Investigating the shape of the Environmental Kuznet's Curve

Introduction

Global warming and climate change has been a leading concern for scientists, economists, policymakers for the past two decades. The Intergovernmental Panel on Climate Change (IPCC) establishes global warming as the most alarming environmental phenomenon. The regulation of Carbon dioxide emissions is a detrimental intergovernmental issue because carbon dioxide is recognized as the primary greenhouse gas leading to global warming (IPCC, 2007). In the "pollution-economics" nexus, the relationship between environmental degradation and economic growth is referred to as the "Environmental Kuznet's Curve" (EKC). Scientists have started to rely on the importance of EKC to decode the impact of energy consumption on the environment in the pathway of attaining sustainable development (Aruga, 2019).

Grossman and Kreuger proposed the idea of an EKC which hypothesizes that there is an inverted U shaped relationship between environmental degradation and economic growth (Grossman and Kreuger, 1991). Initially as per capita income increases environmental degradation increases until it reaches a "turning point". As the economy keeps on growing, there is a greater demand for environmental quality which decreases environmental degradation (Hussen, 2005). This further could lead to the generalization that countries who strive to secure higher levels of economic growth will be rewarded with greater environmental quality (Beckerman, 1992). The strong conclusions drawn by researchers regarding the inverted U hypothesis suggests that the quality of the environment is dependent on economic growth. This places a strong emphasis on pursuing economic growth solely rather than focusing on policies to combat environmental degradation in order jointly achieve economic and environmental objectives (Elkins, 1997). Different authors have contested the idea of the "inverted U hypothesis" and concluded that the relationship could be "N shaped" where environmental degradation exuberates again at higher levels of income (Bhattarai et al. 2009; Álvarez-Herranz and Balsalobre Lorente 2016). This indicates when the economy grows beyond the carrying capacity of the environment the turning point of the inverted U shaped curve might never be reached. Thus cities experiencing rapid economic growth rates must take careful consideration of the relationship between economic growth and the environment (Gao et al, 2017).

Literature Review

The idea of the inverted U shaped EKC curve was further confirmed by different researchers. Al-Mulali et al, (2016) used dynamic OLS to find the relationship between between environmental degradation and income for Europe, East Asia and the Pacific, South Asia and the Americas (Al Mulali et al, 2016). A fixed effects panel model (FEM) was also employed by Farhani. Meizak, Chaibi and Rault (2014) and they found an inverted U shaped relationship between environmental degradation and income. Culas (2012) found the inverted U shaped EKC for 9 Latin American countries by using a random effects model (REM).

N shaped curved was also studies by various authors. A fixed effects model of a panel data were used by Poudel, Paudel and Bhattarai, 2009 to determine the relationship between CO2 emissions and per capita income in Latin American Country and Carribean countries. They found the existed of an N shaped curve. Moomaw and Unruh (1997) find the existence of an N shaped EKC using both FEM and cross sectional methods (Moomaw and Unruh, 1997).. Allard (2018) employed POLS, FEM and quantile regression methods to study the relationship between income and CO2 emissions of high income, upper middle income and lower income groups. The results were inconclusive. He concluded that an N shaped EKC is derived through majority of the statistically significant results. However the results are heterogenous (Allard, 2018).

Different authors employed a dynamic panel data approach (Liu, 2005 ; Omri, 2013 ; Omri et al, 2014) by using the lagged emissions as a regressor. They employed the GMM method formulated by Arellano and Bond (1991) which accounts for dynamism and endogeneity. Chakravarty and Mandal (2016) used a dynamic quadratic model to determine the relationship between CO2 and emissions using BRICs economies for the years 1997-2011. They found the existence of an inverted U shaped EKC using the GMM model but not the FEM model (Chakravarty and Mandal, 2016)

Data

The sample consists of panel data of 129 countries spanning the years 1990-2017. The data consists of 4 income groups : high, low, upper middle and lower middle income . These classifications are according to the World Bank's World Development Indicators (WDI). The variables included in the study : per capita carbon dioxide (CO2) emissions, real GDP per capita and the urban population (% of total population). Data for per capita CO2 emissions was obtained from the Global Carbon Project, Carbon dioxide Analysis Centre and GAP Minder and UN population estimates. The rest of the variables were downloaded from the WDI obtained from the World Bank.

The variable CO2 serves as a proxy for environmental degradation. A production based approach to calculated through the use of this variable because it does not calculate from imports and does not deduct from exports. This variable is measured in metric tons thus this helps to accommodate the impact of population growth on the pollution level. The variable real GDP per capita is used to calculate the effect of economic growth on environmental degradation.

Descriptive Statistics

Figure 1 describes descriptive statistics of dependent and the independent variables for the total of 129 countries spanning 28 years. All the variables are expressed in natural logarithm to reduce heteroscedasticity : *LCO2, LGDP, LURBAN.*

The variable *LURBAN* has the most skewness to the left while *LCO2* has some skewness to right. A skewness of +- 2 from the normal distribution is deemed acceptable (Allard, 2018). A normal distribution has a kurtosis of 3, however our variables have kurtosis ranging from -0.05 to 0.46.

Figure 1: Descriptive Statistics

	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
LCO2	1	4062	1.26	0.93	1.08	1.19	1.14	0.00	4.22	4.22	0.46	-0.78	0.01
LGDP	2	4062	8.81	1.26	8.84	8.82	1.52	5.51	11.73	6.22	-0.05	-0.85	0.02
LURBAN	3	4062	3.87	0.53	3.99	3.93	0.52	1.69	4.61	2.92	-0.90	0.31	0.01

Methodology

Grossman and Kreuger (1991) and Stern (2004) deduced the relationship between environmental degradation as the following :

$$GHG_{it} = \alpha + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_2 GDP_{it}^3 + \ + \beta_2 Z_{it} + \varepsilon_{it}$$

GHG is greenhouse gas emissions in country i and year t. GDP is GDP per capita in country i and year t. α calculates the mean environmental pressure when GDP has no effect. Z_{it}contains a set of variables which might affect the environmental quality. εit is the random error term. β are slope parameters that determines the significance and direction of the exogenous variable.

The error term ε_{it} can be decomposed as the following :

$\varepsilon_{it} = \mu_i + \delta t + e_{it}$

The component μ_i represents the "non-observable effects" that do not change over time but they vary between countries. The component e_{it} is a random error term. If we consider $d_t = 0$, and a fixed effect is applied to the μ_i for each country, then a linear model is deduced for each country such that the intercept is specific to each country. Changes between countries but not time are accounted for by treating μ_i I as a random, non observable component (Álvarez-Herranz and Balsalobre Lorente 2016).

Scholars often argue about whether to choose fixed effects or random effects as their mode of analysis. It is important to consider different factors. For a fixed effects model the "non observed heterogeneity" is included in the intercept term, this changes the expected value of the dependent variable. The external aspects of each country's pathway of economic growth that impacts the environmental degradation variable are represented through the country specific intercept. Greene argues that the fixed effects model can be used when the differences between the units of measurement(countries) can be explained as "parametric shifts of the regression function" (Greene, 1999).

In the random effects model the error term comprises of the unobservable differences which alters the variance of the model (Greene, 1999). The random and fixed effects models focuses on calculating the "rate of change in the conditional mean" of greenhouse gas emissions but they ignore the country level heterogeneity. Thus this could have implications regarding largely heterogeneous country specific data sets. (Yaduma et al, 2015). Cole, 2003 and Lee at al, 2003 noted that using fixed and random effects model poses problems such as heterogeneity and more importantly endogeneity. Thus this could hinder the analysis in determining the true relationship between carbon dioxide emissions and economic growth (Cole, 2003; Lee et al, 2013). We reproduced the static model used in earlier studies to draw comparisons of the derived EKC.

The static model used in the study is :

$$CO_{2it} = \alpha + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_3 GDP_{it}^3 + \beta_4 Urban_{it}$$

Where i and t are indexes for country and time respectively. The logarithm of all the variables will be used.

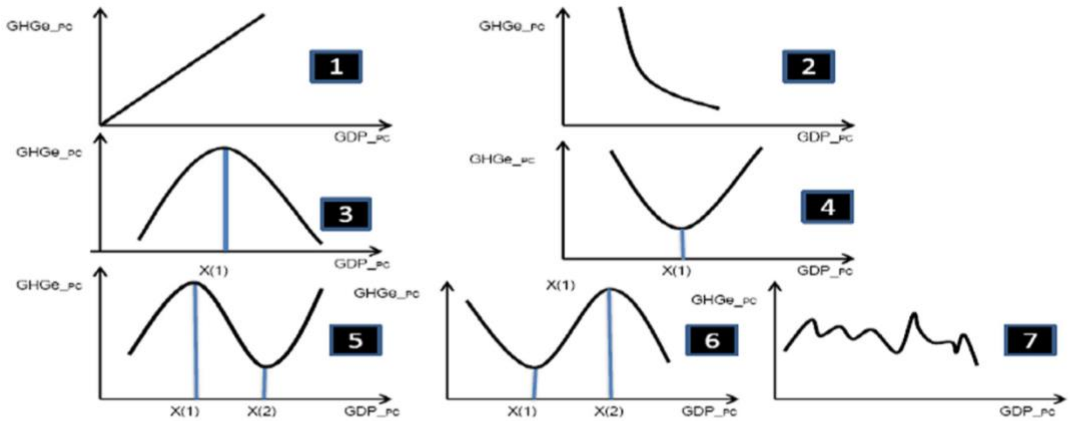
The complex interplay between carbon dioxide and economic growth is dynamic rather than static (Carson 2010; Dinda, 2004). A static model is unable to capture the "feedback effect" between environmental degradation and income and the dynamic nature of CO2 emissions (Chakravarty and Mandal, 2016).There is endogeneity in the model because the environmental quality of today is associated with that of yesterday. Thus a lagged dependent variable needs to be used as a regressor to resolve this issue. The strict exogeneity assumption of a FEM, REM and pooling model is violated if a lagged dependent variable is added as a regressor. Thus a simple instrumental variable procedure or the Generalized Method of Moments (GMM) procedure is appropriate while using lagged dependent variables as regressors (Wooldridge, 2007). The dynamic GMM model has been used to resolve endogeneity issues and maintain consistency and accuracy. . The GMM works under the premises that all the regressors other than the lagged dependent variable are endogenous and function as valid instruments. Thus the GMM method works to build efficiency and eliminate heteroskedasticity (Beck and Joshi, 2015). The dynamic panel data model suggested by Halkos, 2003 and Taguchi, 2012 allow for inertia in the emission level such that there is no rapid adjustment between GDP and emission level. The following model will be used

$$CO_{2it} = \alpha + \beta_1 LGDP_{it} + \beta_2 GDP_{it}^2 + \beta_3 GDP_{it}^3 + \beta_4 Urban_{it} + \beta_5 CO_{2\,it-1}$$

Where i and t are indexes for country and time respectively. The logarithm of all the variables will be used.

Hypothesis

Depending on the slope of the B parameters the Kuznet's curve will adopt different shapes such as (Álvarez-Herranz and Balsalobre Lorente 2016):



(i) $\beta_1 > 0$, $\beta_2 = \beta_3$ monotonically increasing relationship between income and environmental degradation such that increases in income in associated with increases in environmental degradation.

(ii) $\beta_1 < 0$, $\beta_2 = \beta_3$, monotonically decreasing relationship such that increases in income is associated with decreases in environmental degradation

(iii) $\beta_1 > 0$, $\beta_2 < 0$ $\beta_3 = 0$, quadratic relationship (inverted U pattern) such that increases in income is associated with decreases in environmental degradation after a certain level of income has been achieved.

(iv) $\beta_1 < 0$, $\beta_2 > 0$ $\beta_3 = 0$, quadratic relationship (U pattern) such that the results are in contrast to the EKC hypothesis

(v) $\beta_1 > 0$, $\beta_2 < 0$ $\beta_3 > 0$, cubic polynomial (N shaped) such that the inverted U hypothesis holds till a certain level of income, then environmental degradation increases.

(vi) $\beta_1 < 0$, $\beta_2 > 0$ $\beta_3 < 0$, cubic polynomial (inverted N shaped) such that the U pattern holds till a certain level of income, then environmental degradation decreases.

$\beta_1 = 0$, $\beta_2 = 0$ $\beta_3 = 0$, no relationship between income and environmental degradation (Álvarez-Herranz and Balsalobre Lorente 2016).

Discussions

The results for the pooled OLS, FEM and REM estimations for the balanced panel in Table 2. The FEM and REM estimations are fixed over countries and time periods.

Figure 2: Output for the whole Sample

FEM, POLS vs REM for the whole sample

	Dependent variable:		
	LCO2		
	FEM	POLS	REM
	(1)	(2)	(3)
LGDP	-6.248***	-6.719***	-6.917***
	(0.279)	(0.625)	(0.306)
LGDP_2	0.780***	0.773***	0.846***
	(0.032)	(0.073)	(0.036)
LGDP_3	-0.030***	-0.027***	-0.033***
	(0.001)	(0.003)	(0.001)
LURBAN	0.197***	0.206***	0.133***
	(0.029)	(0.020)	(0.029)
Constant		17.840***	18.529***
		(1.767)	(0.863)
Observations	3,612	3,612	3,612
R2	0.399	0.807	0.391
Adjusted R2	0.372	0.807	0.390
F Statistic	573.914*** (df = 4; 3452)	3,780.811*** (df = 4; 3607)	2,311.653***
Note:			*p<0.1; **p<0.05; ***p<0.01

The POLS FEM and REM estimation supports the hypothesis that the relationship between CO2 emissions and GDP is inverted N shaped. Thus the coefficient for GDP, GDP squared and GDP cubed is significantly negative, positive and negative, respectively. Different factors such as being a well endowed and educated country is correlated with GDP. The inverted N shaped curve obtained by pooled OLS and FEM models are consistent with the results of Yaduma et al, 2015. For the FEM , if GDP is increased by 1% then carbon dioxide emissions decreases by ~5.50% overtime on average per country. For the REM, when GDP increases across time and between countries by 1% CO2 emissions decreases by ~6.10 %. For the pooled OLS model when GDP increases by 1%, CO2 emissions decreases by ~5.73%. The F test comparing the pooling model and FEM is displayed in figure 3.

Figure 3: Redundancy F Test

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        F test for twoways effects

data:  LCO2 ~ LGDP + LGDP_2 + LGDP_3 + LURBAN
F = 246.33, df1 = 155, df2 = 3452, p-value < 2.2e-16
alternative hypothesis: significant effects
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The null hypothesis for the redundancy F test is that the pooling model is better than the FEM (Croissant and Milo, 2008). The low p value shows that we reject the null at 1% significance level and conclude that FEM model is appropriate for the sample set. The Hausman test is displayed in figure 4 :

Figure 4 : Hausman Test

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        Hausman Test

data:  LCO2 ~ LGDP + LGDP_2 + LGDP_3 + LURBAN
chisq = 299.29, df = 4, p-value < 2.2e-16
alternative hypothesis: one model is inconsistent
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The null hypothesis for the Hausman test is that the model is consistent and the preferred model is the REM. The low p value suggests that we reject the null at 1% significance level and conclude that the FEM is appropriate for the sample.. For all the three models LGDP, LGDP^2 and LGDP^3 are significant. The LURBAN variable is significant and positive for all the models. For FEM model. Increasing urbanization by 1% will cause emissions to increase by 0.197% overtime on average per country. Going forward we assume homoscedasticity to investigate the shape of the EKC using both the FEM and the GMM models.

We test the sensitivity of the FEM estimations against a GMM model by incorporating endogeneity.

Figure 5: FEM vs GMM for the Whole Sample

FEM vs GMM Model

	Dependent variable:	
	LCO2	
	panel linear	panel GMM
	(1)	(2)
lag(LCO2)		0.675***
		(0.036)
LGDP	-6.248***	-2.074*
	(0.279)	(1.237)
LGDP_2	0.780***	0.269*
	(0.032)	(0.146)
LGDP_3	-0.030***	-0.011*
	(0.001)	(0.006)
LURBAN	0.197***	0.054
	(0.029)	(0.047)

The significant and positive lagged CO2 (lagged dependent variable) in the GMM estimation suggests that high CO2 emissions from the past affects the future. Thus there is some endogeneity in the model. The coefficients of GMM's GDP, GDP squared and GDP cubed variables are significantly negative, positive and negative respectively suggesting an inverted N shaped EKC. The signs of the coefficients are the same for both the models. However the magnitude of the coefficient are quite different. After the GMM model corrects for endogeneity, an increase in 1% of the GDP variable leads to a decrease of ~1.82% of the CO2 emissions. The magnitude of this value is much lower compared to the FEM model discussed previously. The Urban variable is not significant in the GMM model. One possible explanation for the differences between the models is the dynamic specification captured by the lagged dependent variable. The sargan test has a null hypothesis that the moment of method conditions

satisfied. As the p value is 1, we fail to reject the null and conclude that the method of moment conditions are satisfied.

Then we divide the sample into different income groups : low income, lower middle income, upper middle income and high income. Then we ran FEM and GMM regressions moving forward (Figure 6 and Figure 7).

Figure 6 : The FEM Estimations for Different Income Groups

FEM for Different Income Groups

	Dependent variable: LCO2				
	Whole Sample (1)	High Income (2)	Low Income (3)	Upper Middle Income (4)	Lower Middle Income (5)
LGDP	-6.248***	13.432***	2.838*	-4.251**	0.373
	(0.279)	(4.651)	(1.644)	(1.684)	(1.917)
LGDP_2	0.780***	-1.112**	-0.442*	0.511***	-0.102
	(0.032)	(0.464)	(0.241)	(0.195)	(0.241)
LGDP_3	-0.030***	0.030*	0.024**	-0.018**	0.008
	(0.001)	(0.015)	(0.012)	(0.007)	(0.010)
LURBAN	0.197***	-0.236**	0.095***	0.247***	0.360***
	(0.029)	(0.117)	(0.022)	(0.060)	(0.050)
Observations	3,612	1,036	560	1,092	896
R2	0.399	0.219	0.218	0.555	0.316
Adjusted R2	0.372	0.165	0.141	0.524	0.266
F Statistic	573.914*** (df = 4; 3452)	67.929*** (df = 4; 968)	35.439*** (df = 4; 509)	318.032*** (df = 4; 1022)	96.388*** (df = 4; 833)

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

Figure 7: GMM Estimations for Different Income Groups

GMM for Different Income Groups

	Dependent variable:			
	LCO2			
	Whole Sample	High Income	Upper Middle Income	Lower Middle Income
	(1)	(2)	(3)	(4)
lag(LCO2)	0.675***	0.724***	0.579***	0.776***
	(0.036)	(0.040)	(0.071)	(0.053)
LGDP	-2.074*	15.093**	-4.185	2.619
	(1.237)	(7.327)	(7.592)	(3.100)
LGDP_2	0.269*	-1.441**	0.532	-0.327
	(0.146)	(0.724)	(0.865)	(0.387)
LGDP_3	-0.011*	0.046*	-0.021	0.014
	(0.006)	(0.024)	(0.033)	(0.016)
LURBAN	0.054	-0.044	0.360**	0.112
	(0.047)	(0.155)	(0.144)	(0.082)

For the GMM the whole sample and for FEM, the whole sample and the upper middle income group follow the inverted N shaped pattern. Here the coefficients of the GDP, GDP squared and GDP cubed variables are significantly negative, positive and then negative. The highest R squared among the different groups using FEM is that of the upper middle income group. The upper middle income represent a larger portion of the data compared to the low income and lower middle income countries. This could show why the whole sample follows the same pattern as that of the upper middle income countries for FEM. An economy follows an inverted N shaped relationship economic growth and environmental degradation when economic growth causes environmental problems to decrease till a certain turning point is reached (U shaped curve), initially. Then, economic growth intensifies environmental issues till a turning point is reached when the environmental quality starts improving(Gao et al, 2017). The high income countries follow an N shaped pattern for both FEM and GMM. Here the coefficients of the GDP, GDP squared and GDP cubed variables are significantly positive, negative and then positive.Similar results were found by Özokcu and Özlem, 2017, on a panel of 26 high income OECD countries. Developing environmental friendly pathways do not led to an increase in

environmental quality. Even though countries with greater levels of income would be the closest to reaching their turning points (inverted U shaped hypothesis), results show that they follow do not follow this pattern. Important factors to consider here are the irreversible damage and resilience capacity of the environment. Thus the turning points cannot be reached even if high income levels are reached due to irreversible damage to the environment (Özokcu and Özlem, 2017). This shows the countries with higher levels of income could follow an N shaped EKC. The low income group follows an inverted N shaped hypothesis for the FEM. The coefficients of GDP, GDP squared and GDP cubed are significantly positive, negative and then positive. This might be due to the consumption pattern of households. As the demand for environmental quality increases, the price increases. This causes households with lower incomes to substitute from green products that ensure environmental quality to products that are harmful for the environment. For countries with low income the substitution effect is larger than the income effect, and for countries with high incomes income effect is superior to the substitution effect (Shibayama and Fraser, 2014). The GDP variable for the upper income group being statistically significant in the FEM and insignificant in the GMM model could be due to the significant dynamic specification captured by the lagged dependent variable. For upper middle income countries, initially high energy efficiency offsets the "scale effect" causing emissions to decrease. Then, as the economy improves, the country's trade and technological infrastructure leads to an influx of foreign direct investment and technology from high income countries. Thus technological frontiers outweighs the scale effect. This could show high income and middle income countries have different EKCs (Allard, 2018). Thus this shows that an influx of technological factors exacerbates the endogenous nature of the carbon dioxide emissions. the Urbanization is a positive and significant variable in all the groups other than the high income group in both the FEM and GMM. The estimations of the GDP variable for the FEM and GMM are not significant for the lower middle income group. The heteroskedasticity in the lower middle income group could have eliminated the significance of the GDP variable. Both the one step GMM and FEM model assumes homoscedasticity (Allard, 2018). Thus a more robust estimation procedure need to be used.

The urban variable is statistically significant and positive for all the groups except the high income group for FEM. For GMM, only the upper middle income group has a statistically significant and positive for the upper middle income. The positive and negative relationship between CO2 emissions and urbanization has been widely studied. Tupy identified that urbanization could lead to high efficiency in resource consumption which causes an improvement in environmental quality. High income countries with highly developed urban areas have higher access to environmentally friendly resources such as public facilities which decreases environmental degradation (Tupy, 2017). Several studies have confirmed a positive relationship between CO2 emissions and urbanization. Thus the positive coefficient of the urban variable makes sense in the light of low income, lower middle income and upper income countries. This is because the urban areas in these groups do not have access to resource efficient urban hubs. Katircioglua and Katirgcioglub studied the role of urbanization in Turkey's environmental degradation. They concluded that energy consumption leads to urban development is a key method of CO2 emissions (Katircioglua and Katirgcioglub, 2015). Wu et al showed that the urbanization process itself leads to high levels of CO2 in the atmosphere (Wu et al, 2017). Thus this explains the reasons as to why the urbanization variable is positive or negative for different groups.

The results shown by using the POLS, FEM, REM and GMM models are inconclusive in deciding the pattern that the EKC curve follows. However majority of the regressions ran using the FEM and GMM support an N shaped EKC. Thus it is difficult to draw comparison between studies.

Conclusion and Policy Implications

The main objective of this study was to decode the relationship between environmental degradation and economic growth including variables linked to environmental degradation such as urbanization.

This study used a panel estimation of 129 countries in the years 1990-2017. Static panel data models including the fixed effects, pooled OLS and random effects were used. To account for endogeneity, the dynamic panel estimation method of GMM was used.

The pooled OLS estimator, the fixed effects model, the random effects model and the GMM model of the whole sample show evidence of a inverted N shaped EKC. This indicates that when economic growth increases in the first stage, CO_2 emissions decreases till the first turning point. Then the economies experience a change in their CO_2 emissions. In the second stage CO_2 emissions begin to increase in the second stage till reaching a second turning point. Then the economies again experience a decrease in emissions. Inclusion of energy innovation and renewable energy methods will decrease the scale effect which causes CO_2 emissions to decrease after the second turning point. The previous notion of increasing economic growth to decrease emissions is strongly rejected in our study because the pathway to better environmental quality should include environmental friendly studies. The results suggests policies that promote energy innovate could led to a decrease in emissions (Álvarez-Herranz and Balsalobre Lorente 2016).

The FEM and GMM estimations of the high income, low income upper middle and lower middle income groups have inconclusive results regarding the shape of the EKC. The inconclusive results regarding the shape of the EKC of different income groups might be due to heterogeneity which exists across within and across income groups of countries. The results indicate that policies need to be country specific or income group specific. Thus the intensity and economic growth levels of each country and income group must be thoroughly examined Middle income and high income countries have different emitting and growth patterns, thus implementing the same policies to both the groups would be inefficient (Allard, 2018).

The GMM estimations contain a lagged dependent variable which is significant across all groups. This indicates that adaptation between GDP and CO_2 emissions is not rapid, however there lies stagnancy (Taguchi, 2012). Even though the GDP, GDP squared and GDP cubed variables are negative, positive and then negative for the FEM and GMM estimations. There are differences in the magnitude of these coefficients indicating the importance of the econometric specification and technique used in studying the dynamic nature of the CO2 emissions and GDP.

The urbanization variable was positive for the whole sample, lower middle and upper middle income groups while it was negative for the high income groups in both the FEM and GMM estimations. It was only significant for the upper middle income group for GMM, while it was significant for all groups using the FEM. Policymakers should include urbanization in their environmental policies mainly for middle income and lower income groups because the allocation of their resources to energy efficient technologies such as public transport is undeveloped (Tupy, 2017). Thus relying on energy efficient technologies in urban areas could improve the environmental quality in low income and middle income countries.

Works Cited

Al-Mulali, Usama, et al. "Investigating the Environmental Kuznets Curve Hypothesis in Seven Regions: The Role of Renewable Energy." *Ecological Indicators*, vol. 67, 2016, pp. 267–282., doi:10.1016/j.ecolind.2016.02.059.

Alam, Md. Mahmudul, et al. "Economic Growth; CO2 Emissions; Population Growth; Energy Consumption; Environmental Kuznets Curve, Brazil, China, India, Indonesia." 2019, doi:10.31235/osf.io/8hq6z.

Allard, Alexandra, et al. "The N-Shaped Environmental Kuznets Curve: an Empirical Evaluation Using a Panel Quantile Regression Approach." *Environmental Science and Pollution Research*, vol. 25, no. 6, 2017, pp. 5848–5861., doi:10.1007/s11356-017-0907-0.

Bhattacharya, Mita. "The Environmental Kuznets Curve." *Environmental Kuznets Curve (EKC)*, 2019, pp. 9–14., doi:10.1016/b978-0-12-816797-7.00002-3.

Culas, Richard J. "REDD and Forest Transition: Tunneling through the Environmental Kuznets Curve." *Ecological Economics*, vol. 79, 2012, pp. 44–51., doi:10.1016/j.ecolecon.2012.04.015.

Ekins, P. "The Kuznets Curve for the Environment and Economic Growth: Examining the Evidence." *Environment and Planning A: Economy and Space*, vol. 29, no. 5, 1997, pp. 805–830., doi:10.1068/a290805.

Farhani, Sahbi, et al. "The Environmental Kuznets Curve and Sustainability: A Panel Data Analysis." *Energy Policy*, vol. 71, 2014, pp. 189–198., doi:10.1016/j.enpol.2014.04.030.

Greene, William H. *Análisis econométrico*. Prentice Hall, 1997.

Grossman, Gene, and Alan Krueger. "Environmental Impacts of a North American Free Trade Agreement." 1991, doi:10.3386/w3914.

Hübler, Michael. "The Inequality-Emissions Nexus in the Context of Trade and Development: A Quantile Regression Approach." *Ecological Economics*, vol. 134, 2017, pp. 174–185., doi:10.1016/j.ecolecon.2016.12.015.

Jebli, Mehdi Ben, and Slim Ben Youssef. "The Environmental Kuznets Curve, Economic Growth, Renewable and Non-Renewable Energy, and Trade in Tunisia." *Renewable and Sustainable Energy Reviews*, vol. 47, 2015, pp. 173–185., doi:10.1016/j.rser.2015.02.049.

Katircioğlu, Setareh, and Salih Katircioğlu. "Testing the Role of Urban Development in the Conventional Environmental Kuznets Curve: Evidence from Turkey." *Applied Economics Letters*, vol. 25, no. 11, 2017, pp. 741–746., doi:10.1080/13504851.2017.1361004.

Liu, Xuemei. "Explaining the Relationship between CO2 Emissions and National Income—The Role of Energy Consumption." *Economics Letters*, vol. 87, no. 3, 2005, pp. 325–328., doi:10.1016/j.econlet.2004.09.015.

Lorente, Daniel Balsalobre, and Agustín Álvarez-Herranz. "Economic Growth and Energy Regulation in the Environmental Kuznets Curve." *Environmental Science and Pollution Research*, vol. 23, no. 16, 2016, pp. 16478–16494., doi:10.1007/s11356-016-6773-3.

Moomaw, William R., and Gregory C. Unruh. "Are Environmental Kuznets Curves Misleading Us? The Case of CO2 Emissions." *Environment and Development Economics*, vol. 2, no. 4, 1997, pp. 451–463., doi:10.1017/s1355770x97000247.

Omri, Anis. "CO2 Emissions, Energy Consumption and Economic Growth Nexus in MENA Countries: Evidence from Simultaneous Equations Models." *Energy Economics*, vol. 40, 2013, pp. 657–664., doi:10.1016/j.eneco.2013.09.003.

Poudel, Biswo N., et al. "Searching for an Environmental Kuznets Curve in Carbon Dioxide Pollutant in Latin American Countries." *Journal of Agricultural and Applied Economics*, vol. 41, no. 1, 2009, pp. 13–27., doi:10.1017/s1074070800002522.

Poudel, Biswo N., et al. "Searching for an Environmental Kuznets Curve in Carbon Dioxide Pollutant in Latin American Countries." *Journal of Agricultural and Applied Economics*, vol. 41, no. 1, 2009, pp. 13–27., doi:10.1017/s1074070800002522.

Shibayama, Katsuyuki, and Iain Fraser. "Nonhomothetic Growth Models For The Environmental Kuznets Curve." *International Economic Review*, vol. 55, no. 3, 2014, pp. 919–942., doi:10.1111/iere.12076.

Tupy, M. "Urbanization Is Good for the Environment." *Cato Institute*, 2 Oct. 2017, www.cato.org/blog/urbanization-good-environment.

Wu, Jianxin, et al. "Convergence of Carbon Dioxide Emissions in Chinese Cities: A Continuous Dynamic Distribution Approach." *Energy Policy*, vol. 91, 2016, pp. 207–219., doi:10.1016/j.enpol.2015.12.028.

Wu, Jianxin, et al. "Convergence of Carbon Dioxide Emissions in Chinese Cities: A Continuous Dynamic Distribution Approach." *Energy Policy*, vol. 91, 2016, pp. 207–219., doi:10.1016/j.enpol.2015.12.028.

Özokcu, Selin, and Özlem Özdemir. "Economic Growth, Energy, and Environmental Kuznets Curve." *Renewable and Sustainable Energy Reviews*, vol. 72, 2017, pp. 639–647., doi:10.1016/j.rser.2017.01.059.