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Environmental Accounting Moderated by Technological Advancement and Firm Value of Listed Multinational Firms in Nigeria

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Abstract: Objectives: This study investigated environmental accounting moderated by technological advancement and firm value of listed multinational firms in Nigeria. **Prior Work:** Nigerian atmospheric and social environments have suffered environmental abuse and degradation occasioned by the indiscreet acts of firms in a bid to improve their values. **Approach:** The study adopted *ex-post facto* and longitudinal research designs, and population comprises 50 multinational firms listed on the Nigeria Exchange Group as at 31st December 2022. The population formed the sample size of the study using census sampling method. The data obtained were from secondary source via published annual reports within a period 2008 to 2022; descriptive statistics and panel regression analysis were used for the analysis. **Results:** Technological advancement significantly moderated environmental accounting and firm value with co-efficient of 1.870349 and P-value of 0.026. **Implications:** It was also concluded that technology advancement played significant influence on firm value which assisted in environmental accountability and performance. **Value:** It was recommended that multinational firms were encouraged to invest more in technology, particularly as related to recycling of energy.

Keywords: Economic Development; Innovation; Technological Change; Growth

JEL Classification: H23

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1. Introduction

Environmental accounting requires an advanced level of business activities to guarantee maximum production, effectiveness, efficiency and improvement of service delivery. More so, the operation of a firm in an environment will ensure that wastes discharged from its activities are properly disposed into a useful form either material cycling or energy cycling. This exposes the moderating role of technological advancement regarding environmental accounting practices of listed multinational firms and their firm value (Mohammed et al., 2016). Technological advancement involves the level of knowledge and advances in technology. Nigerian firms are expected to compete with their counterparts globally where there is relative advancement in technology. This technological advancement shows the method through which a product is produced that has a multiplier effect of reducing the resources input required for production (Al-Tuwaijri et al., 2014). The ideology of environmental accounting goes beyond reporting but serves as the ethical behaviour of firms to perform their business operation in a manner that will be able to preserve the world (Yang et al., 2021). This perspective, therefore, emphasizes the significance of technological advancement in the discussion of environmental accounting and firm value.

The Nigerian atmospheric and social environments have witnessed their fair share of global environmental abuse and degradation. These abuses have resulted in the defacement of the environment and the molestation and dehumanization of human and animal habitats by companies in a bid to make more profits and maximize shareholders' wealth (Ekubiat, 2019). This environmental degradation has propelled stakeholders to seek measures of holding firms accountable for their environments. Part of the accountability measures saw the advent of the concept of environmental accounting which has largely been accepted in most developed countries. In the case of Nigeria, proper attention has not been given to the disclosure of non-financial information because no framework mandated environmental accounting reporting in Nigeria (Igbekoyi et al., 2021).

Existing literature have argued that environmental abuse and degradation still occur in Nigeria because there are no enabling regulations regarding environmental disclosure in Nigeria (Adegbie et al., 2020; Igbekoyi et al., 2021; Khanifah et al., 2020). Although these assertions hold true, this study however views the inadequacies in disclosure and compliance with environmental laws from the perspective of technological deficiencies. If an organization has adequate and

relevant technological tools in line with global regulations, they are bound to utilize them irrespective of the provisions of regulatory law; because they will want to ensure effectiveness and cost minimization through the process of cycling energy and material waste. This form the basis upon which this study postulates that technological advancement has a moderating effect in determining the extent to which a firm would be environmentally accountable to maximize firm value. Technology is a vital tool for development, especially with multinational firms that have international competition and promote market capitalization (Carandang & Ferrer, 2020). The material recycling and energy recycling strength have impact on determining the environmental sustainability potential of the firm (Narcyz et al., 2019). It is therefore expedient that technological advancement is introduced to achieve a realistic result when assessing the interaction between environmental accounting and firm value; which this study actualized.

2. Conceptual Focus

2.1. Environmental Accounting, Technological Advancement and Firm Value

Narcyz et al. (2019) discussed the importance of technological advancement that could be used to assess development and growth in a country through the firm's operation that would produce multiplier effects on people's welfare within and outside the firm operation alongside tax payment to the government.

Yuniarti et al. (2022) stated that a positive effect would be ensured on the firm value when introducing green innovation in the operation of a firm in a given period. This serves as a practical step for a firm by devising the technological method of converting the environmental effect of material and energy cycling into more viable ways that will improve firm value in the long run.

Dian et al. (2019) stated that green innovation ensure a significant impact between environmental accounting and firm value, and the application of technological advancement in operation of a firm could result in a greater return on firm value for a given period. This serves as a better way of converting most environmental waste resources into usable forms that can generate more value in the operation of a firm.

A technological advancement is a vital tool for development, especially with multinational firms that have international competition and promote Nigerian capital

market (Carandang & Ferrer, 2020). The material recycling and energy recycling strength ensured environmental sustainability of a firm (Narcyz et al., 2019).

Also, environmental accounting has majorly been assessed as a whole component. Although the findings of the studies revealed positive effects (Uyagu et al., 2017); some negative effects (Votsi et al., 2017; Abdulrahman, 2018); while others showed no effect on financial performance (Hasan & Hakan, 2012; Emeka-Nwokeji & Osisioma, 2019).

The weakness of these holistic evaluations is that it will be difficult to provide lasting solutions to the deficiencies of environmental accounting in developing countries, especially in Nigeria. There is a need to evaluate each component of environmental accounting to determine how each component interacts with firm performance. This will give the opportunity to adequately provide information that will help firms determine the area of environmental accounting that require more concentration.

In conclusion, the literatures reviewed on technological advancement of environmental accounting and firm value as discussed above necessitated current study to further examine relationship that exist between technological advancement as a moderating variable on environmental accounting and firm value within time frame specified.

2.2. Technological Advancement

Technological advancement is a process of saving energy through conservation and efficient improvement in energy consumption with help of initiatives that ensured energy recycling and generated more revenues that produce positive effect on firm value in a given period (Oyedokun et al., 2019). Technological advancement would improve firm value in developing countries that would ensure economic growth and development (World Bank, 2015 & Akinwale et al., 2017). Hartoyo and Daryanto (2016) stated that introduction of various enterprises would improve firm value, and this replaces existing information systems that would provide new market opportunity. Technological advancement would ensure dissemination of information and knowledge that encourage development, social and economic changes (Osborn et al., 2015).

Technological advancement serves as a means of generating employment opportunities, social and economic development in a country that ensured globalization through recycling waste in the operation of a firm (Rampersad &

Troshani, 2018). The application of technological advancement in the operation of a firm majorly depended on management of environmental issues in a country that produces multiplier effects on cost reduction and efficiency. (Tarutė & Gatautis, 2014).

The changes in environment as a result of technological advancement would ensure business development and survival (Dut, 2015). It was submitted that firms could overcome technological applications through effective planning and good innovation (Neneh & Zyl, 2012). Rahim and Zainuddin (2016) stated that operation of a firm in an environment involves rapid technological and market changes that could lead to low productivity in a given period. Narcyz et al. (2019) stated that technological advancement led to more development and growth within and outside organizational operation area. It was further stated that technological advancement was major idea that could be used to bring development within internal systems of a firm with consideration of different sectors in an economy.

Technological Advancement relates way a product is produced that reduces resource input required for production. This is the basis where study was proxied on material and energy recycling. The material recycling involves recycled input materials while energy recycling contains power saved through conservation and efficient on energy consumption through initiatives that ensured energy recycling that generate more revenues and improve firm value (Oyedokun et al., 2019).

3. Theoretical Focus

3.1. Diffusion of Innovations Theory

The theory was propounded by Everett Rogers (1962) as argued that diffusion is a process where innovation is communicated through certain channels among participants in a social environment. This theory explained method new idea and technological advancement could be utilized to assess firm value and environmental civilization. Nwosu et al. (2015) said that innovations propounded above served as a means of spreading information within an organization that ensured survival.

The theory integrates previous sociological theories of behavioral change and explains passage of an idea through stages of adoption by different actors. The main assumptions in the diffusion of innovations theory are:

Innovators: People who are open to risks and try new ideas;

Early adopters: People who are interested in trying new technologies and establish them in an environment;

Early Majority: These are people develop innovation within mainstream of society;

Late Majority: these are people who follow early majority in adopting innovation as part of daily life;

Laggards: These people lag behind general population in adopting innovative products and new ideas.

3.2. Empirical Review

Nwosu et al. (2015) examined impact of technological innovation of manufacturing firms and firm value in Nigeria. Structured questionnaire was used to gather data with utilization of T-test for the analysis and the result revealed that technological innovation displayed a significant impact on firm value. The study recommended that multinational firms in Nigeria should give more attention to technological advancement in order to ensure efficiency and effectiveness.

Dian *et al.* (2019) stated that green innovation ensures a significant impact between environmental accounting and firm value, and application of technological advancement in operation of a firm could result in a greater return on firm value for a given period. This serves as a better way of converting most environmental waste resources into usable forms that can generate more value in the operation of a firm.

Adeniyi and Adebayo (2020) examined effect of green management cost on financial performance of listed Oil and Gas firms in Nigeria. Secondary data were used and applied panel regression analysis; it was discovered insignificant relationship among variables and recommended adequate information disclosure by firms at required period.

Okeke et al. (2021) examined effect of carbon emission disclosure on economic value added (EVA) of Oil and Gas companies in Nigeria. Secondary data were used to collect data from annual reports within 2008-2020 with utilization of ordinary least square regression analysis. The results showed positive relationship between variables and recommended proper environmental sustainability reporting.

Zhang and Zhu (2022) examined environmental accounting system model based on artificial intelligence block chain and embedded sensors, and the study was conducted as a result of increasing communication technology in the business environment in China. The study was based on theoretical where suggestions were given on reliability assurance of accounting information process.

Al-Adeem (2023) examined accounting as a sustainable crafted technology for human exchange activities with nature: A defense of accounting continuity. The paper was produced to address ecological problems in a business environment that based on theoretical issues in Nigeria. Olaoye and Alao (2023) examined effect of green accounting practice on business health of listed oil and gas firms in Nigeria. Secondary source was used to collect data with utilization of regression analysis, and ex-post facto research design was applied. It was discovered insignificant relationship among variables and concluded that green accounting practices greatly influenced business health of firms in Nigeria.

Kong et al. (2023) examined moderating role of technological innovation on Environment, Social, and Governance (ESG) Performance and Firm Value as a result of inability of previous studies to consider impact of technology on environmental issues in the world. Secondary source was used to gather data and analysed through multiple regression, and it was discovered that positive relationship existed between variables.

4. Research Methods

The research designs adopted are *ex-post* facto and longitudinal research designs. Data for the study were obtained from secondary sources via published annual and sustainability reports of multinational firms as listed in the Nigerian Exchange Group as at December, 2022. The population of the study comprised 50 multinational firms listed on Nigerian Exchange Group as at 31st December 2022. The firms were drawn from various sectors of the Nigerian Exchange Group comprising; agricultural, basic material, consumer goods, consumer services, financial services, industrial goods, ICT, health care, natural resources and oil and gas sectors. The sample size was whole of 50 multinational firms through using census sampling method.

In the moderating effect of technological advancement on effects of environmental accounting on firm value was investigated. The model was stated to reflect how

technological advancement affects each component of environmental accounting used in this study. The econometric model is stated thus:

$FV_{it}=\beta_0 + \beta_1 EFA_{it*}TA + \beta_2 ECA_{it*}TA + \beta_3 EMA_{it*}TA + \beta_5 ENA_{it*}TA + \mu_{it}$ ---------- *equation 3.1*

Where;

FV = Firm value

EA = Environmental Accounting

EFA = Environmental Financial Accounting

ECA = Environmental Cost Accounting

EMA = Environmental Management Accounting

ENA = Environmental Nation Accounting

TA = Technological Advancement

Description of Variables

Table 1

	Explanation	Measurement	
Material recycling	This is a percentage of materials used such as recycled input materials	This is the value spent on recycled input materials that is measured with allocation of 20.	Oyedokun et al. (2019)
Energy recycling	This involves direct and indirect energy consumption by primary energy source and energy saved due to conservation and efficiency improvements. This ensures energy-efficient or renewable energy-based products and services	This is the amount spent on primary energy source for conservation and efficiency improvement that is measured with allocation of 30.	Oyedokun et al. (2019)
Firm value	This is the incremental value in the operation of a firm for a given period in conjunction with the effective organization management	Tobin's Q is total market value divided by total asset value	(Garg) 2015

Source: Researcher's compilation 2026

Expected Findings

The *a priori* expectation of this equation based on evidence of literature reviewed is that technological advancement significantly moderated effects of environmental accounting on firm value.

Data Analysis and Findings

Descriptive Statistics

Table 2

Variables	Obs	Mean	S.D	Std. E	MIN	MAX	SUM	SKW	KURT	J.B.	P. Value
Tobin's Q	750	.01338	.0191	.0006	0.000	.1370	10.042	2.464	11.203	2897.5	0.0000
Material Cycling	750	.8057	.4579	.0167	0	1.386	604.27	-.593	2.2914	59.704	0.0000
Energy Cycling	750	.44497	.4192	.0153	0	1.386	333.73	.1588	1.648	60.371	0.0000

Source: Researcher's Compilation 2026

In the Table 2, it was indicated that energy cycling showed a mean value of 0.44497 with a standard deviation of 0.4192, and this moderated variation in firm value of sampled multinational firms considering its distance to mean value. The total sum of energy cycling was 333.73 and standard error of mean was 0.0153 as indicated a 15.3 per cent difference in sampled mean and population mean. The multinational firms with minimum energy cycling scored of 0 and maximum was 1.386; the variable data were positively skewed and normally peaked as indicated 0 .1588 for skewness and 1.648 for kurtosis. The Jarqueberra test for normality showed that data were not normally distributed considering its statistics of 60.371 with a P-value of 0.0000 which indicated a significance for null hypothesis test and data abnormality at $P<0.05$.

Panel Unit Root Test

Table 3

Variable	Levin, Lin & Chu t*		Harris-Tzavalis unit-root test	
	Test-statistics	P-value	Z-Statistics	P-value
Firm Value	-26.7903	0.0000	-3.7592	0.0001
Material recycling	-5.0009	0.0000	-24.6880	0.0000
Energy recycling	-5.7776	0.0000	-22.8391	0.0000

Source: Researcher's Compilation 2026

The results of unit root tests were displayed in Table 3 where all variables were integrated order of zero which was 1(0) and significant at a 5 percent level. Therefore, null hypothesis was rejected and concluded that series were stationary.

Therefore, it was not necessary to conduct co-integration test to determine long-run relationship among variables. The panel least square was capable of estimating an efficient model that was less spurious.

Regression Results

Table 4

Variable	**Co-ef.**	**Std. Err.**	**z**	**P>|z|**
WDP*Materials cycling*Energycycling	1.870349	0.841439	2.220.026	
GBW*Materials cycling*Energycycling	-2.371168	0.4782327	-4.96	0.000
DFWR*Materials cycling*Energycycling	0.7380694	1.130432065	0.514	
DPZL*Materials cycling*Energycycling	-3.268984	0.9721639	-3.36	0.001
DNRE*Materials cycling*Energycycling	2.504756	0.6581046	3.81	0.000
AAEPVC*Materials cycling*Energycycling	2.418776	0.9373008	2.58	0.010
EDTC*Materials cycling*Energycycling	0.9914082	0.7326147	1.35	0.176
EIFC*Materials cycling*Energycycling	1.223401	1.080995	1.13	0.258
EXFC*Materials cycling*Energycycling	-0.9983024	1.240735	-0.80	0.421
EVRM*Materials cycling*Energycycling	-2.771166	0.7783996	-3.56	0.000
AEMR*Materials cycling*Energycycling	-1.545287	0.8192886	-1.89	0.059
EVMG*Materials cycling*Energycycling	0.3642871	0.9589603	0.38	0.704
CLPC*Materials cycling*Energycycling	0.321043	0.4463486	0.72	0.472
NER*Materials cycling*Energycycling	-1.549708	0.7798989	-1.99	0.047
CNA*Materials cycling*Energycycling	3.620661	1.646503	2.20	0.028
_constant	5.944642	0.341378	17.41	0.000
R-sq = 0.1198				
Number of obs = 750				
Wald chi2(15) =74.69				
Prob> = 0.0000				

Source: Researcher's Compilation 2026

The regression result showed how technological advancement moderated relationship between environmental accounting with its proxies such as environmental financial accounting, environmental cost accounting, environmental management accounting and environmental national accounting affected firm value after meeting basis for a Best Linear Un-bias Estimate (BLUE) as shown in Table 4.34. After correcting statistical problems of heteroskedasticity and cross-sectional dependence observed in model specified using panel-corrected standard error regression, and results indicated that linear relationship between models showed that linearity of variables were different from zero as indicating wald chi2 of 25.11 and probability value of 0.0224; this showed that model was a significant.

The overall result showed that technological advancement positively moderated effect of environmental accounting on firm value in Nigeria, and showed an R-square value of 0.1198 which implied that joint power of variables as influencing firm value was 11.98 percent. As displayed in Table 4 that technological advancement positively moderated between waste disposal and Tobin's Q showing with a coefficient of 1.870349, z-statistics of 2.22 and probability value of 0.026. Also, technological advancement negatively moderated between global warming and firm value of multinational firms in Nigeria. This was evidenced by showing a coefficient of -2.371168, z-statistics of -4.96 and a probability value of 0.000. Furthermore, technological advancement negatively moderated between depletion of ozone layers and firm value in Nigeria. This is evidenced by showing a coefficient of -3.268984, z-statistics of -3.36 and probability value of 0.001, and this showed that whenever firm discovered its potential on material and energy recycling, this would lead to continuous exploitation of table water and improved firm value in long run.

The technological advancement positively moderated between depletion of non-renewable energy and firm value of multinational firms in Nigeria. This was evidenced with a co-efficient of 2.504756, z-statistics of 3.81and probability value of 0.000. The results also showed that technological advancement positively moderated between environmental prevention cost and firm value in Nigeria with a coefficient of 2.418776, z-statistics of 2.58 and probability value of 0.010. Likewise, in Table 4.34, technological advancement negatively moderated effect of environmental risk management (EVRM) on firm value in Nigeria with a co-efficient value of -2.771166, z-statistics of -3.56 and a probability value of 0.000.

It was discovered that technological advancement negatively moderated natural environmental resources (NER) on firm value as measured by Tobins' Q in Nigeria

with a co-efficient value of -1.549708, z-statistics of -1.99and probability value of 0.047. Likewise in table 4.54, it was shown that technological advancement positively moderated conventional national account on firm value with a co-efficient value of 3.620661, z-statistics of 2.20 and probability value of 0.028; this showed that technology advancement would improve firm value through natural environmental resources. These findings aligned with results of Momoh (2020) that investigated environmental practices and firm performance of listed telecommunication in China, and discovered significant relationship between variables. Likewise, in Arumona et al.(2020) as assessed effect of environmental practices on financial performance of quoted oil and gas firms in Nigeria, and discovered a positive relationship between variables.

5. Discussion of Findings

The moderating effect of technological advancement on environmental accounting displayed positive effect on firm value. These findings aligned with results of Osborn et al. (2015) which investigated environmental practices and firm performance of listed telecommunication firms in China, and discovered that there was a significant effect of environmental management on firm value. Also, in the study of Arumona et al.(2020) on effect of environmental practices on financial performance of quoted oil and gas firms in Nigeria, and the outcome revealed that environmental practices displayed a significant effect on financial performance of quoted oil and gas firms.

6. Conclusion

In considering moderating effect on variables, it was shown that technological advancement positively moderated relationship between (WD &Tobin's Q: Co-eff = 1.870349; Z-statistics = 2.22; P = 0.026). Also, technological advancement indifferent moderated relationship between (GW & Tobin's Q: Co-efficient = -2.371168; Z-statistics = -4.96; P = 0.000). Furthermore, technological advancement indifferent moderated relationship between (DOL & Tobin's Q: Co-eff = -3.268984; Z-statistics = -3.36; P = 0.001). Technological advancement significantly moderated relationship between (DNRE: Co-efficient = 2.504756; Z-statistics = 3.81; P = 0.000). (EPC: Co-eff = 2.418776; Z-statistics = 2.58; P = 0.010). (CAN: Co-eff = 3.620661; Z-statistics = 2.20; P = 0.028). Likewise, technological advancement negatively moderated (EVRM& Tobin's Q: Co-eff = -2.771166; Z-statistics = -3.56;

P = 0.000). (NER& Tobin's Q: Co-eff = -1.549708; Z-statistics = -1.99; P = 0.047). It was also concluded that technology advancement played significant influence on firm value which assisted in environmental accountability and performance.

7. Recommendations

It has been substantiated that technological advancement positively moderated relationship between environmental accounting and firm value. It is recommended that multinational firms are encouraged to invest more in technology, particularly as it relates to the recycling of energy.

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Appendix 1

TOTAL	List of Multinational Companies in Nigeria
24	7up Bottling Company FMCG Multinational
47	ABSA CAPITAL Investment bank
29	Accenture Consulting Multinational
33	Addax Oil & Gas Multinational
28	Airtel Nigeria Telecommunication Multinational
56	Aspen Pharmacare
22	Baker Hughes Oil & Gas Multinational
48	BANK OF BEIRUT
50	British Airways
20	British American Tobacco FMCG Mull 'National
11	Cadbury FMCG Multinational
2	Chevron Oil & Gas Multinational
53	CiscoPlc
13	Coca cola FMCG Multinational
39	Dangote Group
36	DHL Logistics Multinational
52	Diageo plc
35	ENI (Saipem) formerly AGIP Oil & Gas Multinational
9	Etisalat Nigeria Telecommunication Multinational
55	Fidson Healthcare Plc
41	First Bank of Nigeria
19	Friesland Foods WAMCO FMCG Multinational
16	GE Conglomerate Multinational
18	GlaxosmithklinePharmaceticals Multinational
40	Globacom
12	Google Technology Multinational
42	Guaranty Trust Bank

17	Guinness FMCG Multinational
6	Halliburton Energy Oil & Gas Multinational
43	Honeywell Flours
37	IBM Technology Multinational
57	John Holt Plc
49	JP MORGAN CHASE & Co
10	Julius Berger Construction Multinational
8	KPMG Consulting Multinational
25	Lafarge Cement Construction Multinational
38	MAERSKGROUP Conglomerate Multinational
3	Mobil Oil & Gas Multinational
27	MTN Telecommunication Multinational
44	Multichoice (Media) Multinational
54	*Neros Pharmaceuticals*
5	Nestle Nigeria FMCG Multinational
14	P&G FMCG Multinational
23	Price Waterhouse Cooper (PWC) Consulting Multinational
15	PZ FMCG Multinational
21	Schlumberger Oil & Gas Multinational
1	Shell Petroleum Development Company (SPDC) Oil & Gas multinational
31	Stanbic IBTC Banking Multinational
34	Standard Chartered Bank Banking Multinational
51	The International Business Machines Corporation (IBM)
4	Total Oil & Gas Multinational
45	Transcorp (Transnational Corporation of Nigeria Plc.)
26	UAC FMCG Multinational
7	Unilever FMCG Multinational
46	United Bank for Africa (UBA)

Source: Researcher's Compilation culled from NGX websites, 2022