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Original Article

Trade Liberalization, Energy Consumption, and Pollution: An Empirical Investigation of Kuznets' Hypothesis in 60 Developing Countries

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Abstract - *This study examined the long-run relationship between trade liberalization, energy consumption, income per capita, and environmental air quality proxied by carbon dioxide (CO_2) emissions in metric tons. The income per capita and income per capita squared were included in the model to capture the Kuznets' hypothesis. Cross-sectional data were obtained from the world development indicators, 2010 spanning over the period 1960 -2004. Both Fixed and Random effects, robust Heteroscadacity estimation techniques were used to investigate the links amongst the variables for 60 developing countries. The result of the findings shows that energy consumption and trade liberalization in both the short and long run have a positive relationship with pollution for less developed countries using the pooled and heteroskedasticity panel corrected standard error estimates. The significance of the positive coefficients of energy consumption and trade liberalization on CO_2 emissions suggests that an increase in the level of energy consumption and trade liberalization have unfavorable effects on environmental quality in less developed countries. The results of the study also showed that income has a negative relation with the measure of environmental quality; meanwhile, income squared has a positive link with CO_2 emissions. The coefficient of the squared term of income per capita is positive for the least developing countries suggesting that the countries have not yet reached the threshold income level, where they will tend to give more priority to the protection of the environment. This means that an increase in income will lead to the deterioration of the environment. The study recommends that developing countries can open their markets by uplifting tariffs and quotas to encourage trade whilst adopting strong pro-environmental policies.*

Keywords - *Trade Liberalization, Energy Consumption, Pollution, Kuznets' Hypothesis, Panel Co-integration.*

I. INTRODUCTION

Trade liberalization, which is aimed at fostering development in most developing countries around the world today through reducing trade barriers, still poses a challenge for developing countries that are still struggling to achieve development with low levels of income per capita. The literature on trade liberalization shows that increased openness is usually aimed at achieving economic growth, which is seen as a prerequisite for economic development (Spanu, 2003; Baek and Kim, 2011; Chen and Gupta, 2006). However, due to differences in environmental policies, trade liberalization across different countries and blocks has given rise to unequal shares of the benefits. As a result, trade and environmental policy gaps exist between and within countries, and the liberalization of trade with the view of widening the size of the market poses a major problem to the environmental quality of developing countries, that is, countries with low levels of capital per worker. Furthermore, the expansion of trade through a reduction of trade barriers was typically followed by rapid and unsustainable exploitation of the natural resources in most developing countries. Cosbey (2004) has argued that this rapid exploitation is a great destroyer of the environment. For instance, the total area of the world's forests (including natural forests and plantations) was estimated at about 3.454 billion hectares in 1995, and about half of this area is located in developing countries. Just between 1990 and 1995, the net loss of this forest was about 56.3 million. Wood fuels which are the major source of energy consumption, accounted for about 7 percent of the world's total energy supply during the 1980s, while developing countries were assessed to consume 77 percent during the same period (FAO, 1997a).

This poses a problem to the environment as well as to the asset stock of the resources, especially in the case of non-renewable resources. Environmentally unsustainable activities like deforestation are responsible for ozone depletion and global warming.

II. THEORETICAL REVIEW

The Population of the poor, living on less than one dollar per day, increased from 474.4 million in 1987 to 552 million in 2000. As a result, most countries tended not only to rely on the exploitation of natural resources to make ends meet but also to make up for what they could not produce domestically through international trade. This was even accentuated with the process of liberalization. The extraction of these resources, just like other activities of production and consumption, usually results in some element of waste that goes to the environment as residuals. Most developing countries find it difficult to get the advanced technology that can be used to recycle this waste or residuals. Such technologies can, by helping to recycle these wastes, lead to a reduction in natural resource exploitation and thus to their sustainable use. Economic activity and the environment are interrelated through a network of a complex system that involves extraction, production, and consumption. For example, environmentalists are of the view that raising the scale of economic activities through trade liberalization will lead to a higher level of investment and consumption and hence a higher demand for natural resources (Ropke, 1994). Economists, in contrast to the argument of environmentalists against trade liberalization, argue that liberalization does not lead to environmental degradation (Low, 1992). As such, the nature of the relationship between trade liberalization and environmental air quality is still hotly debated by environmentalists and economists (ICTSD, 2006), but the existence of the relationship is not denied. The World Trade Organization (WTO) holds the view that trade liberalization and sustainable development are mutually supportive, and the reaffirmation of the link between them was in many ways the raison d'être of the Doha Development agenda of 2001. The World Bank equally estimated that liberalization of merchandise trade with a supportive domestic policy would lead to a gain of 5% in developing countries and would move 300 million people off the line of poverty by 2015. Anderson and Martin (2005), in a study on the gain of multilateral trade reform, found that free global merchandise trade boosts real income in Sub-Saharan Africa and Southeast Asia proportionately more than in developed countries. According to the World Bank, the Doha Round agreement signified that lifting trade restrictions in agriculture would stimulate trade and cause income to increase, thereby raising the standards of living, which is a requisite for sustainable development.

This paper intends to examine the effects of trade liberalization, energy consumption, and income per capita (proxied by gross domestic product growth per capita) on pollution (proxied by carbon dioxide emissions) within and between developing countries.

Environmentalists, on social grounds, perceive the effect of trade liberalization on sustainable development to be nothing but a boding evil. They view trade liberalization as anti-environmental, driven by the quest for high profits, jobs, increased production, and consumption. The theory of idealized market conditions supports the view that trade liberalization will lead to economic welfare and optimal environmental quality, whereas the theory of imperfect market conditions argues that although trade liberalization can lead to economic growth, it has a negative impact on the environment (as well as society), especially where environmental and social protection measures are lacking. Trade liberalization has direct, indirect, and dynamic effects between and within economies.

III. EMPIRICAL REVIEW

Baek and Kim (2011) examined the dynamic interrelationship between trade, income growth, energy consumption, and CO_2 emission for G-20 economies within the framework of a co-integrated vector auto-regression using time series data that spanned from 1960-2006. They used the degree of openness defined as the ratio of the value of total trade to real GDP as a proxy for trade openness (or liberalization), which they obtained from the Penn World Table. Their finding shows that trade and income growth have a favorable (positive) effect on the environmental quality of the G-20 member countries, while they have an adverse effect on the environment of developing member countries. There exist three dominant views on the relationship between trade liberalization and economic growth: it can be examined from the neoclassical perspective, endogenous growth perspective, or from the institutional perspective. From the neoclassical standpoint, trade patterns are determined by comparative advantage (David Ricardo, Stolper-Samuelson, Ohlio), where each country maximizes its welfare by specializing in the activities in which it is most economically efficient. This results in gains from specialization. There is static as well as dynamic gain from trade. It is said to be static if it can only improve the allocative efficiency of the resources used. But if it allows mobility and amelioration of technology in the sense of technical progress, then it is classified as a dynamic gain from trade. The neoclassical theory holds that trade liberalization does not lead to a long-run increase in the rate of growth; it only permits an increase in the level of income. Endogenous growth theory, on its part, argues that trade policy, in general, has an impact on both the level of income and on long-run growth via economies of scale, spill-over effects, rudimentary effects, and allocative efficiency (Duncan and Quang, 2000).

Van and Azomahou in 2007 used parametric and semi-parametric models to investigate the link between the deforestation process and per capita income and the level of openness. Their study did not provide any indication of the environmental Kuznets' hypothesis (EKC), so they concluded that trade liberalization does not have a positive effect on the deforestation process, where they considered deforestation as one of the elements of environmental quality.

Loi Nguyen used a cross-country data set for six East Asian Countries spanning from 1980 to 2006 to examine the interrelationship between trade liberalization and environmental degradation. The results of the study indicate that trade grows rapidly as a result of liberalization, but the environmental problems can either be alleviated or exacerbated depending on the comparative advantage and efficiency of environmental policy. If environmental policy is considered as the endogenous factor, then increasing liberalization could reduce emissions. This supports the finding of Antweiler et al. (2001) that trade liberalization reduces pollution. Dasgupta et al. (2002), on the other hand, have found that trade liberalization does not have a positive effect on the environment in developing countries. In the literature, there are different channels through which economic growth influences environmental quality (Krueger and Grossman, 1995; Coperland and Taylor, 1994 and 2003), namely: the scale, the decomposition, and the technique effects. The scale effect measures the increase in the level of emissions as a result of economic growth and the growing market access through liberalization. Meanwhile, the decomposition effect indicates changes in the structure of the economy that come with trade liberalization. The technique effect is concerned with the use of cleaner techniques (or technologies) of products that come with trade liberalization.

IV. METHOD AND PROCEDURES

A. *Areas of the Study*

The inclusion of the countries in the study is based primarily on the level of development of the countries and on the availability of data. All the countries in the model are developing countries based on the world development indicators classification of 2010. In this study, 26 countries are selected from Sub-Saharan Africa, 6 from East Asia and Pacific, 5 from Europe and central Asia, 6 from South Asia, 6 from Latin America and Carrabin, and 11 from the Middle East and North Africa. The human development index was also considered as a support factor in the choice of the sample of countries in the analysis.

Table 1. List of Selected Countries in the study

Sub-Saharan Africa	East Asia and Pacific	Europe and Central Asia	The Middle East and North Africa
Angola	Indonesia	Kazakhstan	Algeria
Benin	Malaysia	Tajikistan	Djibouti
The Gambia	Myanmar	Turkey	Egypt, Arab Rep.
Ghana	Thailand	Albania	Iran, Islamic Rep.
Guinea	Vietnam	Azerbaijan	Iraq
Guinea-Bissau	Papua New Guinea		Jordan
Kenya			Lebanon
Botswana			Libya
Burkina Faso			Morocco
Cameroon			
Congo, Dem. Rep.	**Latin America and the Caribbean**	**South Asia**	
Chad		Afghanistan	
Congo, Rep.	Venezuela, RB	Bangladesh	
Cote d'Ivoire	Cuba	Bhutan	
Senegal	Dominican Republic	India	
Nigeria	Bolivia	Pakistan	
Niger	Ecuador	Sri Lanka	
Zambia	Nicaragua		

Zimbabwe			
Togo			
Sudan			
South Africa			
Mozambique			
Gabon			
Ethiopia			
Tanzania			

Source: Selected by Authors based on the availability of Data, 2018

B. *Specification of Model*

To examine the link between income per capita, trade liberalization, energy consumption, and environmental air quality, we have to look at the theoretical framework of Baek et al.(2009), known as the growth, trade, energy, and environment nexus. The economic equation that shows the level of emission (E) as a function of trade openness (T) and per capita income(Y) is

$$E = f(T, Y) \qquad (1)$$

The theoretical argument in the literature is that trade openness will lead to economic growth through the increased scale of economic activity in the country. The assumption is that trade has a positive relationship with income, that is, $dY/dT > 0$ (Jungho Beak and Hyun Seok Kim, 2011). Following the assumption of the environmental Kuznets hypothesis, emission levels will rise initially with income at the initial level of development (that is $dE/dY > 0$) to a certain threshold, beyond which income will instead decrease as emission levels rise ($dE/dY < 0$). In this study, we use panel regression estimation techniques to estimate the parameters. Model (1) is extended by incorporating into it energy consumption per capita. The introduction of energy consumption is derived from the finding from the literature that suggests a close link between global warming and the emission of greenhouse gases. In 1997, Dietz and Rosa carried out a study aimed at investigating the role of population pressure on carbon dioxide emission, using the IPAT model, where "I" stands for the level of emission, "P" stands for population size, "A" stands for affluence and "T" stands for technology or the energy efficiency of the economic activities. Based on the above justification from the literature, the hypothesized functional model becomes:

$$E = f(Lib, Income, EU) \qquad (2)$$

Where Lib represents trade liberalization and EU represents energy consumption. The empirical model will take the following form:

$$E_{it} = \alpha + \beta_1 Lib_{it} + \beta_2 Inc_{it} + \beta_3 EU_{it} + \varepsilon_{it} \qquad (3)$$

We apply the log-log specification following Baek and Kim (2011) for model (3). We obtain

$$LE_{it} = \alpha + \beta_1 LLib_{it} + \beta_2 LInc_{it} + \beta_3 LEU_{it} + \varepsilon_{it} \qquad (4)$$

$$LE_{it} = \alpha + \beta_1 LLib_{it} + \beta_2 LInc_{it} + \beta_3 LEU_{it} + \varepsilon_{it}$$

(4

Where "i" stands for the "i th" cross-sectional unit meanwhile "t" for the "tth" time period. Some countries in the sample have 9 observations at maximum, while others have at least 3 observations. So we have an unbalanced panel due to a lack of data for some countries. It is assumed that all the explanatory variables in the model (3) and (4) are non-stochastic, and the disturbance term e_{it} follows a uniform normal distribution with a zero expected mean and constant variance. The parameters to be estimated, i.e., both intercept and the slope coefficients of all the sampled countries, are identical over time and space, and the disturbance term is expected to capture differences over time and over individuals. This restricted assumption might distort the true picture of the relationship that exists between the variables in the model. We introduce the square of income in the model (4) to capture the polynomial term of affluence, that is, the Kuznets' hypothesis. However, other studies have found an inverted U-shaped relationship between affluence and emissions, where emissions initially worsen but subsequently improve with income (Stern, 1998; Bruyn et al., 1998; Rothman, 1998).

$$LE_{it} = \alpha + \beta_1 LLib_{it} + \beta_2 LInc_{it} + \beta_3 LInc_{it}^2 + \beta_4 LEU_{it} + \varepsilon_{it} \qquad (5)$$

The apriori expected signs are β_1>0 or β_1<0, β_2>0, β_3>0 or β_3<0 and β_4>0.

C. Sources of Data and Definition of Variables

1) Per Capita Gross Domestic Product (RGDP)

Per capita GDP, which is measured in constant US dollars, serves as a measure for income. The data was obtained from the World Development Indicators (WDI) database, 2010. This variable is used to capture the effect of income on emission (pollution) in model 5. Other studies have also used this variable as a measure of income (Grossman and Krueger, 1993; Hettige et al., 1998; Rothman, 1998). Some past and current studies have suggested an inverted U-shaped relation between income and emissions known as the “environmental Kuznets Curve (EKC),” indicating that emissions will initially worsen but ultimately improve with income (de Bruyn et al., 1998; Rothman, 1998).In order to check if there is an inverted U-shape relation between emissions and per capita GDP, otherwise known as affluence, a quadratic term was incorporated in the specification of model 2. The expected sign for the coefficient of the quadratic term of the per capita GDP according to the EKC literature survey is positive for developing countries and negative for the developed countries. (Rock, 1996; Friedl and Getzner, 2003; Cole, 2004; Deacon and Norma, 2006; Merican et al.(, 2007).

2) Energy Consumption Per Capita

Energy use per capita measured in kg of oil equivalence per capita is obtained from the world development indicators database (2010) to capture the role of energy use on emissions. Energy use is used as the measurement for the level of technology. This variable has been used by other studies (Shi, 2001; Baek and Kim, 2010), and it derives its roots from the IPAT model. The coefficient is expected to be positive with the level of emissions. Individual countries experience different levels of openness and income, and therefore energy use or consumption reflects the process of development, thus can serve as a measure of the level of development (Baek et al.2009).

3) Trade Liberalization

The level of openness as a percentage of GDP is used as an indicator of trade liberalization, trade openness, and the integration level of the world economy. It is measured as the ratio of the sum of export and import of goods and services over GDP. The data of exports and imports were obtained from the International Monetary Fund (IMF), 2011. The level of openness plays a dual role in this study; one is to capture the effects of trade liberalization on environmental quality, the second is to examine the impacts of trade liberalization on income in the least developing countries. The use of this variable is not uninformed, for we follow previous studies that have used it to estimate the impact of trade openness on environmental quality. One of the objectives of the Doha ministerial round meeting in November 2001 was to achieve the development dimensions of a trade by mainly focusing on developing countries (LDCs). It was decided to lower trade barriers on LDC exports and reduce their debt burden through a fast and effective implementation of the HIPIC (Heavily Indebted Poor Countries Initiative) program. Hakura and Jaumotte (1999), in their study on the role of inter and intra-industry trade on technology diffusion, found that trade plays a crucial role for international technology transfer to developing countries, but those developing countries receive relatively less technology transfer from trade than developed countries. The question then is, what if liberalization does not succeed in promoting growth in the least developed countries as a result of its consequences on their environment?

4) Pollution

It is the most significant environmental problem and is linked to the emission of greenhouse gasses, of which CO_2 is the dominant contributor. CO_2 emission is used as a proxy for environmental air quality. The data is obtained from the world development indicators database of 2010.

D. Estimation Techniques

1) Fixed effect and Random Error Component Panel Estimation Technique

Fixed effects and random effects models are the two most commonly used estimation methods in panel regression to control for potential endogeneity bias induced by unobserved factors that can either vary over time but are constant over individuals (time effects) or vary over individuals but are constant with time (individual effects). The fundamental difference between the fixed and random effects lies in the assumption we make about the dummy. If the dummy is considered as part of the intercept, then the model is a fixed-effects model. In the random-effects model, the dummy acts as the error term (Park, 2005).

The general fixed effects model is given as

$$Y_{it} = \alpha + H_i + X'_{it}\beta + V_{it}$$

Where β is a $\boldsymbol{k \times 1}$ vector of the coefficients of X and $\boldsymbol{X'it}$ is a $\boldsymbol{1 \times N}$ vector of the variables that vary over individuals (or groups) and overtime and $\boldsymbol{V_{it}}$ are independently unobservable with zero means. $\boldsymbol{H_i}$ Is the individual effect or the unobserved heterogeneity while $\boldsymbol{V_{it}}$ captures the transitory unobserved shock in the model for an individual $\boldsymbol{i}$ at a time $\boldsymbol{t}$. The linear combination of the unobserved heterogeneity and the transitory shock is described as the idiosyncratic term, which constitutes the error term in the random-effects model. However, in the random-effects model, the country-specific error component is assumed to be uncorrelated with the other predictors in the model, whereas in the fixed effects model, the country-specific errors can be correlated with the predictors. Our model (5) becomes;

$$LE_{it} = \alpha + \beta_1 LLib_{it} + \beta_2 LInc_{it} + \beta_3 LInc^2_{it} + \beta_4 LEU_{it} + \varepsilon_{it} \quad (6)$$

Where $\varepsilon_{it} = \boldsymbol{Hi + Vit}$ is the idiosyncratic shock in the random-effects model.

The model was tested for the non-constant variance of the error term. The Breusch and Pagan heteroskedasticity test (1979, 1980) is used to test for non-constancy of the disturbance term in econometric studies. The null hypothesis of the test assumes that the variance is constant over time and individuals, while the alternative suggests that the variance is different across individuals and time. Rejection of the null hypothesis will mean an indication of the presence of heteroskedasticity, which of course, is a common problem with panel data. Moreover, the Langragian Multiplier (LM) test for heteroskedasticity (Baltagi, Bresson, and Pirotte, 2005) was also conducted. The decision rule is to compare the LM statistics with the chi-square critical value; if the LM statistic is greater than the chi-square, we conclude that the variance of the error term is not constant. The non-constancy of the variance of the error term violates one of the classical assumptions of constant variance. The implication of the non-constant variance is that the estimated standard errors will be biased, and this will affect the efficiency of the estimators. To correct for the non-constant variance in the regression, the robust standard error component model can be used, as pointed out by Wooldridge (2002).

2) Panel Unit Root Tests

One of the classical assumptions of regression analysis is that the variables must be covariance stationary (i.e., each of the variables should exhibit mean reversion in that it oscillates around a constant long-run mean or has a theoretical correlogram that diminishes as the lag length increases). This is because the variables are randomly collected and ordered in time. They tend to exhibit a stochastic process that can be stationary or non-stationary. One of the well-known methods used in the investigation of unit roots or stochastic processes in times series data is the Augmented Dickey-Fuller (ADF) and Phillip Perron (PP) tests. But in this study, we use the Levin, Lin, and Chu (LLC) and Im, Pesaran, and Shin W-stat (IPS) to investigate the stationarity status of the variables and their level of integration so as to avoid the inclusion of I(2) variables in the model, and also to ascertain that the dependent variable is I(1) (Fosu and Magnus, 2006). However, Baltagi (2005) quotes Levin, Lin, and Chu (2003), who argue that ADF has a very low power against the alternative hypothesis of highly persistent deviations from the equilibrium and that the problem is intensified in small size samples. LLC test assumes a common autoregressive parameter for all panels, so this test is restrictive in the sense that it does not consider that some countries' series may have unit roots while others do not. This test still improves the power of the null hypothesis against the alternative (Levin and al., 2002), despite its restrictive nature. To solve these problems of LLC, Im, Pesaran, and Shin (2003) proposed an alternative test that considers heterogeneity across cross-country observations based on averaging individual unit root test statistics. In the test, the null hypothesis asserts non-stationarity and the alternative hypothesis asserts stationarity. The rejection of the null hypothesis will mean the variable exhibits a mean reversion around its long-run constant mean.

Table 2. Results of the Panel Unit Root Test

	LLC		**IPS**		
Variables	**Level (W)**	**First Difference (Δw)**	**Level (W)**	**First Difference (Δw)**	**Order of Integration**
LPollution (E)	**-0.95**	**-4.07*****	**-0.52**	**-13.90*****	**I(1)**
Llib	**-0.96**	**-5.95*****	**-0.44**	**-13.45*****	**I(1)**
Leu	**0.39**	**-15.22*****	**-1.09**	**-22.82*****	**I(1)**
Lrgdp	**-1.89*****	**-5.05*****	**-1.58**	**-21.01*****	**I(1)**
Lrgdp2	**11.29**	**-6.83*****	**8.46**	**-21.01*****	**I(1)**

*Notes: LLC is the panel unit root test recommended by Levin, Lin, and Chu (1993), while IPS is the test introduced by Im and al. (2003) both at level (w) and first difference (Δw). *'**'*** indicates that the null hypothesis can be rejected at 10%,5%, and 1% significance levels, respectively.*

The lag length is chosen based on the default information given by the information criterion AIC or SIC. LLC and IPS both agree in classifying all the variables as I (1) (i.e., they need differencing once in order to become stationary) except for Lrgdp and Lrgdp2, which both yields are conflicting results at level, though they still end up classifying both as I(1). We reject the null hypothesis of non-stationarity and conclude that the variable is I(1). This satisfies the pre-condition of the co-integration test and rules out the possibility of any spurious regression.

3) Cointegration Test

Co-integration means that the combination of non-stationary series is stationary. We use co-integration to examine the long-term equilibrium in the movement of the series. The purpose of this test is to avoid the problems of spurious regression, i.e., a regression that is statistically significant but economically non-significant. Hence the study conducted a residual-based panel co-integration test developed by Pedroni (1999, 2004). Pedroni proposes several tests for co-integration that allow for heterogeneous slope coefficients across cross-sections. This consists of seven component tests: the panel v-test, panel rho-test, panel PP-test, panel ADF test, group rho-test, group PP-test, and group ADF test. These tests assume the null hypothesis that the residuals are non-stationary (i.e., there is no co-integrating relationship) against the alternative hypothesis that residuals are stationary (i.e., there is a co-integrating relationship among the variables).

Table 3. Results of the cointegration tests

Pedroni Residual Cointegration Test		
Model tested $L\,E_{it}=\alpha+\beta 1LLib_{it}+\beta 2LInc1_{it}+\beta 3LInc^{2}_{it}+\beta 4LEU_{it}$	Statistic	P-Value
Panel v-Statistic	-138.00	(0.94)
Panel rho-Statistic	-2.37	(0.00)*
Panel PP-Statistic	-9.29	(0.00)*
Panel ADF-Statistic	-9.02	(0.00)*
Group rho-Statistic	-1.33	(0.09)***
Group PP-Statistic	-14.95	(0.00)*
Group ADF-Statistic	-10.05	(0.00)*

Note:'**'*** denote significant at 1%,5% and 10% respectively.*

Source: Computed using Eview 7 by Author, 2018

Table 3 shows the results of the co-integration test on model 5. The null hypothesis of no co-integration is rejected in six of the seven cases at 5%, except for Group rho-Statistic at 10% significance level. We conclude that there is a co-integration relationship between the variables at the level. This means that the combination of the non-stationary series is stationary.

V. RESULTS AND DISCUSSION

We estimate the usual ordinary least squares (OLS) regression under the assumption that the intercept and the slope coefficients are constant across time and individuals and that the error term captures the differences over individual cross-sections and time. Even though this method may be inappropriate as the errors are likely to be contemporaneously correlated across time and across cross-sectional units, we still report the OLS estimates for comparison purposes.

Table 4. Pooled Panel Regression (OLS)

	in pollution
	OLS
Variables	
Llib	1.26***
	(2.78)
Lrgdp	0.02
	(1.05)
Lrgdp2	0.10***
	(6.92)
Lenergy	0.27***
	(4.08)
Constant	-8.13***
	(-12.76)
Observation	1148.00
adjusted R-square0.12	
F(4,1143)	40.77
prob>F	0.00

*Note: Values in parentheses below each coefficient are the t-statistic. *** indicate that the coefficient is significant at 1, 5, and 10 percent with a relatively low level of p-statistic*

Source: Computed by Author, 2018

The dependent variable CO_2 per capita is regressed on the explanatory variables: trade liberalization ((X+M)/GDP)) being the main explanatory variable; real gross domestic product per capita; energy use per capita. And the square term of per capita income to capture the effects of the inverted Kuznets curve. The entire coefficients are individually statistically significant at 1, 5, and 10 percent, with the slope coefficient having a positive sign. The pooled regression suggests that CO_2 emission per capita is positively related to trade liberalization. The trade variable reflects either the pollution heaven hypothesis or factor endowment hypothesis (Grossman and Krueger, 1992; Agras and Chapman, 1999; Van and Anzomahou, 2007). Trade liberalization coefficient has a positive sign, which is positive for developing countries and negative for rich countries according to the pollution heaven hypothesis (PHH) and factor endowment hypothesis, respectively.

The model also shows some level of global significance with F(4, 1143)=40.77, far greater than the critical value of F(0.00) at 1, 5, and 10 percent significance levels. The Fisher test for the null hypothesis of non-significant conjoint explanatory variables against the alternative of conjoint significance is rejected. We conclude that the conjoint effects of the explanatory variables are significant. Due to the restrictive assumption of the OLS estimation, we proceed to test for the fixed effects and random effects.

Table 5. Result of Fixed and Random Effect Estimation

		Simple Fixed and Random Effects Estimated Model		**Control Model**
		LPollution		**LPollution**
		Fixed Effect (FE)	**Random Effect (RE)**	**Heteroskedasticity Panel corrected standard errors**
	Variables			
	Llib	1.43***	1.53***	1.26***
		(2.86)	(3.27)	(3.58)
	Linc	-0.08	-0.08	0.35
		-(0.68)	-(0.65)	(0.98)
	$Linc^2$	17.05***	15.95***	10.44***
		(4.82)	(4.94)	(9.74)
	Lenergy	0.07	0.07	0.28***
		(0.93)	(0.98)	(3.12)
	constant	-9.82***	-9.48***	-8.13***
		-(7.18)	-(7.48)	-(14.49)

	observation	1148.00	1148.00	1148
R-square	within	0.17	0.17	0.12
	between	0.09	0.09	
	overall	0.12	0.12	
	F-test	55.69		
	prob>F	0.00	0.00	0.00
	wald $X^2(4)$		226.32	231.14
	Hausman Test ($X^2(4)$)(prob)		0.48(0.97)	
	Breusch and Pagan Test $X^2(1)$		11925.74	
			0.00	

*Note: Values in parentheses below each coefficient are the t-statistics for fixed effect and z-stat for a random effect. *** indicates that the coefficient is significant at 1, 5, and 10 percent with a relatively low level of p-statistic.*

In table 5, the dependent variable is CO_2 emission, while the explanatory variables are liberalization, per capita income, energy use per capita, and the square term of per capita income. The estimation indicates that CO_2 emission, which is a measure of environmental air quality, is positively related to trade liberalization. That is to say, for a unit increase in the level of liberalization, CO_2 emissions will rise by 1.43 units between countries (FE) and 1.53 units (RE) between and within countries. This means that if the level of openness changes by 100 units, then the number of emissions in metric tons per capita will rise by 143 and 153 respectively between and within developing countries. Hence trade liberalization will result in environmental deterioration. The coefficient of per capita income in both the short and long run also has a positive sign for less developed countries using the pooled and heteroskedasticity panel corrected standard error estimates. The significance of the positive coefficients of GDP per capita on CO_2 emissions suggests that an increase in GDP per capita has unfavorable effects on environmental quality in less developed countries. The positive sign of GDP per capita on CO_2 emissions conforms to previous studies (Rock, 1996; Friedl and Getzner, 2003; Cole, 2004; Merican et al., 2007). This is because, in the early stage of development, pollution will increase with the increase in economic growth. The coefficient of the squared term of GDP per capita is positive for the least developing countries. This indicates that the countries have not yet reached the threshold income level, where they will tend to give more priority to the protection of the environment. This model can explain 9% of between countries variation, and this value is better than the R-square in the OLS estimated. The fixed effect also confirms the conjoint significance of the explanatory variables, and we thus reject the null hypothesis of non-significant conjoint explanatory variables owing to the fisher test F (4, 1148) =55.69 with p (0.00).

For the random effects, the coefficient of trade liberalization and GDP per capita are individually significant and have positive signs, while energy use per capita and the square term have negative signs. In both fixed and random effects models, energy use per capita is not significant, while in the OLS, energy use per capita has the expected signed. The fixed-effects model controls for all the time-invariant differences between the individuals, the coefficient of the fixed effects model cannot be biased as a result of the individuals' changeable characteristics. However, the fixed effect error component model assumes that the unobserved individual effects, αi, and the explanatory variables $\boldsymbol{X_{it}}$ may be correlated, against the alternative that $\alpha i|\boldsymbol{X_{it}}$ is different from zero (Mundlak, 1978).

The decision rule is that if the unobserved individual effect is correlated with the explanatory variables, the null hypothesis is rejected but if otherwise, we cannot reject the null hypothesis. The result of the Hausman test in the simple fixed and random effect in Table 4 gives a chi-square value of 0.48 and p = 0.98, which is greater than the 5% level of significance. Thus we accept the null hypothesis of no correlation between the individual effect and the explanatory variables. Baltagi (2001) suggests that the rejection of the null hypothesis means the adoption of the fixed-effects model. Hence the acceptance of the null hypothesis of the Hausman test will mean the significance of the random-effects model. The Breusch-Pangan lagrangian multiplier test for random effects with the null hypothesis that the random effects are the appropriate method to estimate the model shows a chi-square of 11925.74 and probability value of 0.00, which is greater than the 5% level of significance. Thus we accept the alternative hypothesis that the variances across countries are different and conclude that random effect is appropriate, and thus there's evidence of significant differences across countries. Hence, the OLS may not be appropriate to explore the nexus between CO_2 and the explanatory variables in the model. The test of Breush-Pangan suggests that the model suffers from heteroskedasticity, which is a common problem with cross-sectional data where the scale of the dependent variable and the explanatory power of the model tend to vary across observations (Green, 1993).

VI. CONCLUSION

The reduction of tariffs in view of widening the size of the market under the banner of liberalization will lead to a higher level of income in developing countries. This study also finds that increases in income both in the short and long run will increase pollution in under-developed countries. The energy use per capita will also increase with the amount of pollution. There is a need for the governments of and policymakers in developing countries to address trade policies and the trade-related activities of their trading partners. This should not just be a multilateral arrangement but a host of regional arrangements as well as bilateral arrangements that countries are engaged in by setting up regulations and monitoring agents and clauses governing trade roles as well as anti-dumping policies. However, most under-developed countries lack the basic capacity (roads, infrastructure, education, health care, etc.) to support trade, so we suggest that developed countries should help their developing trading counterparts to meet up the standards. They also lack financial adequacy and efficient institutions and are exposed to exchange risks due to the existence of many different (stronger) currencies. This study suggests that trade liberalization can play a key role in the economic performance of the selected under-developed countries though it tends to deteriorate the environment in these countries. Effective rules and regulations, as well as monitoring agents, need to be established in the process of liberalization for the effective and efficient promotion of economic growth. Developing countries can open their markets by lifting their tariffs and quotas to encourage trade while adopting pro-environmental measures and policies. The negative effect of liberalization on the economies of the least developed countries lies in the fact that it will affect the future stocks of resources in the sense that more resources will have to be allocated to cleaning the environment. Trade liberalization and environmental protection are very important for sustainable development, and this can be achieved with the right policies at the right time.

REFERENCES

[1] Agras, J., & Chapman, D., A Dynamic Approach to the Environmental Kuznets Curve Hypothesis. Journal of Ecological Economics, 28(2) (1999) 267-277.

[2] Ang, J. B., Economic development, pollutant emissions, and energy consumption in Malaysia. Journal of Policy Modeling, 30 (2008) 271-278.

[3] Antweiler, W., Copeland, R. B., & Taylor, M., Is free trade good for the environment? Review of Economics and Statistics, 80 (2001) 15-27.

[4] Asafu-Adjaye, J., The relationship between energy consumption, energy price, and economic growth: time series evidence from Asian Developing Countries. Journal of Energy Economics, 22 (2000) 615-625.

[5] Baek, J., & Kim, H. S., Trade Liberalization, Economic Growth, Energy Consumption, and the Environment: Time Series Evidence from G-20 Economies. Journal of East Asian Economic Integration, 15(1) (2011).

[6] Baek, J., Cho, Y., & Koo, W. W., The Environmental Consequences of Globalization: a Country-specific Time-series Analysis. Journal of Ecological Economics, 68 (2009) 2255-2264.

[7] Baltagi, B., & Wu, P., Unequal spaced panel regressions with AR(1) disturbance. Economic Theory, 15(6) (1999) 814-823.

[8] Ben-David, D., & Kimhi, A., Trade and the rate of income convergence. Cambridge, Mass., U.S.A: National Bureau of Economic Research., (2000).

[9] Bruesch, T. S., & Pagan, A. R., A simple test for heteroskedasticity and random Coefficient variation. Econometrica, 47 (1979) 1287-1294.

[10] Bruesch, T., & Pagan, A., The LM test and its applications to model specification in econometrics. Journal of Review of Economic Studies, 47 (1980) 239-253.

[11] Chen, P., & Gupta, R., An investigation of Openness and Economic Growth using Panel Estimation. The University of Pretoria., (2006).

[12] Cole, D. H., New Forms of Private Property: Property Rights in Environmental Goods., from Bouckaert B. and G. DeGeest (eds.) (1999) (2000). Encyclopedia of Law and Economics.

[13] Cole, M. A., & Anthony, J. R., The Uruguay Round and Air Pollution: Estimating the Composition, Scale and Technique Effects of Trade Liberalization. Journal of International Trade and Economic Development, 9(3) (2000) 339-354.

[14] Cosbey, A., The Kyoto Protocol and the WTO. International Institute for Sustainable Development and The Royal Institute of International Affairs., (1999).

[15] Cosbey, A., A capabilities approach to trade and sustainable development: Using Sen's conception of development to re-examine the debates. International Institute for Sustainable Development., (2004).

[16] Cosbey, A., & Cameron, J., Trade Implications of the Kyoto Protocol: Policy Matters. Newsletter of the IUCN Commission for Environmental, Economic and Social Policy(4) (1999).

[17] Dasgupta, D. e., Pollution and Capital Markets in Developing Countries. Journal of Environmental Economics and Management, 42(3) (2001) 310-335.

[18] Dollar, D. a., Trade, Growth, and Poverty. The Economic Journal, 114(493) (2004) 22-49.

[19] Duncan, R., & Quang, D., Trade, Liberalisation, Economic Growth and Poverty Reduction Strategies. National Centre for Development Studies, The Australian National University., (2003).

[20] Engel, R. F., Co-integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55 (1987) 251-279.

[21] Environmental impacts of a North American free-trade agreement., National Bureau of Economic Research, 3914 (1991).

[22] Eusufzai, Z., Openness, Economic Growth, and Development: Some Further Results. Journal of Economic Development and Cultural Change, 44(2) (1996) 333-338.

[23] FAO., Review of the state of the world marine fishery resources. FAO Fisheries Circular, No (1997a) 920: 173p.

[24] Friedl, B., & Getzner, M., Determinants of CO2 emissions in a small open economy. Journal of Ecological Economics, 45 (2003) 133-148.

[25] George, C. a., Trade and development: Assessing the impact of trade liberalization on sustainable development. Journal of World Trade, 38(3) (2004) 441-470.

[26] Grossman, G. M., & Kreuger, A. B., Environmental impacts of a North American Free Trade Agreement: The Mexico-U.S. Free Trade Agreement, edited by P. Garber., (1993).

[27] Holtz-Eakin, D. a., Stoking the Fires? CO2 Emissions and Economic Growth. Journal of Public Economics, 57 (1995) 85-101.

[28] Im, K. S., Pesaran, M., & Shin, Y., Testing for Unit Roots in Heterogeneous Panels. Journal of Econometrics, 115 (2003) 53-74.

[29] IPCC., Climate Change Mitigation: Contribution of the Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. IPCC., (2001).

[30] Ivanova, I., & Arcelus, F. e., An assessment of the measurement properties of the human development index. Social Indicators Research, 46(2) (1999) 157-179.

[31] Kruger, A., Trade Policy and Economic Development: How We Learn. American Economic Review, 87(1) (1997) 1-22.

[32] Levin, A., Lin, C., & and the Chu, C., Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties. Journal of Econometrics, 108 (2002) 1-24.

[33] Maddala, G. S., & Wu, S., A comparative study of unit root tests with panel data and a new simple test. Oxford Bulletin of Economics and Statistics, 61 (1999) 631-652.

[34] Matthew, A., Air Pollution and 'Dirty' Industries: How and Why Does the Composition of Manufacturing Output Change with Economic Development? Journal of Environmental and Resource Economics, 7., (2000).

[35] Nguyen, H. T., Trade Liberalization, Privatization, and Economic Growth., (2010).

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

[37] Pedroni, P., Purchasing power parity tests in cointegrated panels. Review of Economics and Statistics, 83 (2001) 727-731.

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

[39] [35] Rodriguez, F., & Rodrik, D., Trade Policy and Economic Growth: A Sceptic's Guide to the cross-country Evidence. Centre for Economic Policy Research, 2143(22) (1999).

[40] Sadorsky, P., Trade and energy consumption in the Middle East. Journal of Energy Economics, 33(5) (2011) 739-749.

[41] Sagar, A. D., & Najam, A., The human development index: a critical review. Journal of Ecological Economics, 25(3) (1998) 249-264.

[42] Spanu, V., Liberalization of the international trade and economic growth: Implications for both developed and developing countries. MA Havard University: John F. Kennedy School of Governance., (2003).

[43] Suri, V., & Chapman, D., Economic growth, trade, and energy: implications for the environmental Kuznets curve. Journal of Ecological Economics, 25(1998) 195-208.