Pollution Haven Hypothesis (Phh) Revisited for the BRICS Economies

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Abstract: *This study analyzed the reality or otherwise of pollution haven hypothesis in BRICS countries using panel data spanning from 1990 to 2018. The study used net exports and foreign direct investments as measures of economic activity (dependent variables for the two models) and stringency in environmental regulation while other determinants of trade were captured as independent or control variables. The other model that has foreign direct investment as dependent variable also has infrastructure, income and trade openness as control variables. Cointegration, panel least squares and Panel generalized method of moments (PGMM) were used in analyzing the data. A year lag of the dependent variables was included as one of the independent variables of the models to capture dynamism (Blundell and Bond, 1998). The study confirmed the existence of pollution haven hypothesis true for the BRICS countries. The agglomeration effects of FDI and trade were also confirmed by the study among others. The study recommends that governments of BRICS countries must weigh the beneficial impact of trade and FDI against the pollution impact of 'dirty' trade and investments before deciding or setting its environmental policy. There is a great need for them to tighten their environmental laws and also strengthened the enforcement agencies so as to make those regulations effective.*

Keywords: Pollution Haven, PGMM, Environmental Stringency, Foreign Direct Investments, Trade.

Introduction

Pollution haven hypothesis implied that differences in stringency in environmental regulations are the major motivation for trade and foreign direct investments (FDI). Some scholars proposes that pollution haven hypothesis is unfounded because pollution costs are relatively small compared with the total costs of goods and that multinational companies that produces in both developed and developing countries do not want to be categorized as the originators of dirty production processes to developing countries. They therefore conclude that stricter environmental regulations do not impact substantially on trade patterns (Tobey, 1990; and Xu, 2000). In addition to these, most trade flows takes place between either developed to developed countries and; between developing to developing countries. Secondly, some industries are therefore least likely to relocate to other countries. In addition, environmental regulation costs are small in proportion to the production costs (Ederington et. al., 2005). There are also some who are of the opinion that trade and FDI flows promote environmental performance. This is known as pollution halo hypothesis. Halo hypothesis postulates that the inflows of FDI promote the development of cleaner technologies and productions.

This study therefore is aimed at studying the existence or otherwise of pollution haven hypothesis of the BRICS countries. BRICS countries are; Brazil, Russia federation, India, China and South Africa. BRICS countries are different one from one another in terms of culture, language, background and economic structure; however, they are similar in terms of economic growth. According to Ghouah, Belmokaddem, Sahraoui and Guellil (2015) economic growth in BRICS has greatly exceeded growth of the world's industrialized economies. Even after the economic recession of 2007, they continue to outperform other World economies. While the World economy shrank on the average by 6% , India grew by 5.9%, Brazil remains steady. China grew by 8.1% only Russia shrank by 7%. BRICS are projected to grow more than the G-7 countries. BRICS accounted for 25 percent of the earth's land surface and 40 percent of the World's population, (Wu, 2011).

BRICS is projected to lead the suppliers of manufactured goods, services and raw materials by 2050 due to availability of low labour and production costs. In addition, many companies also cite BRICS nations as their sources of foreign expansion or FDI opportunities since they are promising economies with great potentials for the thriving FDI. Due to the expected growth in size of the BRICS economies, their large populations, and their influence in global policies, the decisions they make has serious effect on the future of global environment.

According to Wu (2011), in 2008, the four initial BRIC countries (excluding South Africa) accounted for over one- third of global carbon emission emanating from deforestation and other unfriendly land activities (these are not accounted for). When deforestation and land use carbon generation are factored in, the size of emission becomes bigger. According to Wu, In Brazil for instance, unsustainable land use practice generated seventy five percent of total emissions as deforestation has considerably lowered the country's Carbon sink thereby increasing Carbon emission by Six billion metric tons.

According to the international energy Agency, coal use (which is pollution-intensive) will more than double in India and China by 2050. The current level of Industrialization in BRICS is the fossil fuels dependant and this is more pronounced in Brazil, India and China. The continued use of fossil fuels in this bloc has devastating consequences in the form of climate change. According to Wu, part of the consequences of climate change projected for India is that wheat production might decline by four to five million tons for every one degree Celsius increase in average temperature and in a country with projected increase of 300 million people within two decades, this translates to a great threat to the global food security.

According to d'Almedia (2017) BRICS have initially been marginalized and have been victims of western growth, but they themselves have become major energy consumers as well as pollution generators. This may be due to a number of factors which include greater FDI inflows and trade liberalization.

Table 1: Environmental performance index (EPI) of BRICS 2018

Country	Ranking	EPI	Environmental health	Ecosystem validity	Air pollution
Brazil	69	60.7	67.44	56.21	37.55
Russia	52	63.79	75.48	55.99	77.78
India	177	30.57	9.32	44.74	37.49
China	120	50.74	31.72	63.42	57.08
South Africa	142	44.73	36.81	50.01	34.67

Source: Environmental performance index (2018)

Based on the environmental performance index in table1, despite the position of BRICS in the production of world output, their performance in terms of environmental performance index is far from being satisfactory. The best performing country of them all is the Russia Federation with a ranking of 52nd in the world. The worst performing country is India with the dismay ranking of 177 in the world. This shows that the environmental performance of BRICS bloc is very poor. Looking also at the (EPI) for the air pollution, South Africa, India and Brazil performed so poorly while China's performance is just fair. The bloc's performance in terms of pollution intensity can also be seen in table 2.

Table 2: Pollutant intensity in BRICS

Country	Sulphur Oxide	Nitrogen Oxide	Carbon dioxide	Methane emissions	Nitrous Oxide	Black Carbon
Brazil	52.49	22.6	21.07	68.37	54.38	24.27
Russia	77.88	77.68	51.59	54.62	42.35	85.29
India	60.12	54.05	63.24	99	99.89	61.84
China	32.60	42.37	38.82	80.10	67.49	48.70
South Africa	31.66	37.68	46.34	59.48	52.60	34.42

Source: Environmental performance index (2018)

On a general view, Brazil, Russia, India, China performed seriously below expectation in terms of environmental performance. Only South Africa has a fairly good performance in terms of intensity while India's performance is the least of all members of the bloc. BRICS countries are signatories to Kyoto protocol with commitment to reduce emission level, however, there are some environmental concerns in those countries.

.This then raise the question of how well are the inward FDI as well as trade flows into the bloc in terms of environmental performance? Is the tremendous boost in trade and FDI not connected with lax in environmental policy and implementation?

This study therefore set out to empirical test the relationship between environmental stringency and export flows (Martinez-Zarazoso, Vidovic and Viocu, 2016) as well as the relationship between environmental stringency and foreign direct investments' inflows in order to know the impact of strictness of environmental policy on trade and FDI for BRICS countries.

Literature Review

Various studies have been conducted on pollution haven hypothesis, some using FDI inflows as dependent variable while others used net exports. In the like manner, there is no general agreement on the measurement of environmental stringency in all these studies. Some researchers have used; permit fees, emissions limits, environmental taxes or fees, regulatory delays, measurement of pollution, public awareness of environmental problems, environmental agencies' budgets, and international environmental agreements joined by the country among other measures. This study reviews some of the earlier studies so as to learn one thing or the other from the previous studies..

Aliyu (2005) evaluates the impact of dirty FDI on host economies using the annual data on carbon dioxide total emission, and total emission on particulate matters, increasing temperature and total energy use. The study used disaggregated data and panel data finds environmental policy as positively correlated with FDI outflow in 11 OECD countries. However, FDI inflow insignificantly explains pollution level and energy use in 14 OECD countries.

Levinson and Taylor (2008) use data for United States regulation and trade with Mexico and Canada to test for pollution haven. They find the pollution control expenditures have significant effects on the flows of trade. They further commented on the issues of aggregation, endogeneity and country heterogeneity and unobserved heterogeneity. All the enumerated factors they stated can bias results of pollution haven studies.

Ayadi (2019) investigates the reality or otherwise of pollution haven hypothesis as well as factor endowment hypothesis in nine West African countries using panel data from 1990 to 2014. The study used net exports as a measure of economic activity (dependent variable) and carbon dioxide emission as a measure of regulatory stringency while other determinants of trade were captured as independent or control variables. The study used the fixed effect model with both time and cross sectional dummies. The study finds the existence of pollution haven hypothesis as well as factor endowment true for West Africa.

Agrawal and Saxena (2012) Utilize input output approach to analyze whether or not India is a pollution haven under some assumptions. They first analyzed the determinants of trade flows and further calculated the impact of changes in CO_2, NO_x and SO_2 emissions on imports and exports. They found that India gains from increased trade via environment suggesting that pollution haven hypothesis is no more applicable to India. This finding is also true when their assumptions are relaxed indicating that their findings are not sensitive to assumptions made.

Da Silva, Flavio and Carlos (2019) investigated the existence of Environmental Kuznets curve (EKC) and pollution haven hypothesis (PHH) as well as the business cycles for the BRICS countries (Except

Russia) using the auto regressive distribution lag (ARDL) for annual data ranging from 1961 to 2013. They found a mixed result concerning the existence of pollution havens for China and Non existence for South Africa, Brazil and India.

Shao, Wang, Zhou and Balogh (2019) examined the existence of pollution haven hypothesis (PHH) using data from 1982 to 2014 for BRICS (Brazil, Russia, India, China and South Africa) and the MINT (Mexico, Indonesia, Nigeria and Turkey) testing the casual relationship between inward FDI and environmental pollution. The study also conducted panel vector error correction model (VECM) and co integration for the two groups. Results indicate bidirectional positive causality between inward FDI and environmental pollution. The study also conducted panel vector error correction model (VECM) and cointegration for the two groups. Results indicate bidirectional positive causality between inward FDI and per capita GDP for the two groups indicating the existence of virtuous cycle of FDI- growth nexus. The two groups also exhibited bidirectional negative causality between FDI inflow and the environmental pressure that suggest the Non-existent of pollution haven for the two groups. They also found trade openness as promoting inward FDI flows.

Zhou, Sirisrisakulchai, Liu, Sriboonchitta, (2019) investigated the effect of economic growth on foreign direct investment (FDI) and on carbon dioxide emission in order to test the validity or otherwise of the existence of pollution haven and environmental kuznet's curve (EKC) for G7 countries (Canada, United states, United kingdom, France, Italy and Germany) as BRICS countries. The study utilized data from 1992 to 2014 using the quantile regression to capture the unobserved heterogeneity and distributional heterogeneity. Their results show differences across quantiles. They found impact of FDI on carbon emission as supporting pollution haven in the BRICS countries among the findings.

To, Ha, Nguyen and Vo (2019) conducted a study on the impact of the foreign direct investment on environmental degradation and to test the validity or otherwise of EKC in same 25 emerging Asia markets using data from 1980 to 2016. The study utilized the panel cointegration, fully modified ordinary least squares (FMOLS) which addresses the endogeniety problem. The study also uses the panel dynamic ordinary least squares to also correct for endogeniety problems .The study found that pollution haven hypothesis and EKC is valid for the region. In addition, FDI impacted negatively on the environment.

Ahmad and Xiaoyan (2016) examined the role of environmental Kuznets curves (EKC) and pollution haven hypothesis (PHH) a comparative overview of developing and developed countries using the descriptive statistics of estimation. Their results show a mixed results as results vary from country to country. However, the applicability of theories depends on whether developed or developing as well as whether or not there are stringent regulations in place as well as the presence of propensity to adhere strictly to regulations.

Shao (2017) analyzed the relationship between foreign direct investment (FDI) and carbon intensity in order to test the existence of pollution haven hypothesis or pollution halo for 188 countries for the period 1990 to 2013. The study employed the dynamic panel data analysis and system generalized method of moment to solve the endogeniety problem. The study found a significant negative FDI impact on carbon intensity after introducing many control variables such as share of fossil fuel, industrial intensity, urbanization and level of trade openness. The study therefore negates the existence of pollution haven hypothesis and support pollution halo hypothesis.

Jun, Zakaria, Shahzad and Mahmood (2018) analyzed the effect of FDI on pollution in china using data from 1982 to 2016. The pollution variables used are; carbon dioxide and sulphur dioxide and they applied the wavelet tool in the study. Their results found that the FDI positively affected the population highly in the short run (during 1980s and after 2000) and affected it at low frequency in the long run. This shows that FDI has created pollution haven in China. The spectral causality result also suggests that China FDI causes carbon dioxide emissions. They concluded that stringent environmental rules are needed to control inflows of dirty FDI in China.

Murthy and Gambhir (2018) analyzed the EKC and pollution haven hypothesis for India between 1991and 2014 using the regression analysis. They ran non linear regression model (quadratic and cubic) and added FDI as explanatory variable. The study found a cubic form of model as the most appropriate model. They also established the existence of pollution haven hypothesis for India.

Ghouali, Belmokaddem, Sahraoui and Guellil (2015) analyzed the relationship existing between total energy consumption, FDI, economic growth and carbon dioxide emission for the BRICS countries using data from 1990 to 2012 utilizing co-integration and panel granger causality. Their results showed a unidirectional casualty running from carbon dioxide to the GDP, FDI and energy consumption. They also found that FDI directly affected economic growth but has no direct effect on carbon dioxide emission within these countries. This implies that FDI is beneficial by increasing economic growth and also reducing carbon dioxide emission through changes in policy and practice.

Ben-David, Kleimer and Viehs (2018) explored the role of exports on pollution level using novel micro data of firms' carbon dioxide emission level on home and foreign countries. The study found that firms headquartered in countries with stricter environmental policies do more of their polluting activities abroad in countries with relatively weaker policies than they do at home indicating the existence of pollution haven. The effect of pollution haven is more pronounced for firms in the pollution-intensive industries and with poor corporate governance. Although firms export pollution, they reduce emission in response to strict environmental policies at home.

Most of the earlier studies focused on a given economic (FDI and trade) activity as affected by pollution with just few concentrating on the effect of environmental regulation on the given economic activity which is the postulates of pollution haven hypothesis. This study differs as it evaluates impact of stringency of environmental policy on trade and FDI for the BRICS. It also employed the needed econometric tools in overcoming the problem of possible endogeneity problem.

Theoretical Framework

According to Tumurshoev (2006) factor endowment theory postulates that disparities in countries endowment or technology are the factors that determine trade. It is not the differences in pollution policy that determines trade but difference in factor endowment or technology. By implication, countries that are rich or well endowed in capital will export capital intensive goods which are mostly categorized as 'dirty'. These capital-intensive goods promote the production capacity and also escalate pollution in capital-intensive economies. Conversely, developing countries with relative disadvantages in the production of capital-intensive goods will have a reduction in the production of capital-intensive goods.

Consequently, their levels of pollution generation declines as a result of the reduced production of pollution-intensive goods.

Generally therefore, the impact of trade on the environment globally and locally hinges on the distribution of comparative advantages and is predicated on differences in factor endowments as well as disparities in pollution policies in the World.

Pollution haven hypothesis is anchored on the fact that environmental regulations imposes extra costs on firms that are subject to stricter environmental regulations than firms that are subjected to laxer environmental regulations or non-existence environmental regulations. Given that two countries are identical in term of endowments and other conditions except for strictness in environmental regulations, economic theory posits that country with less stringency in environmental policy would offer a cost advantage to dirty producers or industries.

By implication, countries with strict environmental regulations would therefore specialize in cleaner production and import the output of dirty industries. This is also in conformity with the standard international trade theory which states that countries will have a comparative advantage in goods manufactured with factors that are in abundance relatively. In this situation therefore, the environment as an allowable dumping ground for pollution and environmental degradation would serve as scarce factor or abundance factor.

The prediction of pollution haven is that with trade, developing countries that are having weaker environmental regulations will specialize in the production of dirty goods. This is because they have weaker environmental policy; they will be dirtier and specialize in dirty production techniques.

Emerging economies will set lower standards for some obvious reasons. First, economic growth for less developed countries means a shift from agrarian economy to manufacturing or industrial revolution. This will fuel large investments in infrastructure and increased in urbanization which fuel pollution intensity. In developed countries however, economic growth means a shift from manufacturing or industrialization to service sector which has lower pollution-intensity.

Secondly, environmental monitoring imposes great costs on countries and these costs are higher in emerging economies because of lack of adequately trained personnel, corruption, high cost of implementing standards, lack of modern equipment among others.

Thirdly, income level is directly related to the demand for good environmental quality. The higher the income level, the higher will be the demand for cleaner environment. The implication of this is that emerging economies due to their poor income levels are more focused on increasing their jobs and earnings rather than investing or having concern for their health and level of pollution as opposed to their counterpart developed countries. Based on the above, the study therefore explore empirically the reality or otherwise of the existence of pollution haven hypothesis for the BRICS countries.

Methodology

The general model adapted for this study is that of Levinson (2003).

$$Y_i = \beta_i R_i + \alpha_i X'_i + \mu_i \quad \text{-------------------------------- (1)}$$

Where Y is the economic activity, R denotes the regulatory stringency, X' are the vectors of other determinants of Y while μ is the error term. In the above model therefore, if there is evidence of pollution haven, $\partial Y / \partial R$ should be significantly negative $(\hat{\beta} < 0)$. The above model was reformulated as:

$$Y_{i,t} = \beta Y_{i,t-1} + \alpha STRG_{i,t} + \psi' X'_{i,t} + \varepsilon_{i,t} \quad \text{--------------- (2)}$$

Where, $Y_{i,t}$ is the measure of foreign direct investment inflows of country i in time t for model one, or a measure of net exports of country i in time t for model two. $STRG_{i,t}$ is the measure of environmental strictness of country i in time t, X'_{it} are vectors of other variables affecting foreign direct investment (FDI) or net exports as the case may be. Lag of dependent variables were introduced to capture dynamism (Baltagi and Levin, 1986).

However, in the models, FDI, Net exports and stringency of environmental regulation (STRG) may be endogenous and $E(STRG_{it}/\varepsilon_i) \neq 0$. Therefore, SER was replaced with its estimates using series of instruments similar to the second stage least squares (TSLS) when the generalized method of moments (GMM) was used for analysis. So the functional forms of the models become:

NEXP = f(NEXP(-1), STRG, OPEN, GDPC, EXR, TARR) ------------ (3)

FDI = f(FDI(-1), STRG, OPEN, INFR) ------------- (4)

Specifically, the econometric models of the study are:

$$NEXP_{it} = \beta_1 NEXP_{it-1} + \alpha_1 STRG_{it} + \Psi_1 OPEN_{it} + \Psi_2 GDPC_{it} + \Psi_3 EXR_{it} + \Psi_4 TARR_{it} + \Psi_6 EXR + \omega_i Z_i + \mu_i \quad ------------------\_-------------(5)$$

$$FDI_{it} = \beta_2 FDI_{it-1} + \alpha_2 STRG_{it} + \Psi_7 OPEN_{it} + \Psi_8 INFR_{it} + \Psi_{12} EXR + \omega_i Z_i + \mu_i \quad ---(6)$$

Where:

FDI_{it} is the inward foreign direct investment of country i in time t measured in US \$. NEXPit is the net exports of merchandize trade and services of country i in time t measured in US \$. $GDPC_{it}$ is the measure of gross domestic product of country i in time t measured in USD. EXR_{it} is the foreign exchange rate of country i in time t measured in dollar to local currency. $OPEN_{it}$ is trade openness (trade to GDP ratio) of country i in time t. $TARR_{it}$ is the tariff rate, applied, weighted mean for all products in percentage in country i in time t. $INFR_{it}$ is the percentage of population with access to electricity generation in country i in time t.

The study tested for stationarity of variables of the model using four approaches and all variables are confirmed to be integrated of order one. Thereafter, Pedroni cointegration was applied on each model and cointegration was confirmed for the variables of the two models. Thereafter, panel least squares was applied to the models. However due to the possibility of the presence of endogeniety, panel generalized method of moments (PGMM) was used in estimation and it produced a more robust and reliable estimates. The inherent features of PGMM and its usefulness here is as follows:

Based on Acemoglu et. al. (2009) endogeneity and other econometric problems inherent in dependent and independent variables' dynamics can be solved using panel generalized method of moments (PGMM). In addition, the models may be heteroscedastic or have correlated errors; PGMM will still produce robust estimates (Nawaz, et. al., 2014). This study utilized a system GMM based on Blundell and Bond (1998) to solve the problem of dynamism and endogeniety.

According to Whitney (2007) the GMM estimator chooses parameter estimators by setting sample moments close to population counterpart. The generalized method of moment is a generalization of the classical method of moments based on knowing the form of up to **P** moments of a variable **Y** as functions of some parameters.

$$E[Y^j] = h_j(\beta_0) \qquad (1 \leq j \leq p)$$

The method of moment's estimator $\hat{\beta}$ of β_0 is derived by representing the population moments by sample moments and then solve for;

$$\frac{1}{n}\sum_{i=1}^{n}(Y_i)^j = h_j(\hat{\beta}) \qquad (1 \leq j \leq p)$$

One important angle where GMM applies is the instrumental variable (IV) estimation.

Given the model:

$$Y_i = X^{'}\beta_0 + \varepsilon_i, \qquad E[Z_i\varepsilon_i] = 0$$

Z_i in the above model is a vector of instrumental variables, X_i is a vector of explanatory variables. The condition that $E[Z_i\varepsilon_i] = 0$ is known as population "Orthogonality Condition" or "Moment Condition". Orthogonality condition means that elements of Z_i and ε_i being orthogonal in the expectation sense. Since $\varepsilon_i = Y_i - X_i'\beta$, the moment condition refers to the fact that the product of Z_i and $Y_i - X_i'\beta$ has expectation zero at the true parameter value. The GMM estimator emanated from the product of the moment functions and vectors of products of instrumental variables and residuals.

$$g_i(\beta) = Z_i(Y_i - X_i'\beta)$$

The GMM estimator can be found by minimizing;

$\hat{g}(\beta)\hat{A}\hat{g}(\beta) \quad OR \quad \hat{g}(\beta) = \sum_{i=1}^{n} Z_i (Y_i - X_i '\beta)/n = Z'(Y - X\beta)/n$

Minimizing the above functions yield:

$\hat{\beta} = (X'Z\hat{A}Z'X)^{-1} X'Z\hat{A}Z'Y$

Where, $\hat{A} = (Z'Z)^{-1}$ which is identical to 2SLS estimator $X'Z\hat{A}Z'X$ which is non-singular.

The above is usually referred to as W estimator which generalizes the usual two-stage least squares estimator. Hence the name generalized instrumental variable method.

Identification condition
There must be at least many instruments as regressors ($q \geq p$) and these should be correlated with them. If this assumption holds and $q > p$, the equation is overidentified. If $q = p$ it is exactly identified.

J statistic test for whether or not model has been correctly specified. Does the model satisfy certain restrictions? Which models appears to be more consistent with the data?

J statistic is the most common diagnostic tool utilized in the general method of moments' estimation to evaluate the suitability of the model. A rejection of the null hypothesis (probability $\leq$ 0.05) has the implication that the instruments are not satisfying the orthogonality conditions. The J-statistic is distributed as chi-square with degrees of freedom equal to the number of overidentifying restrictions (Baum and Schaffer, 2002).

All data except the environmental stringency index data used in this analysis were obtained from World Bank data. Net export was obtained by deducting merchandize and services import from export. Environmental stringency index data from 1990 to 2015 were obtained from the OECD.Stat database while 2016 to 2018 data were imputed using the least squares analysis. Other imputations made are; percentage with electricity for South Africa 1990 to 1995, India 1990 to 1992 and 2018 for all variables. Exchange rate for Russia was forecasted for 1990 to 1992 and 1994 to 1995.

Results and Discussions

Table 3 below showed the results of the panel stationarity test of the variables of the models. The tests were conducted using four approaches. That is, Levin and Lin and Chu t, Im Pesaran and Shin W-Stat, ADF Fisher Chi Square and Phillip Perron chi square. In most cases there are general consensuses on results. Generally, all the variables are integrated of order one at one percent significant level and we can go ahead and conduct the Pedroni cointegration since they are integrated of orders one.

Table 3: Panel stationarity results

VARIABLE	Levin & Lin & Chu t.	Im Pesaran & Shin W-Stat	ADF Fisher Chi Square	PP Fisher Chi Square	Order of Integration
EXR	0.08716(0.5347) -5.7287(0.0000)	1.0910(0.8624) -4.8103(0.0000)	4.8537(0.9007) 41.5388(0.0000)	5.5726(0.8498) 57.6025(0.0000)	I(1)
FDI	-0.4068(0.3421) -7.2195(0.0000)	-0.8429(0.1996) -7.6837(0.0000)	13.5321(0.1954) 69.7787(0.0000)	19.8247(0.0310) 107.559(0.0000)	I(1)
FDIP	-0.7379(0.2303) -6.2493(0.0000)	-0.6280(0.2650) -5.7696(0.0000)	11.7957(0.2990) 50.6040(0.0000)	9.0841(0.5241) 82.8639(0.0000)	I(1)
GDPC	3.6719(0.9999) - 4.1395(0.0000)	4.0988(1.0000) -3.6814(0.0001)	1.8451(0.9974) 33.8795(0.0002)	1.5551(0.9988) 38.3629(0.0000)	I(1)
GDPPC	3.2399(0.9994) -4.3894(0.0000)	3.5451(0.9998) -- 3.8311(0.0001)	2.4780(0.9912) 34.7169(0.0001)	1.8919(0.9971) 40.5918(0.0000)	I(1)
INFR	-2.8347(0.0023) 0.5672(0.7147)	-0.0274(0.4891) -4.8906(0.0000)	9.3905(0.3104) 42.9817(0.0000)	24.3719(0.0020) 84.1921(0.0000)	I(1)
NEXP	-1.3657(0.0860) -3.1688(0.0000)	-1.2042(0.1143) -5.2163(0.0000)	16.0435(0.0984) 45.9022(0.0000)	7.8114(0.6473) 60.7403(0.0000)	I(1)
OPEN	-1.7167(0.0430) -11.505(0.0000)	-1.9167(0.0276) -9.3601(0.0000)	21.9217(0.0155) 57.4307(0.0000)	20.6691(0.0235) 95.3805(0.0000)	I(1)
STRG	4.2832(1.0000) - 4.02463(0.0000)	3.72763(0.9999) -3.6673(0.0001	11.6767(0.3073) 32.6208(0.0008)	5.6800(0.8414) 56.9738(0.0000)	I(1)
TARR	-2.5433(0.0055) -5.0719(0.0000)	-0.7777(0.2184) -5.6017(0.0000)	13.6353(0.1903) 50.6439(0.0000)	28.8930(0.0013) 97.2934(0.0000)	I(1)

The study utilized the Pedroni panel cointegration test in testing for the cointegration of model one and based also on the null hypothesis of no cointegration. To conduct this test and evaluate our results, eleven statistics were estimated and evaluated. The null hypothesis of no cointegration was rejected by seven of the eleven statistics employed at 0.05 level of significance. Therefore, we conclude that there is cointegration among the variables of model one and that Y_t and X_t are cointegrated and; $\hat{\mu}_t \approx I(0)$.

Table 4: Pedroni residual cointegration results for model 2

Pedroni Residual Cointegration Test
Series: NEXP NEXP(-1) STRG OPEN GDPPC EXR TARR
Date: 08/07/20 Time: 23:49
Sample: 1990 2018
Included observations: 145
Cross-sections included: 5
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
Automatic lag length selection based on SIC with a max lag of 4
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	1.963108	0.0248	-0.400628	0.6557
Panel rho-Statistic	-0.338155	0.3676	0.063710	0.5254
Panel PP-Statistic	-3.212248	0.0007	-2.906541	0.0018
Panel ADF-Statistic	-3.229801	0.0006	-2.947199	0.0016

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	0.800239	0.7882
Group PP-Statistic	-2.816612	0.0024
Group ADF-Statistic	-2.877308	0.0020

The study also utilized the Pedroni panel cointegration test in testing for the cointegration of model two and based also on the null hypothesis of no cointegration. To conduct this test and evaluate our results, eleven statistics were estimated and evaluated. The null hypothesis of no cointegration was rejected by seven of the eleven statistics employed at 0.05 level of significance and nine out of eleven at 0.10 level of significance. Therefore, we conclude that there is cointegration among the variables of model two and that Y_t and X_t are cointegrated and; $\hat{\mu}_t \approx I(0)$.

Table 5: Pedroni residual cointegration results for model 2

Pedroni Residual Cointegration Test
Series: FDIP FDIP(-1) STRG OPEN INFR GDPC
Date: 08/08/20 Time: 06:06
Sample: 1990 2018
Included observations: 145
Cross-sections included: 4 (1 dropped)
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
Automatic lag length selection based on SIC with a max lag of 5
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

Weighted

	Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	2.110762	0.0174	1.497493	0.0671
Panel rho-Statistic	-1.507496	0.0658	-1.247672	0.1061
Panel PP-Statistic	-4.883913	0.0000	-4.771776	0.0000
Panel ADF-Statistic	-4.883866	0.0000	-4.766520	0.0000

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	-0.723120	0.2348
Group PP-Statistic	-5.615725	0.0000
Group ADF-Statistic	-5.474636	0.0000

Table six shows least squares results of model one and two. The coefficient of determination is about ninety four percent showing that the model has captured about ninety-four percent variability in FDIP which is a good fit. The F-Statistic also shows about 410 with zero probability indicating high level of significance. Out of the explanatory variables of the model, only the autoregressive coefficient significantly determines the FDIP indicating the positive agglomeration effect of foreign direct investment.

Although stringency of environmental regulation, income, degree of openness and level of infrastructure exhibited their expected signs, their impacts are not substantially felt to influence foreign direct investments of the BRICS economies. Therefore, pollution haven hypothesis is unfounded based on model one.

Table 6: Ordinary Least Squares results

Panel Least Squares		
Independent Variables	MODEL 1 Dependent Variable is FDIP	MODEL 2 Dependent Variable is NEXP
Constant	-9.28E+09 (-1.026709) (0.3064)	-1.59E+10 (-1.404893) (0.1624)
NEXP(-1)	-	0.757179 (0.757179) (0.0000)*
FDIP(-1)	0.979056 (39.88287) (0.0000)*	-

GDPC	0.000848 (0.877956) (0.3815)	0.010871 (4.718403) (0.0000)*
TARR	-	2.99E+08 (0.846051) (0.3990)
INFR	89728473 (0.877956) (0.3815)	-
OPEN	1.46E+08 (1.564072) (0.1202)	3.62E+08 (1.835498) (0.0687)***
STRG	-4.57E+09 (-1.128843) (0.2610)	-1.60E+10 (-1.703839) (0.0907)***
EXR	-	-10182254 (-0.065915) (0.9475)
R^2	0.938638	0.896148
Adjusted R^2	0.936349	0.891463
Durbin Watson	2.134435	1.772684
F – Statistic (Probability)	409.9546(0.0000)	191.2781(0.0000)
Number of Countries	5	5
Periods Included	28	28
Observations (Panel)	140	140

Note: * means p≤ 0.1, ** means p ≤ 0.05, *** means ≤ 0.01. T-Statistics and respective probabilities are in parentheses. **Source:** Author's computation (2020)

The coefficient of determination of model two shows about ninety percent variability in the net exports have been explained by the explanatory variables of the model. The F statistic is also highly significant. A year lag of net exports significantly explained the current net exports. Income significantly explained trade positively as postulated theoretically. Trade openness positively increased trade in conformity with theory. The main variable of interest is the stringency of environmental regulation which has a negatively significant impact on trade. That means, a unit increase in stringency of regulation reduces trade by about 1.7 million US dollars thus confirming the stringency of environmental regulation as reducing trade. Conversely, a unit decline in stringency of environmental regulation will bring about 1.7 million dollar rise in trade confirming the existence of pollution haven hypothesis via trade for the BRICS.

A major flaw with the use of least squares estimates here is the problem of endogeneity between trade, FDI and stringency of environmental regulation. To overcome this problem, we utilized the panel generalized method of moments which utilized instruments to modify the endogenous explanatory variable of the models in a similar way with the method of two stage least squares (2SLS). The results are presented in table 7.

Table 7: Panel Generalized Method of Moments' Results of the models

Method: Panel Generalized Method of Moments (PGMM)		
Independent Variables	MODEL 1 Dependent Variable is FDIP	MODEL 2 Dependent Variable is NEXP
NEXP(-1)	-	0.733513 (5.640727) 0.0000*
FDIP(-1)	0.983847 37.53343 0.0000*	-
GDPC	0.003864 (2.120611) (0.0358)**	0.026248 (1.868171) (0.0639)***
TARR	-	-4.62E+08 (-1.118905) (0.2652)

INFR	10489818 (0.090585) (0.9280)	-
OPEN	2.59E+08 (2.264440) (0.0252)**	1.14E+09 (2.373369) (0.0190)**
STRG	-2.15E+10 (-2.245710) (0.0264)**	-1.26E+11 (-1.983456) (0.0494)**
EXR	-	1.09E+09 (1.691357) (0.0931)***
R^2	0.930632	0.762928
Adjusted R^2	0.928044	0.754082
Instrument Rank	6	7
Hansen J Statistics (Probability)	3.85E-25 (1.00000)	0.373352 (0.62265)
Number of Countries	5	5
Periods Included	28	28
Observations (Panel)	140	140

Note: * means p≤ 0.1, ** means p ≤ 0.05, *** means ≤ 0.01. T-Statistics and respective probabilities are in parentheses. **Source:** Author's computation (2020)

Table 7 above shows the results of the panel generalized methods of moments (PGMM) . The results were gotten from analyzed data of five BRICS countries over the period of 1990 to 2018 based on data availability, so total number of observations is 140 after adjusting the endpoints. Hansen J-statistic test for over-identifying restrictions confirmed the acceptability of instruments employed and that the results for the two models passed the battery of diagnostic tests. The J statistic of 3.85E-25 (with a probability of 1.0000) and 0.373352 (with a probability of 0.62265) are insignificant. An acceptance of the null hypothesis (probability > 0.05) has the implication that the instruments are satisfying the "orthogonality conditions" therefore the instruments used are not only appropriate but uncorrelated with their respective error terms while the excluded variables are correlated with their respective error terms.

Model one has foreign direct investment (FDIP) as the dependent variable to investigate whether or not weaker environmental regulations attracts more FDIP into the BRICS countries analyzed. Lax in environmental regulation index data was readily made available and other determinants of FDIP were added as explanatory variables. The results indicate that a year lag of FDIP itself positively increases the current FDIP significantly. A dollar increase in immediate past period foreign direct investment wiil bring about 0.983847 dollar rise in the current FDIP. This result is in conformity with the apriori expectation because of positive agglomeration effects of FDIP. Gross domestic product (GDPC) a measure of income significantly boosts the foreign direct investment (FDIP) in conformity with theory. A unit increase in income can bring about 0.003864 rises in foreign direct investment.

Percentage of family with access to electricity (INFR) is our measure of infrastructural availability and it is positively associated with foreign direct investment (FDIP) inflows. However, it has no significant impact foreign direct investment (FDIP) inflows into BRICS countries. Trade openness (OPEN) has a positively significant impact on foreign direct investment as a unit rise in trade openness can bring about 2.59E+08 dollar increase in foreign direct investments inflows into the BRICS. This finding is in consonance with the findings of Shao, Wang, Zhou and Balogh (2019).

The result from the main variable of interest- stringency of environmental regulations – shows that there is a significant negative impact of stringency of environmental regulations on foreign direct investment. A unit reduction in stringency of environmental regulations, other things being constant can bring about -2.15E+10 million dollar rise in foreign direct investment (FDI). This result points to the validation of pollution haven hypothesis which posits that lax or weak in environmental regulations will bring about increase in inflows of dirty FDI. This result is in conformity with the findings of Xing and Kolstad (1997), Ben-David, Kleimer and Viehs (2018) and Ayadi (2019).

Model two tested the hypothesis of pollution haven by looking at it from trade angle and specifically net exports. The results indicate that net export of the immediate past period significantly impacted positively on the net export of the current period. Increase in foreign direct investment also helped in boosting the net export in conformity with expectation. A dollar increase in foreign direct investment, other things being constant can bring about 0.010871dollar rise in net export.

As expected, tariff, a variable capturing trade policies showed expected sign. Increase in average tariff insignificantly depresses net export. It is however unclear why the variable is not a significant one explaining net exports as suggested by theory (Hubbard and O'Brien, 2013 and 2015). Trade openness significantly increases net export in agreement with a priori expectation. A unit rise in trade openness can bring about 1.14E+09 million dollar rise in net export thus confirming the beneficial impacts of openness to trade. Exchange rate has been found to be a determinant of trade at ten percent significant level. There is a direct impact of exchange rate on trade. As the exchange rate is lowered trade becomes more beneficial to the bloc. This is in conformity with theory.

The result of the main variable of interest (stringency of environmental regulations) shows that it is negatively related to the trade variable significantly. A unit decrease in stringency of environmental regulations index other things being constant can bring about 1.26E+11 dollar increase in net export indicating that there is a very high negative relationship between lax in environmental regulations and trade inflows of the BRICS. Therefore we can conclude that lax in environmental regulations do encourage dirty international trade in the BRICS economies thus confirming the existence of pollution haven hypothesis (PHH) in the BRICS Countries via trade. This finding is in tandem with the findings of Ayadi (2019), Jun, Zakaria, Shahzad and Mahmood (2018), To, Ha, Nguyen and Vo (2019); Zhou, Sirisrisakulchai, Liu, Sriboonchitta (2019).

Conclusion and Recommendation

This study investigated the reality or otherwise of pollution haven hypothesis in BRICS countries using panel data spanning from 1990 to 2018. The study employed net exports and foreign direct investments as measures of economic activity (dependent variables for the two models) and stringency in environmental regulation while other determinants of trade such as income, trade policy and exchange rate were captured as independent or control variables. The other model that has foreign direct investment as dependent variable has infrastructure, income and trade openness as control variables. Cointegration, panel least squares and Panel generalized method of moments (PGMM) were used in analyzing the data. A year lag of the dependent variables was included as one of the independent variables of the models to capture dynamism (Blundell and Bond, 1998). The study confirmed the existence of pollution haven hypothesis true for the BRICS countries. The agglomeration effects of FDI and trade was also confirmed by the study among others.

These findings above confirmed that pollution haven hypothesis which posits that industries with polluting technologies and dirty international trade tend to move or relocate to countries or areas (pollution havens) with lax or less stringent environmental regulations is a reality for the BRICS economies. The implication of this is that governments of BRICS countries must weigh the beneficial impact of trade and FDI against the pollution impact of 'dirty' trade and investments before deciding or setting its environmental policy. There is a great need for them to tighten their environmental laws and also strengthened the enforcement agencies so as to make those regulations effective.

References

Acemoglu, D., and Johnson, S., Robinson, J. A., and Yared, P. (2009). Re-evaluating the modernisation hypothesis. *Journal of Monetary Economics.* 56 (8): 1043 -1058.

Agrawal, P. and Saxena, K. K. (2012). Empirical study of pollution haven hypothesis for India. *Artha Vijnana,* LIV (2): 228-251.

Ahmed, Z.and Xiaoyam, Z. (2016). Role of EKC and PHH in determining environment quality and

their relation to economic growth of a country. *Asian Journal of Economics and Empirical Research,* 3(2): 139-144.

Aliyu, M. A. (2005). Foreign direct investment and the environment: pollution haven hypothesis revisited. In Paper prepared for the Eight Annual Conference on Global Economic Analysis, Liibeck, Germany, 9-11 June.

Ayadi, F. S. (2005). A vector autoregressive analysis of trade-environment linkage in Nigeria. *World Review of Science, Technology and Sustainable Development***.** (www.inderscience.com)**,** (2) 2: 191 – 204.

Ayadi, F. S. (2019). Investigating the existence of pollution haven hypothesis (PHH) in West Africa. *Journal of Economics and Policy Analysis.* (4) 2: 47 – 66.

Baltagi, B. H., and Levin, D. (1986). Estimating dynamic demand for cigarettes using panel data: the effects of bootlegging, taxation, and advertising reconsiders. *Review of Economics and Statistics*, (68): 138 -155.

Baum, C. F. and Schaffer, M. E. (2002). Instrumental, variables and GMM: estimation and testing.

Boston College Economics Working Paper, (545): 02 November.

Ben-David, I, Kleimeier, S. and Viehs, M.(2018). Exporting pollution. Dice center working paper 2018-03-020. Sept. [http://www.ssm.com/link/fisher-college-of-business.html] [http:www.ssm.com/abstract=3252563] Visited03/09/2020.

Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics.* 87(11): 115 – 143.

Cole, M. A., Elliot, R. J. R. (2005). FDI and the capital intensity of "dirty" sectors: A missing piece of the population haven puzzle. *Rev. Dev. Econ.*. 9: 530-548.

d'Almedia, N. (2017). Climate and environment issues in the BRICS countries: A cosmopolitan time. *Hermes La Revue.* 79 (3): 173-179.

Danladi D. J. and Akomolafe, J. K. (2003). Foreign direct investment, economic growth, and environmental concern: evidence from Nigeria. *Journal of Economics and Behavioral Studies*. (5)7: 460-468.

Da Silva C, G., Flavio, V.V. and Carlos, C.S.S. (2019). Environmental Kuznets curve, Pollution

Haven Hypothesis and Business cycles: Evidence from BRICS countries. *International journal of Ecological Economics and Statistics.* 40(2).

Dinda, S. (2006). Globalization and environment: Can pollution haven hypothesis alone explain the impact of globalization on environment? First preliminary draft. S. R. Fatepuria College, Beldanga, Murshidabad, WB, India. Economic Research Unit, Indian Statistical Institute, Kolkata, India.

ECOWAS (2016). Trade Regional Statistics regional exports to third countries by detailed product values (US Dollar). Community Computer Centre (CCC) in Collaboration with the Directorate of Communication.

Ederington, J., Levinson, A. and Wang, H. (2009) Are foreign investors attracted to weak environmental regulations? Evaluating the evidence in China. *Journal of Developing Economics.* 90 (1): 1-13.

EPI (2018). *Environmental Performance Index*. Yale University.

Grether, J. M. and de Melo, J. (2003). Globalization and dirty industries: do pollution havens matter? NBER Working Paper Series No 9776.

Ghouali, Y. Z., Belmokaddem, M., Sahraoui, M. A. and Guellil, M. S. (2015). Factors affecting CO_2 emmision in the BRICS Countries: A panel data analysis. *Procedia Economics and Finance*. 26: 114-125.

Holian, M. J. (2012). Principles of economics. Flat world knowledge. [http://www.flatworldknowledge.com] Site visited on 22/08/19.

Hubbard G., and O'Brien A.P. (2013). *Macroeconomics*. Pearson publishing 4th editio

Hubbard G., and O'Brien A.P.(2015). *Macroeconomics*. Pearson publishing 5th edition.

Jun, W., Zakaria, M., Shahzad S. J. H., Mahmood, H. (2018). Effect of FDI on pollution in China: New insights based on wavelet approach. *Substainability*. 10, 3859: 1-20.

Keho, Y. (2016). Trade openness and the environment: A time series study of ECOWAS countries. *Journal of Economics and Development Studies.* (4)4: 61 – 69.

Kellenberg, D. K. (2009). An empirical test of the pollution havens hypothesis with strategic environment and trade policy. *Journal of international economics.* Elsevier. 78(2): 242-255

Kellogg, R. (2006). The pollution haven hypothesis: significance and insignificance. selected paper presented at the American Agricultural Economics Association Annual Meeting. Long Beach, California, 23 – 26 July.

Kuo, L. (2015). West Africa's air pollution reaching dangerously high levels – and we don't know the worst of it. *Quartz Africa.* [http://qz.com] Visited on 12/06/20.

Leslie, J. R.(2016). Enterprise location decisions and the pollution haven hypothesis.

Levinson, A. (2003). Environmental regulatory competition: A status report and some new evidence. *National Tax Journal.* (56): 91-106.

Levinson, A. and Taylor, M. S. (2008). Unmasking the pollution haven effect. *International Economic Review.* (49)1: 223 – 254.

Mathys, J. A. (2002). In search of evidence for the pollution haven hypothesis: Mémoire de Licence, Université de Neuchâtel.

Martinez-Zarazoso, I., Vidovic. M., and Viocu, A. M. (2016). Are the central east European countries pollution havens ? proceeding of international academic conference 3505823, International institute of Social and economic sciences. [https//doi.org/10.1177/1070496516670196]. Visited on 3/04/20.

Mukhopadhyay, K. and Chakraborty, D. (2005). Is liberalization of trade good for the environment? Evidence from India. *Asia-Pacific Development Journal.* (12)1: 109-136.

Murthy, K. V. B. and Gambhir, S. (2018). Analyzing environmental Kuznets curves and pollution havens hypothesis in India in the context of domestic and global policy change. *Australasian Accounting, Business and Finance Journal.* 12(2): 134-156.

Nawaz, S., Iqbal, N., and Khan, M. A. (2014). The impact of institutional quality on economic growth: Panel evidence. *The Pakistan Development Review*. 53(1): 15 – 31.

Riti, J. S. and Kamah, M. (2015). Globalization, economic growth and environmental sustainability nexus in Nigeria (1981 – 2013). *IOSR Journal of Humanities and Social Science.* (20)3: 23-25.

Shao, Y. (2017). Does FDI affect carbon intensity? New evidence from dynamic panel analysis. *International Journal of Climate Change Strategies and Management.* 10(1): 27-42.

Shao, Q., Wang, X., Zhou, Q., Balogh, L. (2019). Pollution havens hypothesis revisited: A comparison of the BRICS and MINT countries based on VECM approach. *Journal of Cleaner Production.* 227:724-738.

Temurshoev, U. (2006). Pollution haven hypothesis or factor endowment hypothesis: Theory and empirical examination for the US and China. CERGE-EI Working Paper Series 292, March. Prague.

To, A. H., Ha, D. T., Nguyen, H.M. and Vo, D.H. (2019). The impact of foreign direct investment on environment degradation: Evidence from emerging markets in Asia. *International Journal of Environmental Research and Public Health.* 16: 1636.

Tobey, J. A. (1990). The effects of domestic environmental policies on patterns of World Trade: An empirical test. *Kyklos.* (43)2: 191-209.

Whitney, N. (2007). Course materials for 14.386 new econometric methods, Spring 2007. MIT

Open Course Ware (http://occw.mit.edu) Massachusetts Institute of Technology. Visited on (31/ 05/2019).

World Bank (1999). *World Development Indicators*, Washington DC.RL: [http://data.wordbank.org/indicator]. Visited on (12/09/2020).

World Bank (2018). World Development Indicators Database.

Wu, T. (2011). China, BRICS & the environment: The dilemma of growth vs the environment is becoming more acute for China and other BRICS nations. The diplomat Nov. 07.

Yoon, H. and Heshmati, A. (2017). Do environmental regulations affect FDI decisions? The pollution haven hypothesis revisited. GLO Discussion Paper, No 86. [http://hdl.handle.net/10419/162778]. Visited on (12/5/2020).

Xing, Y. and Kolstad D. C. (1997). Do lax environmental regulations, attract foreign investment? Department of Economics Working Paper 6-95R. University of Califonia, Santa Barbara. February.

Xu, X. (2000). International trade and environmental regulations: Time series evidence and cross section tests. *Environmental and resource economics.* (17) 3: 233-257.

Zhou, y., Sirisrisakulchai, J., Liu, J., Sriboonchitta, S. (Eds.)(2019). *Factors Affecting Carbon Emissions in the G7 and BRICS countries: Evidence from Quantile Regression. In Integrated Uncertainty in Knowledge Modeling and Decision Making.* Springer International Publishing