CO_2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the ekc hypothesis for the usa". Environmental Science and Pollution Research, 23 (2), 1203–1213.

[25] Farhani, S., Chaibi, A., Rault, C., (2014). CO_2 emissions, output, energy consumption, and trade in Tunisia. Econ. Model. 38, 426–434.

[26] Farzin, Y., Bond, C., (2006). Democracy and environmental quality. J. Dev. Econ. 81, 213–235.

[27] Fodha M, Zaghdoud O. (2010). Economic growth and pollutant emissions in Tunisia: an empirical analysis of the environmental Kuznets curve. Energy Policy 2010; 38: 1150–6.

[28] Galeotti, M., Lanza, A., (1999). Richer and cleaner? A study on carbon dioxide emissions in developing countries. Energy Policy 27, 565–573.

[29] Gangadharan L, Valenzuela MR., (2001). Interrelationships between income, health and the environment: extending the Environmental Kuznets Curve hypothesis. EcolEcon; 36: 513–31.

[30] Georgiev, E., & Mihaylov, E. (2015). Economic growth and the environment: reassessing the environmental Kuznets Curve for air pollution emissions in OECD countries. Letters in Spatial and Resource Sciences, 8, www.ccsenet.org/jsd Journal of Sustainable Development Vol. 8, No. 8; 2015 211 29-47. http://dx.doi.org/10.1007/s12076-014-0114-2

[31] Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of the North American Free Trade Agreement. In NBER (Ed.), Working paper 3914.

[32] Halicioglu F., (2009). An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy; 37: 1156–64.

[33] Hansen, L., (1982). Large sample properties of generalized method of moments estimators. Econometrica 50 (3), 1029–1054.

[34] He J, Richard P., (2010). Environmental Kuznets curve for CO_2 in Canada. Ecol Econ; 69: 1083–93.

[35] Issaoui, F., & Abdelghaffar, M. B. (2018). "Institutionalizing inclusive markets as aprerequisite to inclusive growth". International Journal of Public and Private Perspectives on Health care, Culture, and the Environment (IJPPPHCE), 2 (2), 63–71.

[36] Issaoui, F., Toumi, H., & Touili, W. (2015). "The effects of carbon dioxide emissions on economic growth, urbanization, and welfare". The Journal of Energy and Development, 41 (1/2), 223–252.

[37] Issaoui, F., Toumi, H., Touili, W., & Ammouri, B. (2016). "The dynamic effects of time, health, and well-being on pollution: A post-johannesburg earth summit assessment". The Journal of Energy and Development, 4 2 (1/2), 123–146.

[38] Iwata, H., Okada, K., Samreth, S., (2011). A note on the Environmental Kuznets Curve for CO_2: a pooled mean group approach. Applied Energy 88, 1986 –1996.

[39] Jalil, A., Mahmud, S., 2009. Environment Kuznets curve for CO_2 emissions: a cointegration analysis for China. Energy Policy 37, 5167–5172.

[40] Jayantha kumaran, K., Verma, R., Liu, Y., (2012). CO_2 emissions, energy consumption, trade and income: a comparative analysis of China and India. Energy Policy 42, 450–460.

[41] Jammazi, R., & Aloui, C. (2015). "On the interplay between energy consumption, economic growth and CO_2 emission nexus in the GCC countries: A comparative analysis through wavelet approaches". Renewable and Sustainable Energy Reviews, 51, 1737–1751.

[42] Jebli, M. B. (2016)." On the causal links between health indicator, output, combustible renewables and waste consumption, rail transport, and CO_2 emissions: the case of Tunisia". Environmental Science and Pollution Research, 23 (16), 16699–16715.

[43] Jebli, M. B., & Belloumi, M. (2017). "Investigation of the causal relationships between combustible renewables and waste consumption and CO_2 emissions in the case of tunisian maritime and rail transport". Renewable and Sustainable Energy Reviews, 71, 820–829.

[44] Jebli, M. B., & Youssef, S. B. (2017). "The role of renewable energy and agriculture in reducing CO_2 emissions: Evidence for North Africa countries". Ecological indicators, 74, 295–301.

[45] Jeblia, MB, Youssef SB, Ozturkc I (2016). Testing environmental Kuznets curve hypothesis: The role of renewable and non-renewable energy consumption and trade in OECD countries. Ecological Indicators Volume 60, Pages 824–831.

[46] Kaika, D., Zervas, E., (2013). The Environmental Kuznets Curve (EKC) theory — Part A: concept, causes and the CO_2 emissions case. Energy Policy 62, 1392–1402.

[47] Kanjilal, K., & Ghosh, S. (2013). Environmental Kuznet's curve for India: Evidence from tests for cointegration with unknown structural breaks. Energy Policy, 56, 509-515. http://dx.doi.org/10.1016/j.enpol.2013.01.015

[48] Karp LS, Liu X., (1999). Valuing tradable CO_2 permits for OECD Countries. Available at SSRN 1999 200148.

[49] Kris Aaron Beck, Prathibha Joshi (2015). An analysis of the environmental Kuznets curve for carbon dioxide emissions: evidence for OECD and non-OECD countries. European Journal of Sustainable Development, 4, 3, 33-45.

[50] Kunnas, J., Myllyntaus, T., (2007). The Environmental Kuznets Curve hypothesis and air pollution in Finland. Scandinavian Economic History Review 55 (2), 101–127.

[51] Lean HH, Smyth R., (2010). CO_2 emissions, electricity consumption and output in ASEAN. Applied Energy; 87: 1858–64.

[52] Martínez-Zarzoso, I., Bengochea-Morancho, A., (2004). Pooled mean group estimation of an environmental Kuznets curve for CO_2. Econ. Lett. 82, 121–126.

[53] Mongelli, I., Tassielli, G., Notarnicola, B., (2006). Global warming agreements, international trade and energy/carbon embodiments: an input-output approach to the Italian case. Energy Policy 34, 88–100.

[54] Narayan, P-K., Narayan, S., (2010). Carbon dioxide emissions and economic growth: panel data evidence from developing countries. Energy Policy 38, 661–666.

[55] Nasir, M., Rehman, F., (2011). Environmental Kuznets Curve for carbon emissions in Pakistan: an empirical investigation. Energy Policy 39, 1857–1864.

[56] Ozturk, I., Acaravci, A.,(2013. The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Econ. 36, 262–267.

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

[58] Odhiambo, N. M. (2017). "CO_2 emissions and economic growth in sub-saharan african countries: A panel data analysis". International Area Studies Review, 20 (3), 264–272.

[59] Pao, H.-T., & Chen, C.-C. (2019). "Decoupling strategies: CO_2 emissions, energy resources, and economic growth in the group of twenty". Journal of Cleaner Production, 206, 907-919.

[60] Pedroni, P. (1995), "Panel cointegration, asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis", Working Paper in Economics, 92-013, Indiana University. 31.

[61] Pedroni, P. (1997), "Panel cointegration, asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis: new results", Working Paper in Economics, Indiana University.

[62] Pedroni, P. (1999), "Critical values for cointegration tests in heterogenous panels with multiple regressors", Oxford Bulletin of Economics and Statistics, S1, 61, pp. 653-670.

[63] Pedroni, P. (2004), "Panel cointegration. Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis", Econometric Theory, 20 (3), pp. 597-625.

[64] Pesaran, M., Shin, Y., Smith, R., (1999). Pooled mean group estimation of dynamic heterogeneous panels. J. Am. Stat. Assoc. 94 (446), 621–634.

[65] Qu, B., Zhang, Y., (2011). Effect of income distribution on the Environmental Kuznets Curve. Pac. Econ. Rev. 16, 349–370.

[66] Roodman, D., (2009). A note on the theme of too many instruments. Oxf. Bull. Econ. Stat. 71, 135–158.

[67] Salahuddin, M., Alam, K., Ozturk, I., & Sohag, K. (2018). "The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO_2 emissions in Kuwait". Renewable and Sustainable Energy Reviews, 81, 2002–2010.

[68] Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., & Leitão, N. C. (2013). "Economic growth, energy consumption, financial development, international trade and CO_2 emissions in indonesia". Renewable and Sustainable Energy Reviews, 25, 109–121.

[69] Shahbaz, M., Tiwari, A. K., & Nasir, M. (2013). "The effects of financial development, economic growth, coal consumption and trade openness on CO_2 emissions in South Africa". Energy Policy, 61, 1452–1459.

[70] Shafik, N., & Bandyopadhyay, S. (1992). Economic Growth and Environmental Quality: Time Series and Crosscountry Evidence. Background Paper for the World Development Report 1992. Washington,

[71] 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.

[72] Shiyi C., (2009). Energy consumption, CO_2 emission and sustainable development in Chinese industry. Economic Research Journal; 4: 1–5.

[73] Tiwari, A. K., Bhanja, N., Dar, A. B., & Islam, F. (2015). "Time–frequency relationship between share prices and exchange rates in india: Evidence from continuous wavelets". Empirical Economics, 48 (2), 699–714.

[74] Tiwari, A. K., Shahbaz, M., & Hye, Q. M. A. (2013). "The environmental kuznet scurve and the role of coal consumption in india: cointegration and causality analysis in an open economy". Renewable and Sustainable Energy Reviews, 18, 519–527.

[75] Tamazian, A., Chousa, J. P., Vadlamannati, K. C., (2009). Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. Energy Policy 37 (1), 246–253.

[76] Tingting Li, Yong Wang, Dingtao Zhao (2016). Environmental Kuznets Curve in China: New evidence from dynamic panel analysis. Energy Policy 91 (2016) 138–147.

[77] Torras, M., Boyce, J. K., (1998). Income, inequality, and pollution: a reassessment of the environmental Kuznets Curve. Ecological Economics 25, 147–160.

[78] Wang K-M., (2012). The relationship between carbon dioxide emissions and economic growth: quintile panel-type analysis. Quality and Quantity. http://dx.doi.org/10.1007/s11135-011-9594-y.

[79] Wang, S., Zhou, D., Zhou, P., Wang, Q., (2011). CO_2 emissions, energy consumption and economic growth in China: a panel data analysis. Energy Policy 39, 4870–4875.

[80] Yang, H., He, J., & Chen, S. (2015). The fragility of the Environmental Kuznets Curve: Revisiting the hypothesis with Chinese data via an “Extreme Bound Analysis”, Ecological Economics, 109, 41-58. http://dx.doi.org/10.1016/j.ecolecon.2014.10.023

[81] Wang, S., Li, G., & Fang, C. (2018). "Urbanization, economic growth, energy consumption, and CO_2 emissions: Empirical evidence from countries with different income levels". Renewable and Sustainable EnergyReviews, 81, 2144–2159.

[82] Zeb, R., Salar, L., Awan, U., Zaman, K., & Shahbaz, M. (2014). "Causal links between renewable energy, environmental degradation and economic growth in selected saarc countries: progress towards green economy". Renewable Energy, 71, 123–132.