The analysis of CO2 emissions determinants in accommodation and food service activities using quantile regressions

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ABSTRACT

Purpose: *The present research studies the determination elements of carbon dioxide emissions (CO2) in accommodation and food service activities for 26 EU countries over the period 2008-2014.* **Design/Methodology/Approach:** *The quantile regression method is used to analyze the relationships between important variables.* **Main findings:** *Our main finding suggests that GDP per capita and capital investments are the most important regressors of CO2 emissions in tourism, whilst other two selected variables, i.e. visitor exports and electricity generated from renewable sources become significant under the four quantiles.* **Originality/Value:** *According to the results of quantile regression, there is evidence that confirms the Environmental Kuznets Curve (EKC) hypothesis.* **Conclusions/Recommendations:** *The results emphasize the need for corrective actions in order to reduce the CO2 emissions in tourism, and thus combating global warming. Therefore, this paper identifies some mitigation strategies that can be implemented by accommodation and food service sectors toward lowering the CO2 emissions in the tourism industry.*

Keywords: CO2 emissions; quantile regression; accommodation and food service sectors

JEL classification: L83, Z32

1. INTRODUCTION

The raise of greenhouse gas (GHG) emissions generates considerable consequences on the quality of the environment. This remarkable increase represents the consequence of the diverse activities developed by the world population, also connected to agricultural, forestry, construction, industrial activities (UNWTO 2003), bringing tremendous consequence on the livelihood. From all GHG emissions (carbon dioxide (CO2); methane (CH4); nitrous oxide (N2O); fluorinated gases (F-gases) emitted by human activities), CO2 is the most common, and it is responsible for 65% of total gas emissions.

CO2 emissions continued to grow in the recent years, due to various factors, but most commonly associated to the economic development and other variables related to demand and supply in business and energy consumption (Abdullah and Khalid, 2014). According to UNWTO and World Travel & Tourism Council (WTTC), tourism industry has a significant influence at global level, in terms of contribution to GDP, exports, investments, job creation, being an undeniable driver of economic development and, in the next decades, it is expected to keep growing. On the other hand, tourism development also generates an increase in resource consumption and energy use, as this economic sector comprises sub-sectors with energy-intensive activities, which furthermore contribute to GHG emissions and upping these gases in the environment (Dubois G and Ceron JP, 2005). Thus, tourism destinations became more intensive generators of CO2 emissions as similar sized spots, due to diverse activities such as cooking, cleaning, heating, lighting, disposing waste, cooling, etc. which need to take place in order to provide qualitative tourism services (Kelly and Williams, 2007).

Inevitably, tourism's contribution to GHG emissions, and obviously to CO2 emissions, will continue to grow as tourism activities continue to develop and diversify, contributing also to the decrease in tourists' satisfaction and their willingness to visit certain world destinations (Hunter and Green, 1995, Holden, 2000, Sharpley, 2009).

As a review of existing tourism literature has shown, tourism contributes to global energy utilization and emissions of CO2 (Perch-Nielsen et al., 2010, Gössling, 2002, Patterson and McDonald, 2004, Becken and Patterson, 2006, Kelly and Williams, 2007, Forsyth et al, 2008, Peeters and Dubois, 2010, Pu and Peihua, 2011, Huang and Wang, 2015, Unger et al., 2016, Becken and Bobes, 2016), with significant consequences on the atmosphere, reducing also the satisfaction of the tourists participating in various activities in world tourism destinations. According to Challenges and UNWTO (2008), tourism industry generates about 5% of global CO2 emissions (the contribution of transportation is estimated at about 75% of all emissions; the lodging sector approx. 20% of emissions from tourism; other activities – museums, theme parks, events, shopping approx. 3.5%). In the projections developed by Peeters and Dubois (2010), it is underlined that tourism development will generate a growth in emissions at over 3% per year and if this development is unrestricted, the CO2 estimations will be even higher than the global emissions. The business-as-usual scenario developed by Pratt (2011) shows that in the next 3 to 5 decades, tourism industry contribution to GHG emissions will continue to grow by more than 5%, due to the rapid increase in international and domestic travel.

The increasing recognition of CO2 emissions and other GHG emissions as contributing to the decrease in the environment quality underlined the necessity to address this problem in a concerted manner (Becken and Patterson, 2006, Becken and Hay, 2007). Consequently, mitigation actions are more necessary than ever that one may reduce CO2 emissions and the tourism industry is responsible for such actions (Becken and Patterson, 2006). Specialists, institutions, governments, NGOs, etc. have agreed on the need to tackle tourism's contribution to CO2 emissions, derived especially from transport and accommodation activities. Consequently, the operators in tourism industry require finding sustainable solutions to provide hospitality services taking into consideration the necessity to sustain and safeguard the environment, putting into practice the green values. The stakeholders in the tourism industry need to struggle more, to find suitable solutions to reduce CO2 emissions, not just from the perspective of the supply but also from the demand side.

One of the objectives of the present paper is to complete current gaps in knowledge about the generating factors of CO2 emissions produced by European tourism, using quantile regressions. Another objective is to spot the driving factors of CO2 emissions and in particular those that are considered to lower the CO2 emissions in the tourism industry. The third objective is to explore alternative solutions for reducing the CO2 emissions in tourism industry, and reflect on supporting tourism expansion considering on green principles.

The current research is structured in the following manner: the next section shows the review of the literature on the driving factors of CO2 emissions. Section 3 presents both the data and the econometric methodology developed. Section four displays the estimations of empirical models and discusses the results. Last segment concludes the paper and provides future recommendations for reducing the CO2 emissions in the tourism industry.

2. LITERATURE REVIEW

In the existing literature, the Environmental Kuznets Curve (EKC) develops a hypothesized connection linking the quality of the environment and the economic development: the quality of the environment decreases with the development of a country, up to a point, and after that it increases in a certain phase of economic growth. Most often, indicators as CO2 emissions and per capita income express this relationship and it shows an inverted U-shape curve. Many researchers investigated the existing connection between CO2 emissions and economic growth, on the national or the regional level (Holtz-Eakin and Selden, 1995, Friedl and Getzner, 2003, Liu, 2005, Akbostanci et al., 2009, He and Richard, 2010, Iwata et al., 2012, Ece Omay, 2013, Ozcan, 2013, Linh and Lin, 2014, Ren et al., 2014, Kasperowicz, 2015, Kasman and Duman, 2015, Keho, 2015, Dogan and Seker, 2016a, Dogan and Seker, 2016b, Zheng et al., 2016), and the results are different, confirming or not EKC hypothesis.

With the development of the economics literature, the researchers struggled to investigate other driving factors of CO2 emissions, most commonly used indicators being those related to economic growth. Table 1 summarizes some previous results on the existing literature on the linkages connecting CO2 emissions and other relevant regressors.

The decomposition factors used for the global CO2 emissions in the academic literature are related to the following indicators: gross domestic product or income (Friedl and Getzner, 2003,Liu, 2005, Akbostanci et al., 2009, Halicioglu, 2009, Zhang and Cheng, 2009, He and Richard, 2010, Apergis et al., 2010, Sharma, 2011, Hui et al, 2012, Iwata et al., 2012, Omri, 2013, Ozcan, 2013, Wang, 2013, Abdullah and Khalid, 2014, Omri et al., 2014, Linh and Lin, 2014, Ren et al., 2014, Kasman and Duman, 2015, Keho, 2015, Apergis and Payne, 2015, Choi and Abdullah, 2016, Zheng et al., 2016, Jebli et al., 2016, Dogan and Seker, 2016a, Dogan and Seker, 2016b, Gurbuz and Buke, 2016, Halkos and Paizanos, 2016); energy (Halicioglu, 2009, Zhang and Cheng, 2009, Sharma, 2011, Hui et al, 2012, Iwata et al., 2012, Ozcan, 2013, Omri, 2013, Andersson and Karpestam, 2013, Abdullah and Khalid, 2014, Linh and Lin, 2014, Çetin and Ecevit, 2015, Kasman and Duman, 2015, Dogan and Seker, 2016a, Dogan and Seker, 2016b, Gurbuz and Buke, 2016, Wang et al., 2016, Zheng et al., 2016, Behera and Dash, 2017); total/urban population or urbanization (Sharma, 2011,Hui et al, 2012,Zhu and Peng, 2012,A ndersson and Karpestam, 2013, Abdullah and Khalid, 2014, Omri et al., 2014, Çetin and Ecevit, 2015, Kasman and Duman, 2015, Keho, 2015, Choi and Abdullah, 2016, Gurbuz and Buke, 2016, Wang et al., 2016, Zheng et al., 2016, Behera and Dash, 2017); foreign direct investments (Ren et al., 2014, Linh and Lin, 2014, Omri et al., 2014, Behera and Dash, 2017); imports (Friedl and Getzner, 2003,He and Richard, 2010,Ren et al., 2014); exports (He and Richard, 2010,Ren et al., 2014); trade openness (Halicioglu, 2009, Sharma, 2011, Omri et al., 2014, Ren et al., 2014, Kasman and Duman, 2015, Keho, 2015, Dogan and Seker, 2016a, Dogan and Seker, 2016b); capital (Zhu and Peng, 2012, Andersson and Karpestam, 2013, Omri et al., 2014, Halkos and Paizanos, 2016, Zheng et al., 2016), carbon intensity (Hui et al, 2012, Andersson and Karpestam, 2013, Gurbuz and Buke, 2016), industry (He and Richard, 2010, Andersson and Karpestam, 2013, Abdullah and Khalid, 2014, Keho, 2015, Zhang and Cheng, 2009, Zheng et al., 2016), combustible renewables and waste or waste management (Hui et al, 2012,Abdullah and Khalid, 2014), transport (Andersson and Karpestam, 2013, Abdullah and Khalid, 2014, Choi and Abdullah, 2016), renewable energies (Apergis et al., 2010, Apergis and Payne, 2015, Dogan and Seker, 2016b, Jebli et al., 2016), nuclear electricity (Apergis et al., 2010, Iwata et al., 2012), oil price (He and Richard, 2010, Andersson and Karpestam, 2013, Apergis and Payne, 2015), agriculture (Abdullah and Khalid, 2014). The authors have constantly improved their empirical instruments and statistical, econometric and mathematical methodologies.

The impressive number of papers which analyse the (causal) relationship linking CO2 emissions and real income (GDP), renewable and non-renewable energy, investments, trade, population, transport etc. underlined the complex nature of the interactions existing between pollution (expressed by CO2 emissions) and various economic, social and technological factors. Table 1 provides an overview of studies highlighting such links.

A survey of existing literature on CO2 emissions modeling instruments

Table 1

Methodology	Used indicators	Case study / period of investigation	Specific results	Sources
EKC, OLS	CO2; GDP/P; Imp; VAS; T*	Austria, 1960-1999	+R [CO2, GDP/P, T*] -R [CO2, I, VAS] A cubic (i.e. N-shaped) of EKC	Friedl and Getzner (2003)
EKC, 3SLQ	CO2; GDP/P	24 OECD countries, 1975- 1990	-R [CO2, GDP/P]	Liu (2005)
Cointegration, ARDL, VAR, Granger	CO_2; E; IN; TO	Turkey, 1960-2005	CO2⇔ IN	Halicioglu (2009)
EKC, ADF, GLS	CO2; GDP/P	Turkey, 1992-2001	R [CO2, GDP/P] N-shape of EKC	Akbostanci et al (2009)
Granger	CO2; GDP; E	China, 1960-2007	E=>CO2	Zhang and Cheng (2009)
EKC, CPM, PLR, Hamilton's models	CO2; GDP/P; Exp; Imp; Exp of oil; Imp of oil; OP; Ind	Canada, 1948-2004	R [CO2, GDP/P] No conclusion about EKC	He and Richard (2010)
Cointegration, Granger, VECM	CO2; nuclear E; RWE; GDP	19 developed and developing countries, 1984–2007	-R[CO2, nuclear E] long-run +R[CO2, RWE] long-run	Apergis et al (2010)
Dynamic panel data model	CO_2; E; GDP/P; P; TO	69 countries, 1985-2005	R [CO2, P, GDP/P]	Sharma (2011)

Cointegration, Granger, OLS	CO2; P (size, structure, U, household size); K	China, 1978-2008	R [CO2, P (structure, consumption)]	Zhu and Peng (2012)
MR	CO2; E; GDP/P; P density; CRW; CI	Malaysia, Thailand; 1971-2006	-R [CO2, CRW]	Hui et al (2012)
EKC, ARDL	CO2; GDP/P; nuclear electricity; Tr; E	11 OECD countries, 1960-2003	+R [CO2, E] Limited evidence of inverted U-shape of EKC	Iwata et al (2012)
EKC, RSM	CO2; GDP/P	Turkey, 1980-2009	No R [CO2, GDP/P] N-shaped of EKC	Omay (2013)
2 SLS, 3SLS, GMM estimator	CO2; E; GDP/P	14 MENA countries, 1990-2011	GDP/P⇔CO2 E=>CO2	Omri (2013)
BSR	CO2; E /GDP; CI; K; L; U, FP, Ind; OP	1973-2007, developed economies	R [CO2, FT] R [CO2, K]	Andersson andKarpestam (2013)
EKC; Cointegration; Granger; FMOLS	CO2; GDP/P; E	12 Middle East countries, 1990-2008	GDP/P=>CO2 Both U-shape and inverted U-shape of EKC	Ozcan (2013)
Cointegration, QR, VECM	CO2; GDP	138 countries, 1971–2007	+R [CO2, GDP]	Wang (2013)
PFLR	CO2; GDP; P; E; B; T; A; Ind;WM, FM	UK, Malaysia; 1990 – 2010; 1981 - 2005	R [CO2, GDP/P, P]	Abdullah and Khalid (2014)
Cointegration, OLS	CO2; TGDP; TA; TBN; NTR; FD; ND	Maldives, 1972-2010	+ R [CO2, TD]	Amzath and Zhao (2014)
EKC, Cointegration, Granger	CO2; E; FDI; IN	Vietnam, 1980-2010	CO2⇔IN, CO2⇔FDI No Inverted U-shape of EKC	Linh and Lin (2014)
EKC, IO, 2 step GMM estimation	CO2; FDI; TO; Imp; Exp; IN	China, 2000-2010	+ R [CO2, TO, FDI] Inverted U-shape of EKC	Ren et al (2014)
DSEM	CO2; FDI;, GDP/P; K stock; TO; U	Global panel of 54 countries, 1990-2011	CO2⇔FDI	Omri et al (2014)
EKC, ADF, Granger	CO2; E; GDP/P; TO; U	new EU member and candidate countries, 1992-2010	E=>CO2, TO=>CO2, U=>CO2, Inverted U-shape of EKC	Kasman and Duman (2015)
Cointegration, Granger, VECM	CO2; E; P	Sub-Saharan Countries, 1985-2010	R [CO2, E, P] CO2⇔ E CO2⇔ P	Çetin and Ecevit (2015)
EKC, Cointegration, ARDL	CO2; GDP/P; P; Ind; TO	Cote d'Ivoire, 1970-2010	EKC hypothesis validated +R [CO2, GDP/P, Ind, TO]	Keho (2015)
Cointegration, Granger, VECM, FMOLS	CO2; RWE; GDP/P; OP	11 South American countries;1980–2010	+R [CO2, GDP/P, OP] CO2⇔RWE	Apergis and Payne (2015)
PFLR, MLR	CO2; GDP; P; T; FM	Malaysia, 1981 - 2005	R [CO2, GDP, T]	Choi and Abdullah (2016)
LMDI	CO2; P; GDP/P; E; CI	Poland, France and Turkey, 2012 - 2050.	+R [CO2, GDP/P, P] -R [CO2, E, CI]	Gurbuz and Buke (2016)
ADF, Cointegration, VAR	CO2; TGR; TGE; Interest Rate; GDP/P; PC; K, adjusted reserves;NRI; EP	USA, 1973-2013	-R [CO2, TGE]	Halkos and Paizanos (2016)
Cointegration, Granger	CO2; P; E	ASEAN countries, 1980-2009	P=>CO2; E=>CO2	Wang et al (2016)
EKC, Cointegration, Granger	CO2; GDP/P; TO; E; financial development	OECD, 1975-2011	EKC hypothesis validated CO2⇔ E; CO2⇔ TO; GDP/P=> CO2	Dogan and Seker (2016a)
EKC, Cointegration, dynamic OLS, Granger	CO2; RWE; non-renewable E; GDP; TO	European Union, 1980–2012 ,	EKC hypothesis validated R [CO2, GDP] CO2⇔ RWE TO=>CO2	Dogan and Seker (2016b)
EKC, Granger, FMOLS, DOLS	CO2; GDP; RWE; nonRWE; IT	25 OECD countries, 1980-2010	EKC hypothesis validated CO2⇔RWE; CO2⇔nonRWE, CO2⇔GDP, CO2⇔IT IT and RWE reduce CO2	Jebli et al (2016)
LMDI	CO2; E; KW; Ind	China, 1990-2014	+R [CO2, Ind] -R [CO2, E, KW]	Zhang et al (2016)

EKC, extended STIRPAT model; LMEM	CO2; P; GDP/P; U; Ind; E	China, 2002–2012	EKC hypothesis validated + R [CO2, P, GDP/P, Ind, E]	Zheng et al (2016)
Cointegration	CO2; FDI; E; U	South and Southeast Asia, 1980-2012	+R [CO2, FDI, E] R [CO2, U]	Ranjan et al (2017)

Notes:OLS – Ordinary Least Squares; DOLS – Dynamic OLS; GLS – Generalized Least Squares; PLR - Partially Linear Regression; 3SLQ – 3 Stage Least Squares; SLS – Stage Least Squares; MR – Multiple regression; MLR - Multiple Linear Regression; GMM – Generalized Method of Moments; BSR - Band Spectrum Regression; QR - Quantile Regression; RSM - Regression Spline Method; CPM - Cubic Parametric Model; DSEM - Dynamic simultaneous-equation models;EKC - Environmental Kuznets Curve; Granger – Granger Causality Test; LMDI - Logarithmic Mean Divisia Index; VAR – Vector Autoregression; ECM - Error Correction Model; ARDL - Autoregressive Distributed Lag; PFLR - Possibilistic Fuzzy Linear Regression; LMEM - Linear Mixed Effect Model;IO – Input-Output Analysis; FMOLS – Fully Modified OLS; VECM - Vector Error Correction Model; 'X ⇒ Y' - causality running from X to Y; 'X ⇔ Y' two-way causality between X and Y; +/-R[X, Y]=positive/negative relationship; A – agriculture; B – business; CO2 - carbon dioxide; CI - carbon intensity of energy use; CE – carbon emission; CRW- combustible renewables and waste; E - energy intensity of economic activity/ energy supply/ energy consumption; EP - energy prices; Exp - export; FDI – Foreign Direct Investments; FD/ND- distance from international airport; FM - fuel mix; GDP – gross domestic product; Imp – imports; IN - income; Ind. - industry production/ goods production/ industrial scale/ % of industry in GDP; IT – international trade; K –capital (annual expenditure); L – labour; NTR – tourist resorts built; NRI - non-residential investments; OP - oil price; P - population; PC - private consumption; RWE –renewable energy consumption; TD - tourism development; TGDP – tourism gross domestic product; TA – tourist arrivals; TBN – tourist bed nights; T* - deviation from long-term mean temperature; TO- trade openness; Tr –Trade; T/FT – Transport/ freight transport; TGR - Total Government Revenue; TGE - Total Government Expenditure; U- urbanization; VAS-Value added in the service sector; W – productivity; WM - Waste management.

Despite the burgeoning literature, there is a gap regarding the investigation of CO2 emissions and its related variables in the tourism sector. The specialists concentrated more on aspects related to planning, projections, forecasting of CO2 emissions (Abdullah and Khalid, 2014) and less on the generating influences of CO2 emissions in tourism. Since the 1990's, authors have used various mathematical and statistical instruments (i.e. Tourism Satellite Account –TSA, Model of Alpine Tourism and Transportation – MATT, Global Tourism and Transport Model - GTTMbas, Input-Output Analysis - IOA), to approximate or even project/forecast GHG or carbon emissions for hospitality industry at international, national and regional level (Gössling, 2002, Patterson and McDonald, 2004, Becken and Patterson, 2006, Kelly and Williams, 2007, Forsyth et al, 2008, Peeters and Dubois, 2010, Perch-Nielsen et al., 2010, Pu and Peihua, 2011, Huang and Wang, 2015, Unger et al., 2016).

Among global estimation of tourism emissions, tourism and leisure activities may contribute with 5.3% to CO2 emissions at global level(Gössling, 2002). Peeters and Dubois (2010) used GTTMbas to develop 70 scenarios in order to project global CO2 emissions related to tourism activities at the destination. Patterson and McDonald (2004) applied lifecycle assessment, using IOA, while Becken and Patterson (2006) used two methodologies (bottom-up, top-down) in order to estimate total CO2 emissions from tourism within New Zealand. Kelly and Williams (2007) identified bottom-up' modelling procedure to assess tourism destination contributions to GHG emissions in Whistler, British Columbia.

Forsyth et al (2008) used Australian TSA to estimate total GHG emissions employed by tourism sector. Perch-Nielsen et al. (2010) used the TSA in order to gather GHG information in a bottom-up and a top-down approach to estimate the GHG concentration of the hospitality sector in Switzerland. Pu and Peihua (2011) estimated CO2 emissions from tourism industry in China, using statistical analysis and a bottom-up approach. Huang and Wang (2015) estimated GHG emissions of tourism farms in Taiwan using a bottom-up approach and stepwise multiple regression analysis. Unger et al (2016) used MATT as a bottom-up approach to model GHG emissions in Alpine area and to show ODT's emissions patterns.

Consequently, it is very difficult, if not impossible, to calculate tourism energy consumption and produced CO2 emissions. In their papers, authors have concentrated their efforts more on estimation of CO2 emissions. Moreover, it is important to investigate what are the driving factors that increase or decrease the CO2 emissions so as the public and private institutions can take corrective actions and implement mitigation measures.

3. ECONOMETRIC METHODOLOGY AND DATA SPECIFICATION

3.1 Methodology description

The authors that have investigated the influence of various variables on the CO2 emissions have used different methods, such as OLS, GLS, PLS, 3SLQ, SLS, MR, GMM, BSR, RSM, CPM, DSEM, PFLR, VECM, FMOLS, PFLR, LMEM, etc. Standard methods usually provide the average outcome of predictable variables over a given distribution of the regressand (Keho, 2017). In the last years, quantile regression (QR) has been often used in ecology studies with the aim to investigate the predictive connections linking given variables in situations described by weak relationships or even no relationships between their means. The models generated by QR are relevant when (Cade and Noon, 2003):

- the dependent variable is influenced by more than one indicator,
- these indicators have different effects and consequently generate various responses,

- all these multiple factors interact.

According to Koenker and Bassett (1978), QR offers different estimations of the linear connection existing linking predictor variables X and a specified quantile of the regressand Y.

$$y_i = x_i^T \beta_\tau + e_i \tag{1}$$

In the equation, i=1,…,n, and the τ-th quantile of e_i is zero.

Thus, the assumption of previous equation is:

$$Q_\tau(Y/X) = X^T \beta_\tau \tag{2}$$

τ

In this equation, β_τ is the vector of coefficients connected with the -th quantile.

The conditional quantile regression estimator, the estimator β_τ is presented below.

$$\widehat{\beta_\tau} = argmin_{\beta \epsilon R^p} \sum \rho_\tau \left(y_i - x^T \beta\right) \tag{3}$$

Thus, regression quantile is represented as follows:

$$\widehat{Q_\tau}(Y/X) = X^T \widehat{\beta_\tau} \tag{4}$$

Quantile regression represents a useful method used by researchers to estimate models for conditional quantile functions and is regarded as a broad instrument which completes the regression picture (Koenker and Hallock, 2001).

3.2 Data and descriptive statistics

Analyzing both economic literature and tourism literature, we have reached the conclusion that some of the influence factors, generally used to examine the determinants of CO2 emissions, can be replicated and adapted for tourism sector, while others are more specific and require special attention.

Research on the connection between tourism development and carbon emission using regression analysis has revealed that tourism development contribute to the increase in CO2 emission (Amzath and Zhao, 2014), having an important input to the degradation of the natural environment. Within economy, tourism development is generally expressed through tourism contribution to GDP. Nevertheless, authors have tried to take a deeper approach of the problem, considering a decomposition of GDP, looking to investigate what factors have stronger effects on CO2 emissions, for example exports and investments. On the other hand, renewable energy reduces the CO2 emissions and we tried to investigate the effects of a more intensive use of renewable energies in tourism.

The present paper uses the panel data approach in order to investigate the relationship between CO2 emissions and various tourism indicators for 26 EU Member States (Austria, Belgium, Bulgaria, Croatia, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) from 2008 to 2014. The sample period was chosen based on the availability of data. All the data collected were further converted into natural logarithm.

The availability of data indicated just the CO2 emissions in accommodation and food service activities, which represents a very good base for analysis because, after transport, these activities are the most energy intensive component of the tourism industry (Pratt, 2011), and consequently highly contributing to the CO2 emissions.

Description of variables

Table 2

Variable	Description	Sample period	Source of the data
LNCO2	Natural logarithm of CO2 emissions in accommodation and food service activities (tons)	2008-2014	Eurostat
LNGDPPC	Gross domestic product at market prices, euro per capita	2008-2014	Eurostat
LNEXP	Visitor Exports (Foreign spending) billionsUS$ (Real prices)	2008-2014	World Travel &Tourism Council
LNINV	Natural logarithm of investments (capital investments) in travel & tourism, billions US$ (Real prices)	2008-2014	World Travel &Tourism Council
LNELEC	Electricity generated from renewable sources, % of gross electricity consumption	2008-2014	Eurostat

Table 3 provides some descriptive statistics of the previously mentioned data. The Kurtosis exceeds the value of 3 in the case of the electricity from renewable energy, suggesting that the series are leptokurtic, and all the other values of the selected indicators show a platykurtic distribution. The skewness test indicates that CO2 emissions, visitor exports, investment, gross domestic product per capita are positively skewed, while the rest of the variables are negatively skewed. Both Skewness and Kurtosis tests, together with Jarque-Bera test statistics, confirm that the data series are not normally distributed. Consequently, estimation techniques that are based on linear models will be less suitable. Therefore, it is recommended to use other estimation technique, and in this case, the QR technique will be performed.

Descriptive statistics

Table 3

	LNCO2	LNGDPPC	LNEXP	LNELEC	LNINV
Mean	11.832	9.882	1.845	2.793	0.609
Median	11.623	9.831	1.876	2.896	0.634
Maximum	15.177	11.402	4.105	4.250	3.748
Minimum	8.749	8.517	-0.137	-1.204	-1.787
Std. Dev.	1.777	0.656	1.220	0.982	1.415
Skewness	0.277	0.020	0.153	-1.077	0.305
Kurtosis	2.042	2.332	1.952	4.823	2.465
Jarque-Bera	9.132**	3.339	8.888**	59.402***	4.904*

Note:*** p <0.01; **p <0.05, *p<0.1

4. EMPIRICAL RESULTS AND DISCUSSIONS

We started the analysis with the performance of panel unit root test (Levin, Lin and Chu, 2002). The panel unit root test was applied to investigate if the variables under consideration are panel stationary or not, and if they are non-stationary, to be used in the developed model in growth form. According to the results, all five different tested variables (namely CO2 emissions, GDP per capita, visitor exports, capital investment in travel and tourism, and electricity generated from renewable sources) are stationary in their level forms. The results of the unit root test are summarized in Table 4.

After establishing the stationary data, we proceed with the OLS and quantile regression estimations to discover the determinants of CO2 emissions in accommodation and food service activities at EU level.

Unit root test for used variables

Table 4

Variables	Levin, Lin & Chu t*
LNCO2	-5.83690***
LNGDPPC	-4.05518***
LNEXP	-2.57468***
LNINV	-16.6415***
LNELEC	-1.82490**

Notes: *, **, *** Null hypothesis can be rejected at 10%, 5% and 1% level, respectively.

Table 5 presents both panel OLS and quantile regression estimates. The estimation from panel OLS are compared with the estimates for separates quantiles (0.1, 0.25, 0.50, 0.75, 0.9) in the conditional distribution of CO2 emissions in accommodation and food service activities. The panel OLS results display a baseline of mean effects.

In order to facilitate the explanations of the results, Fig. 1 summarizes the progression of the coefficients estimated through the model (elasticity) of the five quantile regressions and provide the effects of GDP per capita, visitor exports, investment in travel and tourism, electricity generated from renewable sources, across the CO2 emissions distribution. Two indicators, namely GDP per capita and tourism investments, proved to be significant (under the 5% level) for both OLS and QR, under the five quantiles, the other two regressors confirmed the significance (under the 1% level) for OLS and QR, under the four quantiles (0.25th – 0.90th).

The results of both models, OLS and QR under the five quantiles, show that at the 1% level, investments in travel and tourism have a significant and positive effect on CO2 emissions, at any rate of CO2 emissions quantiles. The investments elasticity goes down under the quantile of 0.25th - 0.90th, suggesting that while CO2 emissions quantiles increase, CO2 emissions register even lower growth than the investments growth. The results indicate that CO2 emissions increase with growth of tourism investments and sector development, thus explaining the increase in electricity consumption and CO2 emissions. The positive influence of investments on CO2 emissions is in line with the previous empirical studies (Linh and Lin, 2014), (Ren *et al.*, 2014), (Omri, Nguyen and Rault, 2014), Behera and Dash (2017).

The second predictor, which exerts a significant and positive effect on CO2 emissions, is the visitor exports at the 1% level, except for the 0.10th quantile. Also, CO2 emissions proved to be rather inelastic in relationship with visitor exports, the estimates suggest that export elasticity goes up along with rising quantiles. Still, it appears that visitor exports exert a higher influence on CO2 emissions than investments under the quantile of 0.75th - 0.90th, consumption of foreign tourists intensifying the CO2 emissions. The consumption of domestic and foreign tourists varies, as we assume that foreign tourists stay longer, consume more products and services at the destination, leading to increased energy consumption and CO2 emissions for export tourism.

The GDP per capita has a negative influence on CO2 emissions, at 5% level of significance, at any rate of CO2 emissions quantiles. The influence of GDP on CO2 emissions is rather inelastic, decreasing with the increase of the quantiles, thus, for the 0.90th quantile, the GDP per capita is the third influencing factor of pollution, after visitor exports and investments. In the case of developed EU countries, according to EKC hypothesis, we identified a negative relationship between GDP and CO2 emissions, and these outcomes are in accordance with Liu (2005), Ren et al (2014), Kasman and Duman (2015), Keho (2015), Dogan and Seker (2016a), Dogan and Seker (2016b).

As expected, electricity generated from renewable sources has a negative effect on CO2 emissions, which is in line with previous studies (Apergis et al., 2010, Apergis and Payne, 2015, Dogan and Seker, 2016b, Jebli et al., 2016). Except for the 0.10th quantile, other quantiles report significant results (1% level of significance). Under the quantiles of 0.25th, 0.50th, 0.75th, the influence of renewable electricity production is negative but decreasing, and increasing at the 0.90th quantile: still, the coefficient remains to explain the inelasticity of CO2 emissions in relation to the explanatory variable. The results indicate that renewable electricity production helps mitigate CO2 emissions, being more sustainable on the long-run.

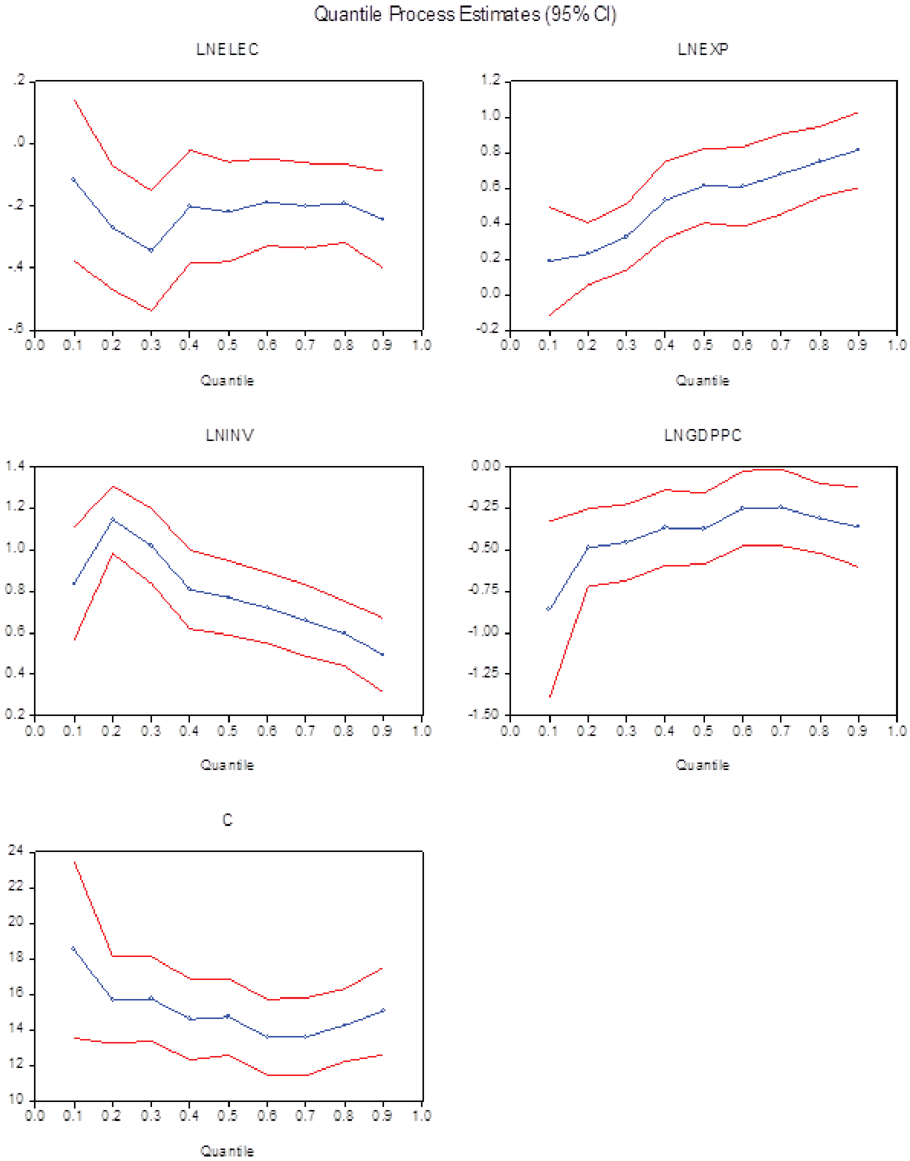
The results for OLS and QR

Table 5

Explanatory variables	Model 1 (OLS)	Model 2 (QR)				
		q=10	q=25	q=50	q=75	q=90
Constant	*14.440****	*18.522****	*15.703*	*14.732****	*13.918****	*15.064****
LNGDPPC	*-0.336****	*-0.861****	*-0.479****	*-0.374****	*-0.275***	*-0.363****
LNINV	*0.805****	*0.836****	*1.115****	*0.768****	*0.633****	*0.492****
LNEXP	*0.533****	*0.189*	*0.264****	*0.612****	*0.704****	*0.816****
LNELEC	*-0.272****	*-0.118*	*-0.292****	*-0.219****	*-0.187****	*-0.244****
R^2	*0.820*					
Pseudo R^2		*0.398*	*0.515*	*0.618*	*0.687*	*0.698*
Adj. R^2	*0.816*	*0.385*	*0.504*	*0.609*	*0.680*	*0.691*
Akaike info criterion	*2.325*					
Schwarz criterion	*2.414*					
F-statistic	*197.73****					
Hannan-Quinn criter.	*2.362*					
Durbin-Watson stat	*0.148*					
Quasi-LR statistic		*95.15****	*186.43****	*369.51****	*499.21****	*410.52****
Equality test (Wald Test)		*39.439****	*30.523****	*30.523****	*30.523****	*40.236****
Symmetric test		*19.662***	*11.245***	*11.245***	*11.245***	*19.662***

OLS estimation; *** p <0.01; **p <0.05, *p<0.1

Figure 1



In order to test the level of reliability on quantile process estimates, we employed the slope equality test (Koenker and Bassett, 1982a)and the symmetric quantiles test(Newey and Powell, 1987). The results of Wald test used to analyze the equality of slope parameters across various quantiles demonstrate that the slope coefficients differ across quantiles, and QR offer superior estimates. The results of the symmetry tests across 0.10th to 0.90th quantiles presented in Table 5 indicate significant evidence of asymmetry, at 5% level of significance.

5. CONCLUSIONS AND FUTURE RECOMMENDATIONS

This empirical research emphasizes the importance of CO2 emission investigation in the tourism sector at EU countries level. The paper investigates the determinants of CO2 emissions in accommodation and food service activities for 26 EU countries, over the period 2008-2014 in order to emphasize which are the driving factors which significantly contributes to air pollution, to facilitate the implementation of suitable solutions for reducing GHG emissions. Our main results are that GDP per capita and capital investments the main regressors of CO2 emissions in tourism, while other two variables such as visitor exports and electricity generated from renewable sources become significant at the level of four quantiles (0.25th, 0.50th, 0.75th, 0.90th).

The CO2 emissions in the accommodation and food sector might be reduced, especially by renewing and modernizing tourism infrastructure and using existing mature technologies in lighting, heating and cooling that considerably upgrade energy efficiency. This proposed strategy that effectively mitigate the carbon emissions of tourist accommodation has been reported also by Becken et al (2001), Dubois and Ceron (2006), Hall (2007), Ceron and Dubois (2007), Tovar and Lockwood (2008), Ceron and Dubois (2008), Molz, (2009), Ruiz-Molina et al (2012), Chan et al (2013a), Ayoub et al (2014), Gabbar et al (2014), Cadarso et al (2015), Chedwal et al (2015). Moreover, this carbon mitigation strategy in tourism should not just be converted into technological and infrastructure improvements, but also into an orientation of demand towards low-carbon tourism products, with the aim to guarantee the sustainable development. This strategy is in line with those reported byBode et al (2003), Gössling et al (2005), Tol (2007), Nepal (2008), Chiesa and Gautam (2009), Weaver (2011), (Scott, 2011), Rahman et al (2012), Scott et al (2013). The environmental impact generated by CO2 emission of the hospitality industry could also be mitigated without the reduction of total tourists number through increased occupancy rate and increased average stay at hotels with low CO2 emissions, and using renewable energy sources, particularly wind and solar energy and supplementary sources fuelled with biomass or natural gas. The use of renewable energy sources as a mitigation strategy is in line with Taylor et al (2010), Chan et al (2013b), Colmenar-Santos et al (2014), Lee (2014).

Another solution in order to reduce CO2 emissions can come from the energy-efficiency regulations including careful monitoring, control, investigation mechanism and mandatory inspections in accommodation and catering tourism sectors. These regulations can be reinforced through information and energy-performance certification schemes and reporting systems that should incorporate energy reporting with enhanced tracking and checking. Studies conducted by Deng and Burnett (2000), Deng (2003), Trung and Kumar (2005), Erdogan and Barris (2007), Beccali et al (2009), (Rossellò-Batle et al. 2010) (Rossellò-Batle, Moià, Cladera, & Martinez, 2010), Liu et al (2011), Priyadarsini et al (2009), Teng et al (2012), Wang (2013), Munday et al (2013), Huang et al (2015), Pieri et al (2015) highlight the importance of energy-efficiency regulations as a mitigation strategy. This leads to rewards for accommodation and catering businesses that perform well on carbon emission reduction and penalties measures for those that perform inadequately. This would offer incentives for accommodation and catering businesses not only to save energy, but also to enhance their positive images by acting to offset their negative environmental and ecological impacts resulting from carbon emissions. The government should set up a carbon pricing system in the hospitality industry (Dwyer, Forsyth and Spurr, 2012). In this way, tourists can be encouraged to select the most energy-efficient accommodation by drawing attention to environmental protection while traveling.

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