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Revisiting the Income, Energy Consumption and Carbon Emissions Nexus: New Evidence from Quantile Regression for Different Country Groups

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ABSTRACT

The environment Kuznets curve (EKC) hypothesis has been widely tested in the energy economics literature. However, previous studies focused only on the mean effects and have not yet examined the role of pollution levels in the income-pollution nexus. This paper uses quantile regression to reexamine the effect of economic growth and energy consumption on dioxide carbon (CO_2) emissions for five panels of 59 countries. The results reveal that energy consumption increases CO_2 emissions in all panels, the effect being larger in low pollution countries. They also provide evidence supporting the EKC hypothesis for Sub-Saharan, American and European countries at all quantiles, and for Asian and MENA countries at lower levels of CO_2 emissions. These findings suggest that economic growth is not everywhere and always the cause and the cure of pollution. Therefore, environmental control policies should be tailored differently across low and high pollution countries.

Keywords: Carbon Dioxide Emissions, Economic Growth, Energy Consumption, Quantile Regression
JEL Classifications: C23, F18, O58, Q53

1. INTRODUCTION

Since the pioneering works by Grossman and Krueger (1991), Holtz-Eakin and Selden (1992), Selden and Song (1994) and Shafik (1994), the environmental Kuznets curve (EKC) hypothesis has been an active field of empirical research in energy economics. This was a result of the emergence of the literature on unit root and cointegration techniques. The EKC hypothesis describes an inverted U-shaped relationship between income and environmental degradation. That is, environmental degradation increases as income increases and then declines after income exceeds a threshold level. The main motivation for testing this relationship is that it allows policy makers to judge the response of the environment to economic growth. Furthermore, the EKC hypothesis suggests that growth is the cause and the cure of air pollution. To curb the pollution level countries have to accelerate economic growth to surpass the income threshold level. However, the empirical evidence regarding the validity of the EKC hypothesis has yielded mixed results (Dinda, 2004; Ozturk, 2010; Smith and Narayan, 2015, for a review). For example, while some studies found evidence supporting the EKC hypothesis (Dinda and Coondoo, 2006; Apergis and Payne, 2009; 2010; Jalil and Mahmud, 2009; Lamla, 2009; Iwata et al., 2010; Lean and Smyth, 2010; Pao and Tsai, 2010; Shahbaz et al., 2013; Shahbaz et al., 2014; Al-Mulali et al., 2015a; Apergis and Ozturk, 2015; Jebli et al., 2016, Zambrano-Monserrate et al., 2016; Rosado, 2017), others found no support for this hypothesis or mixed results (Dinda and Coondoo et al., 2000; Harbaugh et al., 2002; Perman and Stern, 2003; Martinez-Zarzoso and Bengochea-Morancho, 2004; Galeotti, et al., 2006; Aslanidis and Iranzo, 2009; Al-Mulali et al., 2015b; Baek, 2015; Yang et al., 2015; Al-Mulali et al., 2016; Ozturk and Al-Mulali, 2015; Shahbaz et al., 2015; Gill et al., 2017).

One problem with the existing studies is that they have relied on mean-based regression approaches such as ordinary least squares (OLS) or instrumental variables, which implicitly assumes that the impact of income along the distribution of carbon dioxide (CO_2) emissions is the same. However, theory does not provide any guide as to why we should focus the analysis on the mean effects only. Further, the assumption of a mean shift is a testable hypothesis in a statistical framework. While estimating how "on average" income affects CO_2 emissions yields straightforward interpretations, the standard methodology may miss what is crucial for policy purposes, namely how economic growth affects emissions at different points of the distribution of CO_2 emissions. For example, while increases in income may not matter for average CO_2 emissions levels, it would be useful to know if it matters for countries at the tails of the pollution distribution. It is likely that the effect of income on CO_2 emissions is different in high and low pollution countries. In this paper, we are interested to know where economic growth matter not just whether or not it matters on average.

Unlike the previous studies, this paper contributes to the EKC literature by using the quantile regression methodology developed by Koenker and Bassett (1978). This approach allows us to investigate possible differences in the effect of income on CO_2 emissions at different points of the distribution of CO_2 emissions. Using this approach, we also address the issue of parameter heterogeneity in the pollution-income relationship. CO_2 is considered to be the major cause of global warming and has been the most widely used pollutant indicator in the EKC literature. We focus on this pollutant to reassess the validity of the EKC for 59 countries divided into five panels. To our knowledge, the quantile regression approach has not been applied to test the EKC hypothesis.

The remainder of the article is organized as follows. Section 2 outlines the estimation methodology and describes the data. Section 3 discusses the empirical results, while Section 4 concludes.

2. MODEL, DATA AND METHODOLOGY

2.1. Empirical Model

Following the empirical literature (Apergis and Payne, 2009; Lean and Smyth, 2010; Pao and Tsai, 2010), we specify the econometric model as follows:

$$CO_{üüüüüüü}=\theta+\theta E+\theta I+\theta I^2+\mu \quad (1)$$

where i is for country i in the panel, t refers to the time period, CO_2 stands for per capita carbon dioxide emissions, E is energy use per capita, I refers to income measured by real gross domestic product (GDP) per capita. It is expected that higher energy use results in more CO_2 emissions. Therefore the expected sign of θ_1 is positive. Under the EKC hypothesis, the sign of θ_2 is expected to be positive whereas a negative sign is expected for θ_3. If θ_3 is statistically insignificant, it indicates a monotonic increase in the relationship between CO_2 emissions and income.

2.2. The Quantile Regression Approach

Previous studies use standard methods (OLS, instrumental variables, generalized method of moments and generalized least squares) that deliver the average effects of explanatory variables over the whole distribution of the dependent variable. However, in this study we are interested in studying the impact of income on the entire distribution of CO_2 emissions. Therefore we rely on the quantile regression method which was first introduced by Koenker and Bassett (1978) and discussed in further works (Koenker and Machado, 1999; Koenker and Hallock, 2001). This method has two main advantages. First, compared to OLS regression, it is more robust to outliers and to non-normal distribution. Second, it allows for the estimation of the effect of income at different points of the distribution of CO_2 emissions.

The quantile regression model can be formulated as follows:

$$q(CO_{2it}/\Omega_t)=\theta_{0\tau}+\theta_{1\tau}E_{it}+\theta_{2\tau}I_{it}+\theta_{3\tau}I_{it}^2+\mu_{it} \quad (2)$$

Where $q(CO_{2it}/\Omega_{it})$ is the conditional quantile of CO_2 and Ω_t contains the available information known at time t. Equation 2 can be written as follows:

$$y_{it}=x_{it}\theta_\tau+\varepsilon_{it} \quad (3)$$

Whereis $x_{it}=\left(1,E_{it},I_{it,},I_{it}^2\right)$ the vector of explanatory variables; θ_τ are the k×1 regression coefficients at the τ^{th} quantile of the dependent variable y.

Contrary to OLS which is based on minimizing the sum of squared residuals, the τ^{th} quantile regression estimator of θ minimizes an asymmetrically weighted sum of absolute errors:

$$\underset{\theta}{Min}\left[\sum_{y_{it}\,³x_{it}\theta\tau}\tau\left|y_{it}-x_{it}\theta_\tau\right|+\sum_{y_{it}\xi x_{it}\theta_\tau}(1-\tau)\left|y_{it}-x_{it}\theta_\tau\right|\right]$$
$$=\min_{\theta}\sum_{t=1}^{T}\varphi_\tau\left(y_{it}-x_{it}\theta_\tau\right) \quad (4)$$

Where $\phi_\tau(z)$ is a loss function defined as $\phi_\tau(z)=|z|+(2\tau-1)z$, $0<\tau<1$.

The quantile regression method allows the marginal effects of covariates to change at different points in the conditional distribution of CO_2 emissions by estimating θ_τ using different values of τ. It is in this way that quantile regression allows for parameter heterogeneity in the pollution-income nexus.

2.3. Data and Descriptive Statistics

The empirical analysis uses data for 59 countries divided into five groups: 15 Sub-Saharan African countries, 13 American countries, 10 Asian countries, 13 European countries, and 8 MENA member countries. The list of countries is presented in Table 1. The countries were chosen based on data availability. We use annual time series for real GDP per capita expressed in constant 2000 US dollar, per capita energy consumption in kg oil equivalent and per capita CO_2 emissions measured in metric tons. All the data are obtained from the 2015 World Development Indicators by the World Bank. The sample period varies across regions and has been dictated by availability of the data for all the series. All the data were converted into natural logarithms.

Table 2 gives some descriptive statistics of the data. As can be seen, there are some variations in the data within and across groups. European countries have greater per capita income, are greater consumers of energy and pollute more, followed by American and MENA countries. The Kurtosis exceeds 3 in most cases suggesting that series have heavy tails. This shows that data is not normal which is also proved with the Jarque-Bera test statistic. Therefore, estimation technique based on linear Gaussian models will be biased, hence it more appropriate to use quantile regression technique.

3. RESULTS AND DISCUSSION

Tables 3-7 display both pooled OLS and quantile regression estimates. OLS estimates provide a baseline of mean effects, and we compare these to estimates for separate quantiles in the conditional distribution of CO_2 emissions. We report results for the 10th, 25th, 50th, 75th and 90th quantiles. In order to obtain

Table 1: List of countries and sample period

Regions	Countries	Sample period
Sub-Saharan Africa	Benin, Cameroon, Congo democratic, Congo Republic, Cote d'Ivoire, Gabon, Ghana, Kenya, Mauritius, Nigeria, Senegal, South Africa, Togo, Zambia, Zimbabwe	1976-2011
America	Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Ecuador, Guatemala, Honduras, Mexico, Peru, Uruguay, Venezuela	1971-2011
Asia	Bangladesh, China, India, Indonesia, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, Thailand	1971-2011
Europe	Austria, Finland, Greece, Turkey, Belgium, Denmark, France, Italy, Luxembourg, Portugal, Spain, Sweden, UK	1971-2011
MENA	Algeria, Egypt, Iran, Jordan, Morocco, Oman, Saudi Arabia, Tunisia	1976-2011

Table 2: Descriptive statistics

Variables	Observe	Mean±SD	Minimum	Maximum	Kurtosis	Skewness	JB
Panel A: Sub-Saharan African countries							
CO_2 emissions	540	−0.652±1.221	−3.391	2.387	3.536	0.807	65.21
Energy use	540	6.280±0.627	5.336	8.000	3.655	1.153	129.44
GDP	540	6.899±0.946	5.279	9.514	2.857	0.945	80.87
GDP squared	540	48.502±13.931	27.872	90.527	3.133	1.125	114.43
Panel B: American countries							
CO_2 emissions	533	0.596±0.937	−0.885	2.901	3.167	0.792	56.37
Energy use	533	6.830±0.784	5.402	9.033	4.471	1.395	221.13
GDP	533	8.062±0.867	6.660	10.523	3.840	0.878	84.22
GDP squared	533	65.758±14.690	44.355	110.742	4.591	1.199	184.13
Panel C: Asian countries							
CO_2 emissions	410	0.082±1.255	−3.282	2.950	2.745	0.212	4.18
Energy use	410	6.364±0.910	4.449	8.905	3.304	0.529	20.77
GDP	410	7.003±1.191	5.013	10.495	3.722	1.069	87.04
GDP squared	410	50.463±18.297	25.135	110.156	4.673	1.437	189.00
Panel D: European countries							
CO_2 emissions	533	2.034±0.567	0.293	3.703	4.126	–0.135	29.817
Energy use	533	8.064±0.612	6.307	9.474	3.118	–0.532	25.522
GDP	533	10.052±0.602	8.081	11.382	4.628	–1.075	161.640
GDP squared	533	101.411±11.730	65.309	129.561	4.226	–0.845	96.968
Panel E: MENA countries							
CO_2 emissions	288	1.202±0.863	−0.458	3.005	2.267	0.359	12.628
Energy use	288	6.951±0.845	5.457	8.981	2.488	0.541	17.219
GDP	288	8.028±0.902	6.271	9.998	2.324	0.567	20.939
GDP squared	288	65.265±14.968	39.321	99.977	2.391	0.724	29.657

JB refers to the χ^2 statistic from the Jarque-Bera test of normality, with P values in parentheses, GDP: Gross domestic product, SD: Standard deviation

Table 3: Determinants of CO_2 emissions for Sub-Saharan African countries

Variables	OLS	Quantile regression					Test of symmetry[1]		Test of equality[2]
		q10	q25	q50	q75	q90	q10=q90	q25=q75	
Energy use	1.160*	1.207*	1.305*	1.239*	1.205*	0.930*	6.58*	1.96	12.11*
	(21.85)	(11.73)	(18.53)	(24.32)	(23.63)	(20.81)	(0.010)	(0.162)	(0.000)
GDP	2.911*	3.248*	2.982*	1.654*	2.380*	1.911*	5.70*	1.36	1.99**
	(7.07)	(11.57)	(7.17)	(2.29)	(4.98)	(3.74)	(0.017)	(0.243)	(0.094)
GDP squared	−0.162*	−0.191*	−0.160*	−0.077**	−0.133*	−0.094*	6.14*	0.52	2.14**
	(−5.63)	(−9.00)	(−5.10)	(−1.57)	(−4.05)	(−2.75)	(0.013)	(0.469)	(0.074)
Constant	−20.136*	−22.05*	−21.976*	−16.014*	−17.827*	−14.455*	11.70*	5.34*	3.81*
	(−12.64)	(−18.57)	(−15.84)	(−5.80)	(−10.15)	(−7.36)	(0.000)	(0.021)	(0.004)

The numbers in parentheses are t-statistics computed from heteroskedasticity-robust standard errors. Quantile regression results are based upon 1000 bootstrapping repetitions. The asterisks ** and * denote significance at the 10% and 5% levels, respectively. [1]F-statistic and associated P values for symmetry test. [2]F-statistic and associated P values are reported for the test of equality of the coefficients across quantiles (i.e., q10=q25=q50=q75=q90), OLS: Ordinary least squares, GDP: Gross domestic product

Table 4: Determinants of CO_2 emissions for American countries

Variables	OLS	Quantile regression					Test of symmetry[1]		Test of equality[2]
		q10	q25	q50	q75	q90	q10=q90	q25=q75	
Energy use	1.065*	1.496*	1.298*	1.110*	1.051*	1.017*	42.07*	20.71*	13.29*
	(22.83)	(24.29)	(27.44)	(28.18)	(28.13)	(20.38)	(0.000)	(0.000)	(0.000)
GDP	1.705*	2.407*	2.778*	1.637*	1.346*	0.773*	32.38*	27.43*	18.80*
	(8.45)	(11.75	(17.42)	(8.26)	(5.06)	(3.41)	(0.000)	(0.000)	(0.000)
GDP squared	−0.095*	−0.151*	−0.164*	−0.095*	−0.079*	−0.048*	33.80*	34.59*	17.72*
	(−7.73)	(−11.36)	(−16.04)	(−8.70)	(−6.02)	(−3.60)	(0.000)	(0.000)	(0.000)
Constant	−14.128*	−19.457*	−20.09*	−13.848*	−12.057*	−9.103*	61.02*	47.18*	21.16*
	(−14.71)	(−19.92)	(−26.55)	(−15.43)	(−10.85)	(−8.85)	(0.000)	(0.000)	(0.000)

The numbers in parentheses are t-statistics computed from heteroskedasticity-robust standard errors. Quantile regression results are based upon 1000 bootstrapping repetitions. The asterisks * denotes significance at the 5% level. [1]F-statistic and associated P values for symmetry test. [2]F-statistic and associated P values are reported for the test of equality of the coefficients across quantiles (i.e., q10=q25=q50=q75=q90), OLS: Ordinary least squares, GDP: Gross domestic product

Table 5: Determinants of CO_2 emissions for Asian countries

Variables	OLS	Quantile regression					Test of symmetry[1]		Test of equality[2]
		q10	q25	q50	q75	q90	q10=q90	q25=q75	
Energy use	1.522*	2.043*	1.841*	1.567*	1.422*	1.391*	33.71*	37.22*	14.19*
	(40.72)	(18.24)	(26.16)	(31.42)	(34.95)	(71.83)	(0.000)	(0.000)	(0.000)
GDP	0.807*	1.066*	0.866*	0.356*	0.057	−0.021	5.02*	3.96*	2.15**
	(4.41)	(2.45)	(3.05)	(2.12)	(0.16)	(−0.10)	(0.025)	(0.047)	(0.073)
GDP squared	−0.064*	−0.107*	−0.085*	−0.038*	−0.008	0.006	13.28*	6.28*	4.34*
	(−4.88)	(−3.95)	(−3.94)	(−3.05)	(−0.30)	(0.40)	(0.000)	(0.012)	(0.001)
Constant	−12.026*	−15.344*	−13.599*	−10.447*	−8.746*	−8.508*	14.85*	10.54*	5.26*
	(−17.82)	(−9.48)	(−11.42)	(−14.72)	(−6.85)	(−11.50)	(0.000)	(0.001)	(0.000)

The numbers in parentheses are t-statistics computed from heteroskedasticity-robust standard errors. Quantile regression results are based upon 1000 bootstrapping repetitions. The asterisks ** and * denote significance at the 10% and 5% levels, respectively. [1]F-statistic and associated P values for symmetry test. [2]F-statistic and associated P values are reported for the test of equality of the coefficients across quantiles (i.e., q10=q25=q50=q75=q90), OLS: Ordinary least squares, GDP: Gross domestic product

Table 6: Determinants of CO_2 emissions for European countries

Variables	OLS	Quantile regression					Test of symmetry[1]		Test of equality[2]
		q10	q25	q50	q75	q90	q10=q90	q25=q75	
Energy use	0.812*	0.916*	0.696*	0.730*	1.017*	0.994*	0.65*	29.58*	11.59*
	(19.28)	(9.64)	(11.94)	(10.26)	(29.65)	(56.92)	(0.420)	(0.000)	(0.000)
GDP	1.023*	5.146*	2.359*	1.536**	0.934*	1.668*	18.75*	10.13*	12.88*
	(2.88)	(6.65)	(5.09)	(1.76)	(5.60)	(10.67)	(0.000)	(0.001)	(0.000)
GDP squared	−0.051*	−0.285*	−0.118*	−0.074**	−0.049*	−0.085*	21.10*	7.27*	13.35*
	(−2.75)	(−6.74)	(−4.46)	(−1.68)	(−5.91)	(−11.18)	(0.000)	(0.007)	(0.000)
Constant	−9.560*	−28.484*	−15.450*	−11.724*	−10.408*	−13.828*	14.22*	5.58*	10.79*
	(−5.72)	(−7.63)	(−7.05)	(−3.01)	(−13.43)	(−17.77)	(0.000)	(0.018)	(0.000)

The numbers in parentheses are t-statistics computed from heteroskedasticity-robust standard errors. Quantile regression results are based upon 1000 bootstrapping repetitions. The asterisks ** and * denote significance at the 10% and 5% levels, respectively. [1]F-statistic and associated P values for symmetry test. [2]F-statistic and associated P values are reported for the test of equality of the coefficients across quantiles (i.e., q10=q25=q50=q75=q90), OLS: Ordinary least squares, GDP: Gross domestic product

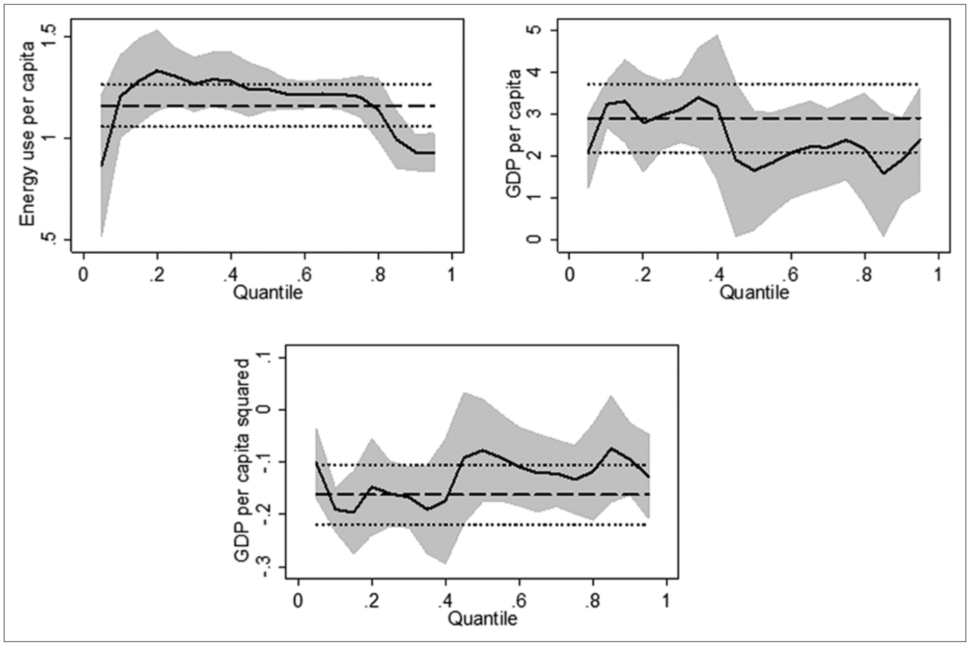
Table 7: Determinants of CO_2 emissions for MENA countries

Variables	OLS	Quantile regression					Test of symmetry[1]		Test of equality[2]
		q10	q25	q50	q75	q90	q10=q90	q25=q75	
Energy use	0.648*	0.962*	0.921*	0.852*	0.629*	0.494*	50.29*	28.05*	13.73* (0.000)
	(12.35)	(29.99)	(39.60)	(39.34)	(10.49)	(7.79)	(0.000)	(0.000)	
GDP	0.485**	0.831*	0.484*	0.488*	0.563*	0.966*	0.14	0.07	1.08 (0.365)
	(1.93)	(3.79)	(1.98)	(2.24)	(1.98)	(3.14)	(0.713)	(0.791)	
GDP squared	−0.007	−0.051*	−0.026**	−0.020	−0.011	−0.028	1.12	0.67	1.35 (0.252)
	(−0.52)	(−3.61)	(−1.74)	(−1.43)	(−0.68)	(−1.58)	(0.291)	(0.413)	
Constant	−6.690*	−9.028*	−7.507*	−7.376*	−6.809*	−7.899*	0.74	0.42	1.14 (0.336)
	(−6.68)	(−9.78)	(−7.85)	(−8.37)	(−6.76)	(−7.95)	(0.391)	(0.518)	

The numbers in parentheses are t-statistics computed from heteroskedasticity-robust standard errors. Quantile regression results are based upon 1000 bootstrapping repetitions. The asterisks ** and * denote significance at the 10% and 5% levels, respectively. [1]F-statistic and associated P values for symmetry test. [2]F-statistic and associated P values are reported for the test of equality of the coefficients across quantiles (i.e., q10=q25=q50=q75=q90), OLS: Ordinary least squares, GDP: Gross domestic product

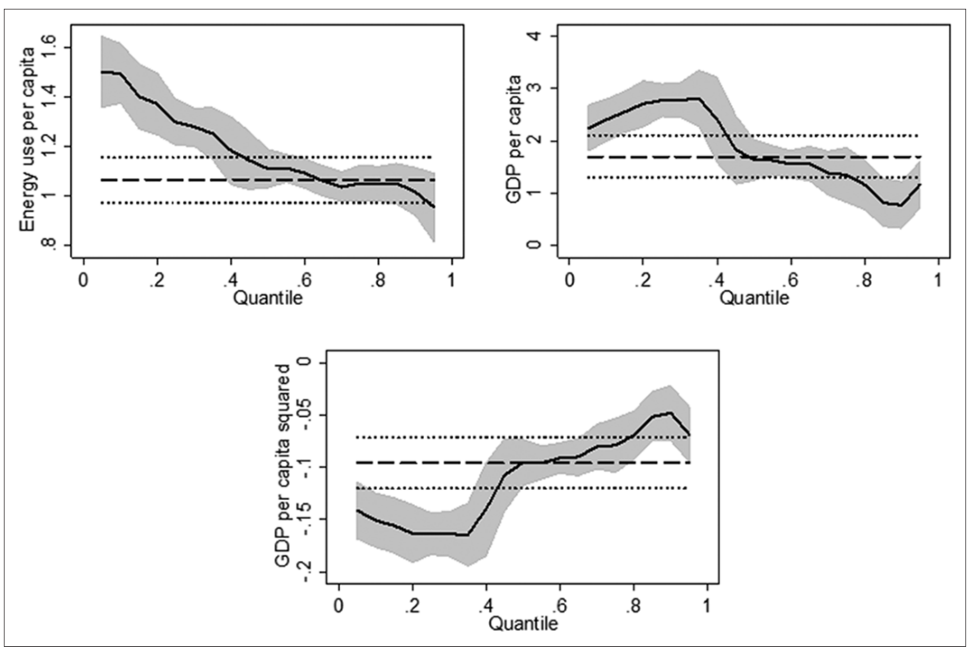
heteroskedasticity-robust estimates, we report robust t-statistics for OLS estimates and quantile regression results from 1000 bootstrapping repetitions. Figures 1-5 represent the effects of income and energy use across the CO_2 emissions distribution.

Figure 1: Ordinary least squares and quantile regression estimates over the conditional quantiles of CO2 emissions: Evidence for Sub-saharan African countries



Source: The x-axis represents the conditional quantile of CO_2 emissions. The horizontal dashed line represents the OLS estimates. The two dotted lines depict the 95% confidence intervals for the OLS estimates. The solid line represents the quantile regression estimates; and the shaded grey area plots the 95% confidence band for the quantile regression estimates

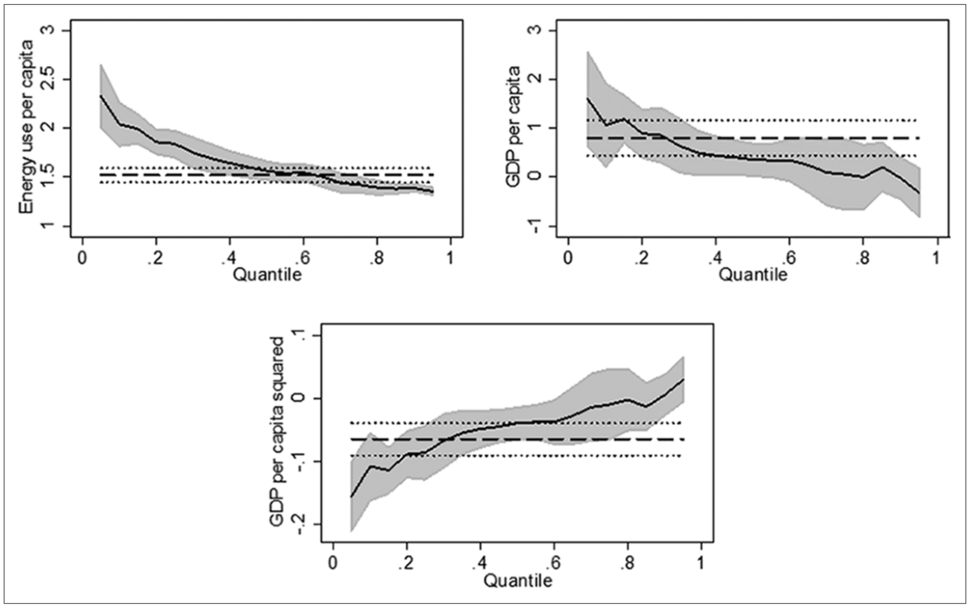
Figure 2: Ordinary least squares and quantile regression estimates over the conditional quantiles of CO2 emissions: Evidence for American countries



Source: The X-axis represents the conditional quantile of CO_2 emissions. The horizontal dashed line represents the ordinary least squares estimates (OLS). The two dotted lines depict the 95% confidence intervals for the OLS estimates. The solid line represents the quantile regression estimates; and the shaded grey area plots the 95% confidence band for the quantile regression estimates

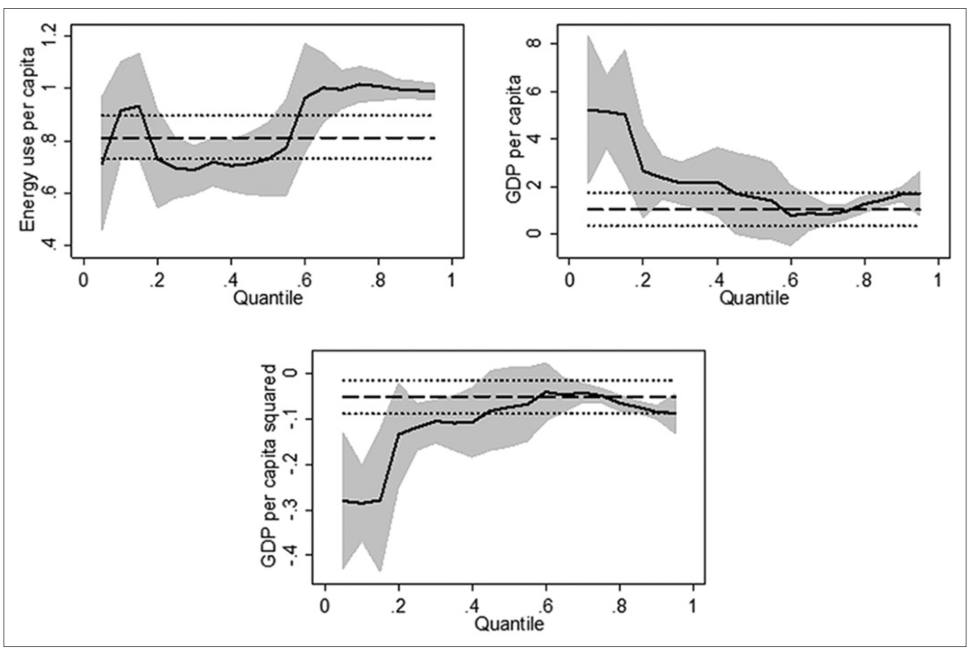
First note the OLS results. As expected, energy consumption has positive impact on CO_2 emissions in all panels, which is consistent with previous studies (Liu, 2005; Ang, 2007; Apergis and Payne, 2009). Further, except for MENA countries, the estimated coefficients on income per capita and squared income per capita are both significant with a positive and negative sign, respectively. This result gives a support for the EKC hypothesis that the level of CO_2 emissions initially increases with income, until it reaches a threshold level, then it declines. Hence, beyond a threshold level of real output, an increase in per capita GDP reduces emissions

Figure 3: Ordinary least squares and quantile regression estimates over the conditional quantiles of CO2 emissions: Evidence for Asian countries



Source: The X-axis represents the conditional quantile of CO_2 emissions. The horizontal dashed line represents the ordinary least squares (OLS) estimates. The two dotted lines depict the 95% confidence intervals for the OLS estimates. The solid line represents the quantile regression estimates; and the shaded grey area plots the 95% confidence band for the quantile regression estimates

Figure 4: Ordinary least squares and quantile regression estimates over the conditional quantiles of CO2 emissions: Evidence for European countries

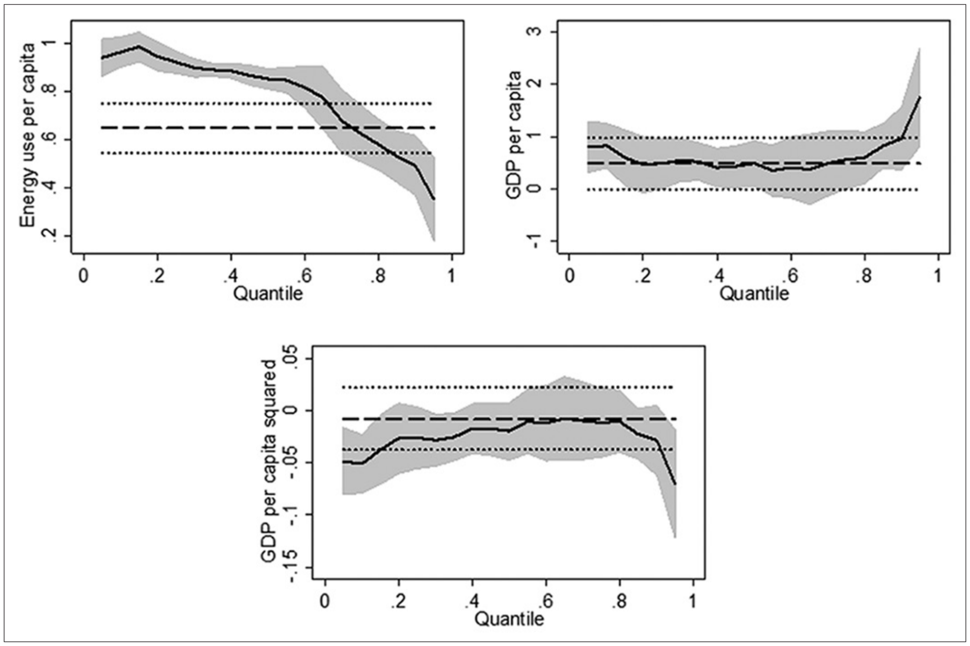


Source: The X-axis represents the conditional quantile of CO_2 emissions. The horizontal dashed line represents the ordinary least squares (OLS) estimates. The two dotted lines depict the 95% confidence intervals for the OLS estimates. The solid line represents the quantile regression estimates; and the shaded grey area plots the 95% confidence band for the quantile regression estimates

as the demand for environmental quality increases and these economies grow.

The quantile regression results suggest some important differences across different points in the conditional distribution of CO_2 emissions. Energy consumption increases pollution in all quantile levels and its impact decreases with the pollution level in American, Asian and MENA countries, suggesting that the effect of energy consumption is larger in low-pollution countries. This result implies that more energy conservation policies will help to reduce CO_2 emissions. It also implies that as incomes grow, in the absence of energy conservation policies, pollution will increase.

Figure 5: Ordinary least squares and quantile regression estimates over the conditional quantiles of CO2 emissions: Evidence for MENA countries



Source: The X-axis represents the conditional quantile of CO_2 emissions. The horizontal dashed line represents the ordinary least squares (OLS) estimates. The two dotted lines depict the 95% confidence intervals for the OLS estimates. The solid line represents the quantile regression estimates; and the shaded grey area plots the 95% confidence band for the quantile regression estimates

With respect to the effect of per capita GDP, the results show that the EKC hypothesis holds for four panels, but not consistently throughout the conditional distribution of CO_2 emissions. In particular, the EKC hypothesis holds for Sub-Saharan African, American and European countries at all quantile levels, whereas it holds for Asian and MENA countries with lower levels of CO_2 emissions. For Asian and MENA countries at the right tail of the distribution of CO_2 emissions, the coefficients on income and its square are insignificant. This means that economic growth is good for the environment for Asian and MENA countries that have a low level of pollution. If Asian and MENA countries with high levels of pollution are to reduce their emission levels, they have to sacrifice their economic growth.

4. CONCLUSION

The EKC hypothesis has been a widely tested hypothesis in the energy economics literature over the past decades. However, previous studies focused only on mean effects and have not yet examined the role of pollution levels in the income-pollution nexus. This short paper uses quantile regression to reexamine whether CO_2 emissions are linked to per capita GDP in a way that is described by the EKC. The empirical analysis has been conducted for five panels of 59 countries.

The results suggest that energy use and income may have significant effects at points in the conditional distribution of CO_2 emissions other than the mean. In essence, our findings indicate where energy use and income may matter, not just whether or not they matter on average. We found that energy consumption tends to increase CO_2 emissions in all panels, the effect being larger in low pollution countries. This suggests that energy conservation policies in low pollution economies may be more beneficial for the environment. The results also provide evidence supporting the EKC hypothesis for Sub-Saharan, American, and European countries at all quantiles. Also, the EKC hypothesis holds for Asian and MENA countries with lower levels of CO_2 emissions. This means that economic growth is good for the environment for Sub-Saharan, American, and European countries and for Asian and MENA countries that have a low level of pollution. These findings give some hope that economic growth can help to reduce CO_2 emissions. They also suggest that economic growth is not always and everywhere the cause and the cure of pollution. A growing per capita income will reduce pollution in Sub-Saharan, American and European countries as well as in Asian and MENA countries with lower levels of pollution. Asian and MENA countries with high levels of pollution should do more to reduce their carbon emissions by adopting more strict environmental and energy policies, increasing the infrastructure for energy efficiency and improving the use of alternative sources of energy that are relatively free from pollutant emissions.

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