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THE NEXUS BETWEEN FOREIGN DIRECT INVESTMENT, OPEN COMMERCE, ICT TAXATION AND CLIMATE CHANGE IN A DEVELOPING COUNTRY

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ABSTRACT

The study explores the relationship between foreign direct investment (FDI), information and communication technology (ICT) taxes, open commerce, and CO2 pollutants in Nigeria from 2010 to 2020 using Pearson Product Moment Correlation (PPMC). CO2 emissions figures are collected in Million Tonnes from the World Data Atlas. Data on ICT taxes and FDI are gathered from the Federal Inland Revenue Service and the OECD database respectively. Trade openness data are obtained from the World Economic Indicators. The findings show that FDI has a very strong negative link with CO2 emissions in Nigeria. Similarly, there is a clear negative association between ICT taxes and FDI. However, there is a significant positive correlation between ICT taxes and CO2 emissions. Open trade has an intangible negative relationship with CO2 and an intangible positive relationship with FDI and ICT taxes. Based on the findings, the study provides recommendations to strengthen government policies in the respective areas of concern.

Contribution/Originality: States find it difficult to resist bids for foreign direct investment (FDI) and information communication technology (ICT) inflows because they sustain economic viability despite their side effects. This research explains the relationships that exist among FDI, international commerce, ICT taxation, and environmental integrity in an emerging economy.

1. INTRODUCTION

In considering global environmental challenges, especially in developing countries, numerous contributing factors have been explored. The roles of foreign direct investment (FDI), information and communication technology (ICT), and open commerce in global warming and climate threats cannot be overestimated. According to Omri and Hadj (2020), the modern global system is characterized by three essential focuses: poor air quality, climate variability, and internationalization (including FDI and trade openness). Consequently, the effects of FDI inflows on increasing carbon emissions have risen to the top of the global agenda (Hao & Liu, 2015). Biodiversity loss has become another critical component of global political, economic, and financial undertakings due to increased global awareness (Ayeche, Barhoumi, & Hammas, 2016). Furthermore, family income, capital inflows, energy consumption, industrial advancement, urbanization, ICT, and trade openness all influence carbon footprints (Sharma, 2011; Tang & Tan, 2015; Wang, Himeda, Muckerman, Manbeck, & Fujita, 2015). The negative impacts of environmental degradation and climate change have drawn the attention of the scientific community to the significant relationships between

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various parameters and environmental toxins. Several studies have been undertaken to analyze the factors that influence greenhouse gas emissions and the connections between them (Jorgenson, Clark, Kentor, & Rieger, 2022; Mohsin, Naseem, Sarfraz, & Azam, 2022).

Furthermore, the use of ICT may boost productive capacity, minimize energy concentration, and put more strain on green energy bills (Moyer & Hughes, 2012). ICT has three distinct ecological effects. First, ICT has a direct environmental effect due to the use of energy and the creation of e-waste. Second, ICT has an indirect influence through the use of ICT devices, advanced driver assistance systems, and micro grids. The third effect is the economic revival brought about by direct or indirect ICT infrastructure (Houghton, 2010). Furthermore, Adedoyin, Bekun, Driha, and Balsalobre-Lorente (2020) identified a favorable association between Industry 4.0 and the role of ICT in encouraging extraordinary improvements in efficiency and quality of life. The expansion of the ICT industry encourages worldwide trade, improves communication networks, and may influence environmental integrity (Ozcan & Apergis, 2018).

In contrast, when industrialized nations give ICT-enabled equipment to developing countries via trade and commerce, it may boost e-waste generation in the latter countries, resulting in environmental degradation. ICT also facilitates intelligence collection and has an impact on modern life (Kurniawati, 2021). As a result of the fourth industrial revolution, which refers to the process of expanding the diversity of alternatives for society, such as knowledge, a healthy lifestyle, and living circumstances, a major shift in social progress is taking place (Yakunina & Bychkov, 2015). Nonetheless, improved cross-national connections and information interchange made possible by FDI and commerce may raise public awareness of the need for environmental protection (Danish, Baloch, Saud, & Tehreem, 2018). Environmentalists and scientists believe that the rapid expansion of the global economy and human activities is to blame for environmental degradation (Mohsin et al., 2022). Traditional energy resources, such as fossil fuels, are seen as contributors to ecological catastrophe. Jorgenson et al. (2022) took a fresh look at the relationship between FDI and the ecosystem. The study found that both the concentration of inward FDI and a country's place in the international FDI network could either expedite ecologically sustainable ripple effects and technological upgrading or result in the outsourcing and detachment of carbon-intensive and ecologically untenable financial transactions. In other words, the environmental implications, whether positive or negative, are potentially greater for states that hold more important positions in the global FDI network, as well as for nations with comparatively higher levels of inbound FDI. Several contemporary studies have found that FDI increases CO_2 emissions (Jorgenson et al., 2022; Mohsin et al., 2022; Tiwari, Nasreen, & Anwar, 2022), whereas others (Danish, 2019; Murshed, 2020) have claimed that ICT reduces CO_2 emissions. Tsaurai and Chimbo (2019) stated that financial development causes an increase in CO_2 pollution in the environment. There is as yet no agreement on the link between FDI, ICT, open trade, and climate change. The current study explores the relationships between the abovementioned components in a developing economy. Moreover, the ICT development tax factor in Nigeria is evaluated in conjunction with the other study variables.

2. LITERATURE REVIEW

Jorgenson et al. (2022) developed cross-national latitudinal estimates of total carbon dioxide emissions and carbon dioxide emissions per unit of GDP to evaluate hypotheses about the influence of FDI, ICT, and open commerce on the climate. Their results demonstrated that, for the whole sample of nations, both pollution concentrations and FDI internet backbone density were strongly associated with inbound FDI stocks, but that these positive correlations were much higher for regions of the world other than the Global North areas. Ultimately, their findings supported the assertion that foreign investment leads to the outsourcing of inefficient and highly polluting industrial processes, resulting in increased fossil fuel use and corresponding greenhouse gas emissions in host societies, particularly those in the Global South.

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Mohsin et al. (2022) used yearly time-series data from 1971 to 2016 to explore the association between a sustainable environment and economic growth in European and Central Asian countries. The ARDL method was used to determine the short-term and long-term connections between the chosen variables. CO_2 emissions indicated environmental protection, whereas energy consumption, personal remittances, GDP, and FDI were independent variables that exemplified economic expansion. CO_2 emissions were the Granger cause of GDP, but energy consumption and FDI were the Granger causes of CO_2 emissions. The findings supported both long-run and short-run connections between variables. The study also found a major negative correlation between CO_2 emissions and GDP in the long run and a positive relationship in the short run that enables the degradation of ecological sustainability as a result of long-term economic expansion.

Tiwari et al. (2022) investigated the influence of stock market development on renewable energy use by endogenizing foreign direct investment (FDI), trade openness, and productivity expansion using a panel dataset of 16 Asian nations from 1990 to 2019. Surprisingly, the empirical results demonstrated the negligible influence of stock markets on Asian renewable energy use. The results also showed that increased commercial activity and economic growth might dramatically cut energy use via a technological effect. Furthermore, PQR data demonstrated that stock market development supported renewable energy initiatives in nations with substantially more established equity markets.

Shehzad, Xiaoxing, and Sarfraz (2021) used the Non-Linear Autoregressive Distributed Lag (NARDL) method to investigate the non-linear impact of FDI and ICT on CO_2 emissions in Pakistan. Furthermore, the study highlighted the influence of population, commerce, and ICT import and production on Pakistan's environmental quality. According to the findings, negative (positive) shocks in ICT increased (decreased) the amount of CO_2 emitted. Furthermore, positive FDI shocks expressly increased CO_2 emissions. However, negative shocks had an insignificant influence on CO_2 emissions. The study found that manufacturing ICT devices at home enhanced environmental quality more than importing them from foreign countries. Furthermore, they revealed a direct relationship between population and CO_2 emissions, although the coefficient of commerce had a negative effect on CO_2 emissions in Pakistan. The study examined the Environmental Kuznets Curve (EKC) theory and concluded that economic growth had a U-shaped relationship with CO_2 emissions, implying that the EKC theory must be rejected.

Kim (2021) looked at the influence of ICT, trade openness, financial deepening, and economic expansion on CO_2 emissions in Korea from 1990 to 2016. An autoregressive distributed lag (ARDL) bounds test validated the variables' co-integration connection. In the long term, economic growth had a quantitatively major influence on the release of CO_2; however, other contributors, including ICT, were not major drivers in greenhouse gas changes. A relationship between economic growth and CO_2 emissions was proved in the long run, but the long-term effects of other elements, notably ICT, could not be ascertained. The study revealed that economic growth and ICT boosted CO_2 emissions in the short run, whereas capital accumulation decreased greenhouse gasses. Trade openness had little influence on pollutant emissions in the short run, as it did in the long run. ICT, specifically, did not help decrease CO_2 emissions in either the short or the long run. To stimulate CO_2 reduction using ICT, the study suggested that the design and implementation of ICT that could successfully save energy should be fostered. The study also observed that ICT taxation has a significant negative relationship with FDI. In other words, ICT development tax policies inhibit FDI in a country. This is another policy issue that requires government intervention to strike a balance with economic productivity; inflows of foreign capital are required to advance an economy despite the accompanying environmental hazards, yet there are many benefits to the host country, ranging from employment to technology transfers. Finally, trade openness was shown to have an insignificant relationship with ICT, FDI, and CO_2. The implication is that open commerce did not affect any of the variables used in the study.

Omri and Hadj (2020) investigated how efficient administration and technical ingenuity supplemented FDI in 23 growing economies from 1996 to 2014. The study revealed that FDI inflows had beneficial effects on the four measures of carbon emissions, whereas enhancing governance quality and technological progress had deleterious

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repercussions on these metrics using the Generalized Method of Moments (GMM) methodology. The connections between FDI and both political and institutional governance reduced CO_2 emissions, while the interactions between technical advancement and FDI lowered CO_2 emissions, except in the model involving CO_2 emissions from electricity and heat production; as a result, environmental quality improved. The authors also highlighted the consequences for policy and future research paths. Murshed (2020) investigated the non-linear effects of ICT commerce on the possibilities of transitioning to sustainable power, optimizing energy efficiency, improving access to greener cooking fuels, and reducing CO_2 emissions across a selection of South Asian economies: Bangladesh, India, Pakistan, Sri Lanka, Nepal, and the Maldives. The study's economic calculations showed that ICT commerce directly boosts renewable energy consumption, raises green energy proportions, decreases energy intensity, supports the use of healthier fuel sources, and minimizes carbon pollution. Furthermore, ICT commerce indirectly reduces CO_2 emissions by increasing renewable energy usage, improving energy efficiency, and increasing access to relatively clean cooking fuel.

Danish (2019) introduced a unique methodological framework by incorporating ICT's connection with FDI and international commerce. The generalized least squares approach was utilized for an empirical analysis of 59 nations along the Belt and Road from 1990 to 2016. According to the findings, ICT reduced CO_2 emissions in nations along the Belt and Road. Furthermore, the stabilizing impact of ICT and FDI lowered CO_2 emissions, as did the interplay between ICT and international commerce. Tsaurai and Chimbo (2019) investigated the impact of ICT and financial inclusion on carbon emissions in developing countries using panel data analysis methods (fixed effects, random effects, pooled OLS, FMOLS), using yearly secondary data from 1994 to 2014. Across all four data analysis approaches, ICT was found to have a substantial beneficial effect on carbon emissions in the absence of interaction factors. After inserting control variables, it was discovered that financial development was a conduit via which ICT boosted carbon dioxide emissions under fixed effects, random effects, and the FMOLS. Financial development was discovered to be a mechanism via which ICT assisted in the decrease of carbon emissions under the pooled OLS. Across all four panel data analysis approaches, economic development was discovered to be a pathway via which ICT reduced carbon emissions in emerging economies.

Shahbaz, Gozgor, Adom, and Hammoudeh (2019) disassembled the ecological Kuznets curve into size, method, and composition implications in a greenhouse gas functionality for the United States, while also including the functions of energy consumption, trade openness, and FDI. The empirical evidence demonstrated the cross-sectional dependence between variables in the presence of structural cracks. Energy usage also contributed to carbon emissions, but the composition impact enhanced environmental quality by cutting CO_2 emissions. Furthermore, trade liberalization reduced CO_2 emissions. Increases in FDI, on the other hand, had a negative impact on ecological quality by increasing carbon pollution. Shahbaz, Khraief, Rehman, and Zaman (2016) studied the relationships between trade liberalization and carbon intensity for three groups of 105 high, middle, and low-income nations, integrating economic development as an additional variable and possible predictor of this association. In the long term, the three variables were shown to be co-integrated. Environmental quality was hampered by trade openness for the high income, medium income, and low income panels, although the impact differed among these different groupings of nations. The panel VECM causality results revealed a feedback effect between trade openness and greenhouse gases at the high and medium income levels, while trade openness Granger causes CO_2 emissions in high and low-income nations. The authors also discussed the policy implications.

Farhani, Chaibi, and Rault (2014) added to the literature by studying the dynamic link between CO_2 emissions, production (GDP), energy consumption, and trade in Tunisia from 1971 to 2008 using the limit testing approach to co-integration and the ARDL methodology. The empirical findings indicated two causal long-run correlations between the variables. There were three unidirectional Granger causation correlations in the short term, which went from GDP, squared GDP, and energy consumption to CO_2 emissions. Arouri, Youssef, M'henni, and Rault (2012) evaluated the link between CO_2 emissions, energy consumption, and real GDP in 12 Middle Eastern and North African (MENA) countries from 1981 to 2005. The findings revealed that, in the long term, energy consumption had

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a considerable positive influence on CO_2 emissions. Sharma (2011) used a dynamic panel data model to study the factors of CO_2 emissions for a worldwide panel of 69 nations. The authors' dataset spanned the years 1985 through 2005, inclusive. The data revealed that trade openness, per capita GDP, and energy consumption, as measured by per capita electric power consumption and total primary energy utilization, all had a favorable influence on CO_2 emissions (Sharma, 2011). In high, middle, and low-income panels, urbanization was found to have a negative influence on CO_2 emissions. GDP per capita and total primary energy consumption per capita were shown to be statistically significant predictors of CO_2 emissions, whereas urbanization, trade openness, and per capita electric power consumption were found to be unfavorable drivers of CO_2 emissions (Sharma, 2011).

3. MATERIALS AND METHODS

The current study has investigated the relationships among FDI, ICT taxation, open commerce, and climate change in Nigeria from 2010 to 2020. The Federal Inland Revenue Service (FIRS) and the OECD database were used to collect statistics on ICT taxes and FDI. Trade openness was calculated using the World Economic Indicators. A quantitative correlational investigation was conducted in this study. A correlational study, according to Cohen, Manion, and Morrison (2007), is a study that includes gathering two sets of data to evaluate the link between them. To achieve the aims of this study, the *Pearson Product Moment Correlation* (PPMC) was applied to test the associations among the selected variables. Correlation coefficients were used to assess the strength of the links between sets of two variables. Since correlation is an effect size, the following parameters were used to describe the strength, as recommended by Evans (1996):

- 00-19 indicates a very weak connection.
- 20-39 indicates a weak correlation.
- 40-59 indicates a moderate association.
- 60-79 indicates a strong nexus.
- 80-100 indicates a very strong relationship.

Thus, the model for this study was specified as follows (1):

$$CO_2 = f(FDI, ICT, TP) \quad (1)$$

where CO_2 is Carbon dioxide emission as calculated by CO_2 emissions per capita (metric tons);

FDI is foreign direct investment in Nigeria.

ICT is the government's information communication technology development tax imposed on internet and ICT-based companies, which includes GSM service providers and all telecommunications firms, internet service providers and cyber companies, and pension administrators and pension-related businesses.

TPN is trade openness, which is determined by the percentage of total exports and imports in GDP (percent).

β_0 = constant.

β_1-β_3 = regression coefficients.

The econometric form is stated as (2):

$$CO_{2t} = \beta_0 + \beta_1 lnFDI_t + \beta_2 lnICT_t + \beta_3 lnTPN_t + \varepsilon_t \quad (2)$$

where *ln* is the natural logarithm,

Et = error term.

On the a priori, we expect; $\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 > 0$.

4. RESULTS AND DISCUSSION

Table 1 displays the descriptive statistics of the variables obtained from EViews software. Inferential analytics are simple summary parameters that describe a specific data set, which might be a depiction of the complete population sample of the population. The results in Table 1 show that the mean, median, and maximum values for lnCO_2, lnFDI, lnICT, and lnTPN are approximately 5, 15, 9, and 12, respectively. The standard deviation values show a low

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dispersion while the skewness has a negative deviation for lnFDI and lnTPN. In this study, normal distribution is established as the kurtosis is not above the value of 3 and the Jarque-Bera p-value is above the value of 0.05 individually and collectively, as shown in Table 2 and Figure 1.

Table 1. Descriptive statistics.

Type	$LNCO_2$	LNFDI	LNICT	LNTPN
Mean	4.62	15.4	9.21	12.7
Median	4.60	15.3	9.20	12.8
Maximum	4.73	15.9	9.79	13.1
Minimum	4.51	14.5	8.68	12.3
Std. Dev.	0.08	0.45	0.30	0.24
Skewness	0.15	-0.01	0.06	-0.53
Kurtosis	1.63	2.08	2.99	2.29
Jarque-Bera	0.89	0.39	0.01	0.75
Probability	0.64	0.82	0.99	0.69
Sum	50.8	167	101	139
Sum Sq. Dev.	0.06	2.02	0.91	0.58
Observations	11	11	11	11

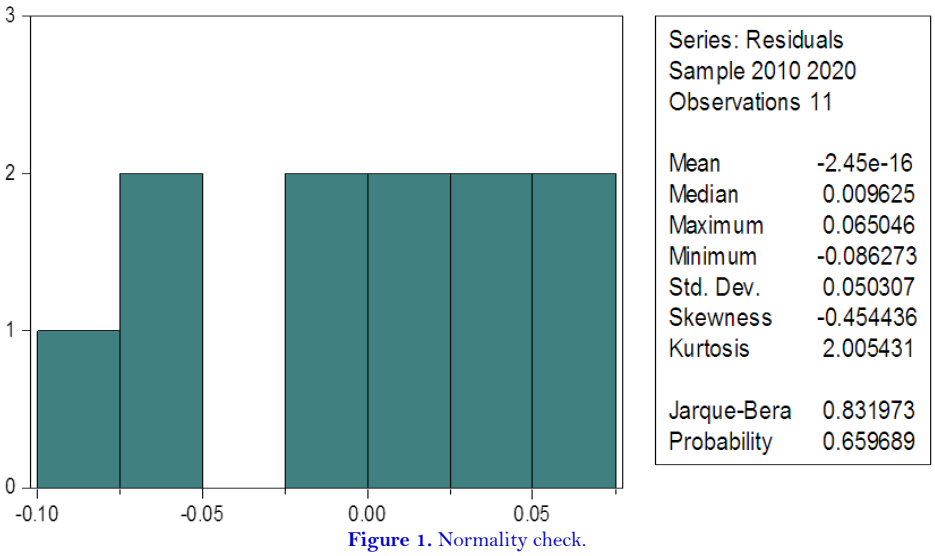

Figure 1. Normality check.

Table 2. Analytical checks.

Type Diagnostic Tests	P-Value
Ramsey RESET Test for Stability	0.68
Breusch-Godfrey Serial Correlation LM Test	0.43
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.23
Histogram Normality Test: Jarque-Bera	0.66
Standard Error of regression	0.06
Durbin-Watson	1.60
Multi-Collinearity test:	VIF
lnFDI	2.45
lnICT	2.13
lnTPN	1.40

Table 3 illustrates the group data's unit root test, which demonstrates that the dataset is stable at level. Consequently, the results of these tests support the stability and applicability of the datasets and the model used for this study.

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Table 3. Group unit root test: Summary.

Series: $LNCO_2$, LNFDI, LNICT, LNTPN				
Sample: 2010 2020				
Method	**Statistic**	**Prob.****	**Cross-sections**	**Obs.**
Null: unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.36	0.01	4	39

Note: **Significant at 1% * Levin, Lin & Chu t unit root confirmation at level.

Figure 1 shows the outcome of the normality check, which validates the normality of the entire dataset and the model utilized in this investigation. The Ramsey RESET test was used to confirm the model's integrity. The assumption is that if the p-value is greater than 5%, the model is correctly specified; on the other hand, if the p-value is less than 5%, the model is unstable. The p-value of the Ramsey RESET test in this study is 0.68, which is more than 0.05, as shown in Table 3. As a result, the model is robust, as further demonstrated by the unit root test in Table 2 and Figures 2 and 3. Similarly, the Breusch-Godfrey Serial Correlation LM Test was used to ensure that the model had no serial correlation or autocorrelation. The resulting p-value of 0.45, which is more than the significance level of 5%, demonstrates that there is no autocorrelation. The Durbin-Watson statistic of about 2 in Table 3 confirms this conclusion, as do Figures 2 and 3, which show the blue line between the 5 percent level boundaries. The standard error of regression in Table 3 helps to establish that the forecast is free from bias.

One of the assumptions of linear regression analysis is homoskedasticity. It is necessary to guarantee the accuracy of the predictions, the validity of the forecast bounds for the dependent variable, and the validity of the 95% confidence interval and p-values for the variables. Thus, the linear regression model is homoskedastic when the p-value of heteroskedasticity is greater than 0.05. The p-value in this analysis is 0.23; as this is above 0.05, it indicates that the model is fairly stable. There is also evidence of an absence of multi-collinearity in the model, as shown by the variance inflation factor (VIF) values in Table 3. The predictor variables show VIF values that are below the value of 10, signifying the absence of multi-collinearity.

Table 4. Correlation analysis.

Sample: 2010 2020				
Included observations: 11				
Correlation				
t-Statistic				
Probability	**$LNCO_2$**	**LNFDI**	**LNICT**	**LNTPN**
$LNCO_2$	1.00			
LNFDI	-0.71	1.00		
	-3.02	-		
	0.01	-		
LNICT	0.65	-0.66	1.00	
	2.56	-2.60	-	
	0.03	0.029	-	
LNTPN	-0.07	0.37	0.06	1.00
	-0.21	1.18	0.17	-
	0.84	0.27	0.87	-

Table 4 shows the correlation results of this research, which is the essential information that the study is attempting to represent. Correlation analysis is necessary to emphasize the link between the variables and to demonstrate the extent to which FDI, trade openness, and taxes from ICT-based businesses in Nigeria correlate with climate change. Table 4 shows that FDI has a substantial negative connection with CO_2 emissions in Nigeria at the 1% significance level. The correlation coefficient is 70.9%, the t-statistic is -3.02, and the p-value is 0.01. The results reveal that FDI inflows into the nation are directly associated with climate change and pollution intensity in the

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country. This observation is consistent with the recent investigations of Jorgenson et al. (2022); Mohsin et al. (2022); Tiwari et al. (2022). Table 4 also demonstrates a link between CO_2 emissions and open commerce, which is insignificantly extremely weak but negative. Similarly, the relationship between ICT taxes and CO_2 emissions is positive and robust, at 65%, with a p-value of 0.03. This indicates that Nigeria's strategy of taxing ICT-based firms is ecologically sound, despite the environmental challenges connected with technology transfer from developed nations.

Furthermore, there is a substantial but negative link between ICT tax and FDI. This finding indicates that Nigeria's ICT tax discourages foreign direct investment. It has also been discovered that open commerce has a weak positive link with both ICT taxation and FDI. The policy implication is that the government will need to revise its ICT tax policy in favor of FDI to stimulate the entrance of technology and encourage job creation.

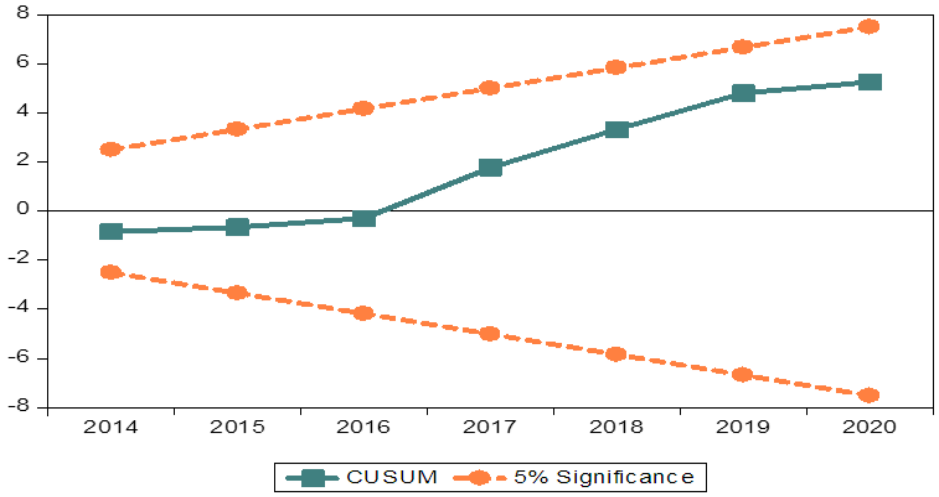

Figure 2. CUSUM test.

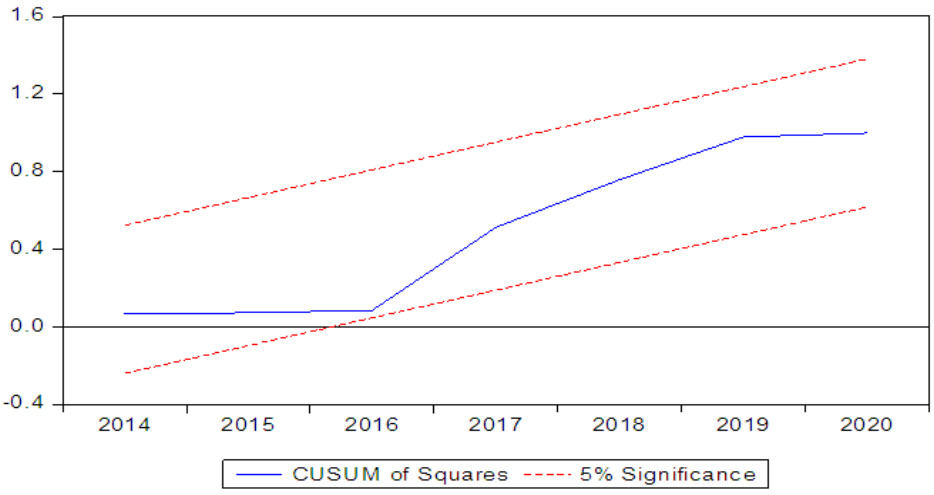

Figure 3. CUSUM of Squares.

5. MODEL ROBUSTNESS CHECK

To avoid linear function measurement errors, the robustness of the coefficients in the generated models was verified using the CUSUM and CUSUMSQ tests (Pesaran & Pesaran, 1997). If the statistic falls between the indicated confidence intervals, the estimated coefficients are constant (Brown, Durbin, & Evans, 1975). The results of these stability tests are depicted in Figure 2 and Figure 3, where Figure 2 displays CUSUM, and Figure 3 shows CUSUMSQ. Because the predicted values for both tests are between the confidence ranges at the 5% significance level, the stability of this model is validated for the given sample period.

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6. CONCLUSIONS

The study's findings reveal that FDI has a direct negative impact on climate change in Nigeria. The policy implication is that the government must screen the types of foreign direct investment that are permitted to operate in the country, although it is necessary to assess both the costs and advantages of FDI before establishing policies favoring or opposing certain FDI inflows. This report will be used to advise government policy about FDI inflows into Nigeria. Therefore, one of the factors that must be carefully evaluated is the environmental impact of such FDI operations. No advantage can equal the health risks associated with FDI activity. Consequently, social and public health concerns must be prioritized in government regulations governing FDI activities.

A secondary policy issue is the apparent negative link between ICT taxes and FDI inflows. This is a policy challenge that the government may want to reconsider in order to boost FDI inflows and operations in the nation. Given this evidence, this research adds great value to the empirical literature while also making crucial policy recommendations.

Thus, the study suggests the implementation of relevant tax regulations to boost FDI and ICT inflows. There is a need for a tax incentive for ICT-based FDI, as it promotes enormous job creation and the improvement of exchange rates and Nigeria's domestic markets. Where applicable, regular tax cuts at intervals will be healthy and helpful to attract foreign investors. Although Nigeria has not set itself up as a tax haven, its usefulness in fostering overseas investment means that it should be experimented with in the country. Most importantly, while ensuring FDI and ICT thrive in the country, this study highly recommends the adoption of pollution reduction laws and charges. Furthermore, this study strongly recommends the adoption of green technology by foreign companies in compliance with sustainable development goals 13 and 3, which center on climate action, ecology preservation, health, and well-being.

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