Threshold Effect Analysis of the Relationship between Environmental Responsibility and Financial Performance

Thomas Adomah Worae
University of Limpopo, South Africa
broyaw65@gmail.com

Collins C. Ngwakwe
University of Limpopo, South Africa
ccngwakwe@ul.ac.za

Cosmas C. Ambe
University of Limpopo, South Africa
ccambe@hotmail.com

The paper examines environmental responsibility threshold effect on the financial performance of JSE SRI's firms for the period 2008–2014. Employing bootstrap dynamic panel threshold estimations, the paper confirms the existence of triple threshold in all the regression relationship. Furthermore, the study established a nonlinear (inverted U-shape) association between environmental initiative, measured by energy usage intensity and return on sale, and a linear (inverse U-shape) relationship between carbon input intensity and market value of equity deflated by sale. We also found that return on sale decreases by −0.08868 when environmental responsibility, measured by energy usage intensity ratio exceeds 0.00093. The results however showed that an increase in energy usage intensity ratio at any point increases equity returns.

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Introduction

Since their seminal presentations on capital structure effect on firms' financial value (Miller and Modigliani 1958; 1963) a great deal of time has been devoted to studying factors influencing financial value of firms from shareholder perspective (Margaritis and Psillaki 2010; Ebaid 2009). More recently researchers in the subject area have examined financial implication of environmental responsibility amidst global warming and fossil-energy depletion.

Capital markets and rating agencies have therefore recognised that carbon emission possesses current and future risks to corporate valuation and competitive advantage (Barley 2009).

The claims suggest that corporate environmental performance is critical in the determination of risks profile, potential liabilities and long-term valuation. Notwithstanding, as to whether there exist a linkage between corporate 'environmental pro-activeness' and its 'bottom line' becomes an important question. This is because there is a belief among some researchers that ethics has no place in business, and that businesses only need to appear ethical in the quest to achieving corporate objectives and preserving their legitimacy (Wagner et al. 2002; Friedman 1970).

A research question worth asking is that, is there not a 'tipping point' of firms' 'environmental responsibility' beyond which corporate financial performance retards or improves significantly? This study focused on providing answers to the question of environmental responsibility 'tipping point' beyond which financial performance retards. The paper is meant to promote internal corporate carbon policy, through the provision of an integrated guide to improve managerial decisions in creating a balance between fossil energy usage, emissions reduction and financial performance in a more sustainable manner. We extended sustainability accounting research by applying bootstrap methodology and dynamic panel threshold techniques, using data from JSE's SRI manufacturing and mining firms for a period 2008–2014.

We confirmed the existence of triple threshold in the regression relationship, and lack of linear relationship between the intensity of energy usage and return on sale, but a linear (inverse u-shape) relationship between the intensity of energy usage and equity market value deflated by sale. It was again found that return on sale decreases by –0.08868 when environmental responsibility, measured by energy usage intensity ratio exceeds 0.00093. On the contrary, increase in energy usage intensity ratio at all levels increase equity returns.

Literature

Sustainability accounting research in the past few decades has examined environmental responsibility effect on firm financial performance, and has thus far provided mixed and conflicting findings. For example, Orlitzky (2001) asserted that firm's that have exhibited higher social responsibility experience lower financial risks and concluded that 'social responsibility' and 'financial risk' appears to be one of 'reciprocal causality.'

Makni, Francoeur, and Bellavance (2009) argued that there exist no significant relationships between corporate social responsibility and financial performance except for market returns. Clarkson, Overell, and Chapple (2011) studied the impact of environmental approaches on financial performance, and found a causal relationship between environmental performance and financial resources and management capability.

Salama (2005) examined effects of 'sustainability performance' on financial performance of British companies, applying median regression, and found stronger relationship between factors when outliers and unobserved omitted variable are accounted for.

Qi et al. (2014) examined 'direct effect' of industrial sustainability pro-activeness on financial performance and 'indirect effects' of 'industrial munificence and resource slack' on environmental and financial performance link, and demonstrated that improvement in corporate 'industrial-level environmental performance' significantly influences corporate economic performance, with 'resource slack' significantly reflecting environmental and financial performance link. Nakao et al. (2007) cited that corporate sustainability performance positively affect financial performance and vice versa. In another related research by Gallego-Alvarez, Segura, and Martínez-Ferrero (2014; the effect of carbon emission variations on firm performance was evaluated after considering extraneous variables such as size, legal, growth; results indicated that improved financial performance is related to firm's carbon reduction.

Horvathova (2012) found a negative effect of environmental performance on financial performance if environmental performance is lagged by 1 year, but a positive effect if environmental performance is 2 years lag. Ki-Hoon, Byung, and Keun-Hyo (2015) demonstrated that carbon emissions decreases 'firm value.' Examining the effect of chemical emissions measured by 'aggregated toxic risk' on 'sale' and 'return on asset,' Fujii et al. (2012) found a significant relationship between firm's sustainability improvement and return on asset.

Nishitani et al. (2011) assessed 'emissions reduction' effect on corporate financial performance in Japan, and found that companies that reduced 'pollution emissions' increased their financial performance through increase in demand for the firms' products. Lioui and Sharma (2012) examined effect of social responsibility, measured by 'strengths and concerns' on financial performance, measured by return on asset and Tobin's q, and found that there exist a negative effect of 'strengths and concerns' on return on asset and Tobin's q. After accounting for the 'interaction' between 'environmental effort and research' the paper demonstrated that the result was no different.

On how 'environmental responsibility engagement' affects corporate financial performance, Wahba (2008), Wingard and Vorster (2001), Sen, Roy, and Pal (2015), and Sambasivan, Bah, and Jo-Ann (2012) showed that there exist a positive association between 'environmental engagements' with financial performance. After controlling for 'omitted variable bias,' Muhammad et al. (2015) also found a positive association between environmental initiative and financial performance.

On the contrary, Gonzalez-Benito and Gonzalez-Benito (2005) demonstrated that certain 'environmental engagement types' produce negative effects on corporate financial performance. Chien and Peng (2011) showed that firms that invest more in 'pollution prevention' financially perform better compared with counterparts who are more engaged with corrective measures after pollution has occurred.

Exploring how 'eco-innovation' impacts 'accounting-based' measures, Przychodzen and Przychodzen (2014) showed that 'eco-innovators' generally enhance 'return on asset,' equity returns, but lowers 'earnings retention.' On how 'sustainability pro-activeness' improves firms' return on sale, Telle (2006) showed that there exist a positive relationship between 'sustainability performance' and return on sale. When the paper controls for firms' 'specific effect,' the results showed an insignificant relationship between the factors prompting a conclusion that an 'estimated positive effect' could have been due to 'omitted variable bias.'

On how 'operations strategy' affect return on asset, return on equity and earnings per share, Klingenberg et al. (2013) cited that there exists no consistent relationship between return on asset, return on equity and earnings per share and 'operations strategy.'

An important research question worth asking is, is there not a 'tipping point' in firms' environmental responsibility beyond which financial performance retards or improves significantly? We therefore hypotheses as:

HO *There is no environmental responsibility threshold effect on financial performance of JSE's SRI manufacturing and mining firms.*

Methods and Materials

This paper examined environmental responsibility threshold effect on the financial performance of JSE's SRI manufacturing and mining firms for the period 2008–2014. Hansen (1999) argued that in order to confirm the existence of threshold effect, it is vital to analyse the threshold significance. Hansen (1999) therefore applied fixed effect for analysing short time dimension and larger cross sectional data.

On the contrary, Chudik et al. (2015) applied panel with large 'cross sectional dimension' and 'time dimension.' Dang, Kim, and Shin (2012) argued that Generalised Method of Moments in short dynamic panel analysis. Seo and Shin (2014) however applied dynamic threshold estimation and presumed 'slope homogeneity' using 'instruments' to cater for 'endogeneity' by first-differencing.

We applied bootstrap methodology and dynamic panel threshold approach in the attempt to determining statistical significance of 'environmental responsibility threshold effect' on the financial performance of JSE's SRI firms. And we specified our dynamic threshold models following Seo and Shin (2014) as:

$$y_{it} = (1, x'_{it})\Phi_1 1(q_{it} \leq \gamma) + (1, x'_{it})\Phi_2 1(q_{it} > \gamma) + \varepsilon_{it}, i, = 1, \ldots, n; \quad t = 1, \ldots, T, \tag{1}$$

where ε_{it} is the regression error, consisting of the error components:

$$\varepsilon_{it} = a_i + v_{it}, \tag{2}$$

where a_i is the 'individual and unbiased fixed effect' and v_{it} is a 'random disturbance.' v_{it} is the 'martingale difference.'

Nickell (1981) cited 'downward biasness' of the linear dynamic panels' fixed effect estimation of autoregressive parameters. Hence, we estimate the 'correlation of independent variables' as in the dynamic panel threshold regression equation (1), applying Arellano-Bond (1991) DPD estimation, and considered the first-difference transformation of equation (1) as:

$$\Delta y_{it} = \beta' \Delta \chi_{it} +' \chi'_{it} 1_{it}(\gamma) + \Delta\varepsilon_{it}, \tag{3}$$

where Δ is the first difference operator,

$$\underset{k_1 x_1}{\beta} = (\Phi_{12}, \ldots, \Phi_{1,k_1} + 1),' \underset{k_1 + x_1}{\ddot{o}} = \Phi_2 - \Phi_1$$

Extending equations (2) and (3), we re-specified our threshold regression as:

$$\begin{aligned} y_{it} = {} & (1, x'_{it})\Phi_1 1(q_{it} \leq \gamma) + (1, x'_{it})\Phi_2 1(q_{it} > \gamma) \\ & + (1, x'_{it})\Phi_3 1(q_{it} > \gamma) + a_i + v_{it}. \end{aligned} \tag{4}$$

In model (4), when environmental responsibility, measured by emissions intensity is used as a transition variable, we used environmental responsibility, measured by energy usage intensity and the financial measure, GROWTH as regressors. Alternatively, when environmental responsibility, measured by if energy usage intensity is used as the transition variable, we utilised both the environmental responsibility, measured by emissions intensity and GROWTH as regressors. Thus, we introduced GROWTH into the model to allow for effect of changes in growth opportunities. We employed 4 indicators to proxy financial performance: (i) ROA – return on assets, (ii) ROS – return on sale, (iii) EQRTNS – return on equity, and (iv) MVE/S – market value of equity deflated by sales. While environmental responsibility is proxy by (i) EMSINT – emissions intensity and (ii) ENGINT – energy usage intensity.

We compiled environmental responsibility data from the Carbon Disclosure Project, UK based company database. While the market and accounting-based performance measures data were compiled from Tickdatamarket, a French-based company, and from respective companies' database. The panel consists of 14 JSE's SRI firms who have consistently reported annual performances (i.e. financial and sustainability) for at least 7 years, (i.e. Anglo American Plc, Anglogold Ashanti, Arcelor Mittal South Africa, BHP Billiton, Exxaro Resources, Gold Fields Ltd, Harmony Gold Mining Ltd, Lonmin Plc, Merafe Resources, Murray and Roberts, Pretoria Portland Cement Ltd, Sabmiller Plc, Sappi Ltd, Sassol) covering an annual data for the period 2008–2014.

Empirical Results

The paper examined 'environmental responsibility' threshold effect on the financial performance of JSE's SRI firms for the period 2008–2014. Financial performance is measured by return on assets (ROA), return on sale (ROS), equity returns (EQRTNS) and market value of equity deflated by sales (MVE/S). Alternatively, 'environmental responsibility' is measured by energy usage intensity (ENGINT) and carbon emissions intensity (EMSINT).

Employing dynamic panel threshold regressions the study allowed sequentially for zero, single, double, and triple thresholds. Statistics results for F1, F2 and F3, critical values and p-values appear in Table 1.

From F1, F2 and associated critical values, we could not reject the null (HO) for the single threshold F1, and double threshold F2. The test for the third threshold F3 rejects the null (HO) at 0.05 significant level with a

TABLE 1 ENGINT Threshold Effect on ROA

F1	16.75533
P-value	0.20
Critical values	20.08167,24.52529,27.9868
F2	16.97452
P-value	0.17
Critical values	22.98719,28.90956,42.13225
F3	36.2881
P-value	0.023
Critical values	19.49541,22.95595,43.6704

NOTES CVS at 10%, 5% and 1%.

TABLE 2 ENGINT-ROA Threshold Estimate

Estimate	95% Confidence Interval
0.0009	[0.0001, 0.0010]
0.0001	[0.0001, 0.0001]
0.0001	[0.0001, 0.0001]

TABLE 3 Estimated Coefficients of ROA

Coeff.	Value	Std. error	White	*t*-stat.
Φ_1	0.14421	0.08778	0.05994	2.40601
Φ_2	0.17430	0.22442	0.21126	0.82505
Φ_3	0.29772	0.07663	0.06966	4.25542
Φ_4	−0.08868	0.12110	0.08944	−0.99156

bootstrap p-value of 0.023. We therefore confirmed the existence of triple threshold in the regression relationship.

Table 2 shows the thresholds and confidence intervals, which are 0.0009, 0.0001 and 0.0001. Thus, four classes of companies are 'low energy usage firms,' 'medium energy usage firms,' 'high energy usage firms' and 'very high energy usage firms.' Table 3 reports the regression slope coefficients, standard errors, the standard errors, t-stats and four regimes. We expressed our estimated model from our findings as:

if $q_{it-1} \leq 0.00013$,
if $0.00013 < q_{it-1} \leq 0.00017$,
if $0.00017 < q_{it-1} \leq 0.00093$,

TABLE 4 EMSINT Threshold Effect on ROA

F1	19.31735
P-value	0.22
Critical values	26.17635, 30.89724, 34.16181
F2	10.76762
P-value	0.41
Critical values	24.51725,29.84084,37.34802
F3	35.52142
P-value	0.03
Critical values	21.92242, 29.38851, 44.77624

NOTES CVS at 10%, 5% and 1%.

if $q_{it-1} > 0.00093$.

In the first regime (low energy usage firms) where the ENGINT ratio is less than 0.00013, the estimated coefficient Φ1 is 0.14421. This indicates that ROA increases by 0.14421 with 1% increase in the ENGINT ratio. In the second regime, i.e. medium energy usage firms, where the ENGINT ratio is between 0.00013 and 0.00017, the estimated coefficient Φ2 is 0.17430. This similarly shows that ROA increases by 0.17430 with 1% increase in the ENGINT ratio. In the third regime, i.e. high energy usage firms) where the ENGINT ratio is between 0.00017 and 0.00093, the coefficient Φ3 is 0.29772. This also shows that ROA increase by 0.29772 in with 1% increase in the ENGINT ratio. The last regime, i.e. very high energy usage) where the ENGINT ratio exceeds 0.00093, the estimated coefficients Φ4 is −0.08868. This indicate that ROA decreases by −0.08868 with 1% increase in the ENGINT ratio. The results indicate that any time the ENGINT ratio improves beyond 0.00093 ROA tends to decline by –0.08868.

The study also estimated the number of thresholds in the carbon output intensity (EMSINT)–ROA relationship estimating equation (4), employing dynamic panel. Based on the test statistics (F1, F2) and critical values the study could not reject the null (HO) of no threshold for the single threshold F1, and double threshold F2. The test for the third threshold F3 rejects the null (HO) at 0.05 significant level with a bootstrap *p*-value of 0.03. The statistics indicate the presence of triple threshold in the regression relationship (table 4). Hence, the rest of the study uses triple threshold estimation.

TABLE 5 EMSINT-ROA Threshold Estimate

Estimate	95% Confidence Interval
0.0005	[0.0004, 0.0005]
0.0001	[0.0001, 0.0002]
0.0001	[0.0001, 0.0001]

TABLE 6 Estimated Coefficients of ROA

Coeff.	Value	Std. error	White	t-stat.
Φ_1	0.19622	0.08492	0.07707	2.54592
Φ_2	−0.32231	0.15698	0.24278	−132755
Φ_3	0.15745	0.08714	0.06052	2.60166
Φ_4	0.51799	0.10768	0.07604	6.81168

Our estimations appear in table 5. The point estimates are 0.00015, 0.00016 and 0.00053. These point estimations represents the 'low emitting firms,' 'medium emitting firms,' 'high emitting firms' and 'very high emitting' firms. Table 6 reports the regression slope coefficients, standard errors, standard errors, t-stat and for four regimes. We expressed our estimated model from the findings as:

if $q_{it-1} \leq 0.00015$,
if $0.00015 < q_{it-1} \leq 0.00016$,
if $0.00016 < q_{it-1} \leq 0.00053$,
if $q_{it-1} > 0.00053$.

In the first regime (low emitting firms) where EMSINT ratio is less than 0.00015, the estimated coefficient Φ1 is 0.19622, indicating that ROA increases by 0.19622 with 1% increase of in EMSINT ratio. In the second regime (i.e. medium emitting firms) where EMSINT ratio lies between 0.00015 and 0.00016, the estimated coefficient Φ2 is −0.32231. This indicates that ROA decreases by −0.32231 with1% increase in EMSINT ratio. In the third regime (i.e. high emitting firms) where EMSINT ratio is between 0.00016 and 0.00053, the coefficient Φ3 is 0.15745, indicating that ROA increases by 0.15745 with 1% increase in EMSINT ratio. In the last regime (i.e. very high emitting firms) where EMSINT ratio exceeds 0.00053, the estimated coefficients Φ4 is 0.51799. This indicates that ROA increases by 0.51799 with 1% increase in EMSINT ratio. The results further showed that ROA decreases when the EMSINT ratio is between 0.00015 and 0.00016.

TABLE 7 ENGINT Threshold Effect on ROS

F1	104.2437
P-value	0.00
Critical values	23.18085, 43.68785, 65.43865
F2	45.51412
P-value	0.00
Critical values	20.17043, 23.37171, 30.69071
F3	286.9418
P-value	0.00
Critical values	33.63791, 55.60378, 106.6214

NOTES CVS at 10%, 5% and 1%.

TABLE 8 ENGINT-ROS Threshold Estimate

Estimate	95% Confidence Interval
0.0009	[0.0009, 0.0010]
0.0011	[0.0006, 0.0012]
0.0001	[0.0001, 0.0001]

TABLE 9 Estimated Coefficients of ROS

Coeff.	Value	Std. error	White	*t*-stat.
Φ_1	0.1170	0.1948	0.1231	0.9504
Φ_2	0.2413	0.1964	0.2051	1.1764
Φ_3	−3.0147	0.3767	0.2854	−10.5644
Φ_4	−0.3467	0.4047	0.1594	−2.1756

To determine the number of threshold in the carbon input intensity (ENGINT)–return on sales (ROS) relationship, equation (4) is estimated by a dynamic panel estimation. The Null (HO) is rejected at 0.01 in the case of F1, F2, and F3, with associated *p*-values showing significant *p*-values of 0.00 in each case. The authors concluded that the relationship contains three thresholds.

Table 8 presents the triple threshold approach with resulting estimations as 0.00017, 0.00093, and 0.00119, representing the 'low energy usage firms,' 'medium energy usage firms,' 'high energy usage firms' and 'very high energy usage firms.'

Table 9 reports the regression slope coefficients, standard errors, the

TABLE 10 EMSINT Threshold Effect on ROS

F1	119.3488
P-value	0.00
Critical values	38.17907, 47.77101, 73.24798
F2	31.97693
P-value	0.035
Critical values	24.9378, 28.02969, 47.28648
F3	200.1955
P-value	0.00
Critical values	33.61706, 47.32239, 77.18123

NOTES CVS at 10%, 5% and 1%.

standard errors, and *t*-stat and for four regimes. Our estimated model from the findings is written as:

if $q_{it-1} \leq 0.00017$,
if $0.00017 < q_{it-1} \leq 0.00093$,
if $0.00093 < q_{it-1} \leq 0.00119$,
if $q_{it-1} > 0.00119$.

In the first regime where ENGINT ratio is less than 0.00017, the estimated coefficient Φ1 is 0.1170. This indicates that ROS increases by 0.1170 with an increase of 1% in ENGINT ratio. In the second regime where ENGINT ratio lies between 0.00017 and 0.00093 the estimated coefficient Φ2 is 0.2413. This means that ROS increases by 0.2413 with an increase of 1% in ENGINT ratio. In the third regime where ENGINT ratio is between 0.00093 and 0.00119, the coefficient Φ3 is −3.0147. This indicates that ROS decreases by −3.0147 with 1% increase in ENGINT ratio. In the last regime where ENGINT ratio exceeds 0.00119, the estimated coefficients Φ4 is −0.3467. This showed that ROS decreases by −0.3467 with 1% increase in ENGINT ratio. The results suggest that the relationship between ENGINT and ROS varies in accordance with different changes in ENGINT, exhibiting a nonlinear relationship (inverted u-shape).

The study similarly determined the number of thresholds in the carbon output intensity (EMSINT)–Return on sales (ROS) relationship estimating equation (4) by dynamic panel estimation allowing for zero, one, two and three thresholds. Test statistics F1, F2 and F3, critical values, and bootstrap *p*-values are reported in table 10. The null hypothesis (H0) is rejected at 0.01 in the case of the single threshold F1, 0.05 in the case of

TABLE 11 EMSINT-ROS Threshold Estimate

Estimate	95% Confidence Interval
0.0005	[0.0005, 0.0005]
0.0006	[0.0006, 0.0021]
0.0002	[0.0001, 0.0002]

TABLE 12 Estimated Coefficients of ROS

Coeff.	Value	Std. error	White	*t*-stat.
Φ_1	0.1944643	0.1552055	0.1213879	1.6020072
Φ_2	−1.3523797	0.3796068	0.2801250	−4.8277716
Φ_3	1.0841738	0.3559689	0.2678195	4.0481507
Φ_4	0.0002893	0.6081785	0.2675641	0.0010812

double threshold F2, and 0.01 in the case of triple threshold F3, with bootstrap *p*-values of 0.00 for F1, 0.035 for F2, and 0.00 for F3. We conclude that the relationship contains three thresholds.

Table 11 shows the threshold estimations, which are 0.00026, 0.00044, and 0.00061 and these constitute low values in the EMSINT-ROS distribution. The point estimates reflect four categories of firms, which are 'low emitting firms,' 'medium emitting firms,' 'high emitting firms' and 'very high emitting firms.'

Table 12 reports the regression slope coefficients, standard errors, the standard errors and *t*-stat. Our estimated model from the findings is written as:

$$\begin{aligned}
&\text{if } q_{it-1} \leq 0.00026,\\
&\text{if } 0.0002 < q_{it-1} \leq 0.00044,\\
&\text{if } 0.00044 < q_{it-1} \leq 0.00061,\\
&\text{if } q_{it-1} > 0.00061.
\end{aligned}$$

In the first regime where EMSINT ratio is less than 0.00026 the estimated coefficient Φ1 is 0.1944643, indicating that ROS increases by 0.1944643 with an increase of 1% in EMSINT ratio. In the second regime where EMSINT ratio is between 0.00026 and 0.00044, the estimated coefficient Φ2 is −1.3523797. This shows that ROS decreases by −1.3523797, with 1% increase in EMSINT ratio. In the third regime, when EMSINT ratio is between 0.00044 and 0.00061, the coefficient Φ3 is 1.0841738. This tends to show that ROS increases by 1.0841738 with 1% increase in EMSINT ratio. In the last regime where EMSINT ratio exceeds 0.00061, the

TABLE 13 ENGINT Threshold Effect on EQRTNS

F1	9.39125
P-value	0.49
Critical values	15.145, 17.79878, 21.07797
F2	14.21751
P-value	0.16
Critical values	15.54133, 16.93608, 23.53217
F3	23.86557
P-value	0.003
Critical values	12.47649, 14.83339, 18.10099

NOTES CVS at 10%, 5% and 1%.

TABLE 14 ENGINT-EQRTNS Threshold Estimate

Estimate	95% Confidence Interval
−9.5011	[−9.7630, −5.1195]
−6.555347	[−9.0956, −6.5373]
−10.34246	[−10.4143, −6.7987]

estimated coefficients Φ4 is 0.0002893. This indicates that ROS increases by 0.0002893 with 1% increase in EMSINT ratio. The results seem to indicate that EMSINT negatively affect ROS when the EMSINT ratio lies between 0.00026–0.00044.

The study also determined the number of thresholds in the carbon input intensity (ENGINT)–Equity returns (EQRTNS) relationship, estimating equation (4), and allowing for zero, single, double, and triple thresholds. Our test statistics F1, F2 and F3, critical values, and bootstrap *p*-values are reported in table 12. Based on the test statistics (F1, F2) and the critical values the study could not reject the Null (HO) of no threshold for the single threshold F1, and double threshold F2. Test for the third threshold F3 rejects the null hypothesis (HO) of no threshold at 0.01 significant level with a *p*-value of 0.003. The study concludes that the relationship contains a triple threshold.

Table 14 presents the estimations, which are −10.34246, −9.672444 and −6.555347. These constitute small values in the ENGINT-EQRTNS distribution. The estimations were for the following clusters of companies, ‘high energy usage firms’ and ‘very high energy usage firms.’ Regression slope coefficients, standard errors, the standard errors and *t*-stat for four

TABLE 15 Estimated Coefficients of EQRTNS

Coeff.	Value	Std. error	White	*t*-stat.
Φ_1	0.04136	0.05654	0.02412	1.71483
Φ_2	0.08056	0.04948	0.02630	3.06249
Φ_3	0.14173	0.05775	0.03151	4.49782
Φ_4	0.16847	0.07131	0.03388	4.97300

regimes are reported in table 15. We expressed our estimated model from the findings as:

if $q_{it-1} \leq -10.34246$,
if $-10.34246 < q_{it-1} \leq -9.672444$,
if $-9.672444 < q_{it-1} \leq -6.555347$,
if $q_{it-1} > -6.555347$.

In the first regime (low energy usage firms) where ENGINT ratio is less than −10.34246, the estimated coefficient Φ1 is 0.04136. This indicates that EQRTNS increases by 0.14421 with 1% increase in ENGINT ratio. In the second regime (medium energy usage firms) where ENGINT ratio lies between −10.34246 and −9.672444 the estimated coefficient Φ2 is 0.08056. This shows that EQRTNS increases by 0.08056 with 1% increase in ENGINT ratio. In the third regime (high energy usage firms) where ENGINT ratio is between −9.672444 and −6.555347 and the coefficient Φ3 is 0.14173 indicates that EQRTNS increase by 0.14173 with 1% increase in ENGINT ratio. In the last regime (very high energy usage firms) where ENGINT ratio exceeds −6.555347, the estimated coefficients Φ4 is 0.16847 and shows that EQRTNS increases by 0.16847 with 1% increase in ENGINT ratio. The results generally indicate that increase in ENGINT ratio generally increases EQRTNS.

The study again estimated the number of thresholds in the carbon output intensity (EMSINT)–Equity returns (EQRTNS) relationship estimating equation (4) and sequentially allowed for a zero to triple thresholds. Table 16 presents the statistical tests showing the critical values for F1, F2, and F3.

Based on the test statistics (F1, F2), and the critical values the study accepts the Null (HO) of no threshold for the single threshold F1, and double threshold F2. Test for third threshold F3 rejects the Null (HO) of no threshold at 0.01 level with a bootstrap *p*-value of 0.00. We therefore conclude that there exists a triple threshold in the regression relationship.

Our point estimates of the triple threshold together with confidence in-

TABLE 16 EMSINT Threshold Effect on EQRTNS

F1	7.181246
P-value	0.74
Critical values	15.60819, 18.62255, 21.69831
F2	8.942155
P-value	0.51
Critical values	13.98637, 16.7379, 20.41019
F3	30.33787
P-value	0.00
Critical values	12.00513, 13.27987, 17.9077

NOTES CVS at 10%, 5% and 1%.

TABLE 17 EMSINT-EQRTNS Threshold Estimate

Estimate	95% Confidence Interval
−10.0995	[−11.2147, −6.1184]
−8.0528	[−11.2147, −7.3666]
−10.0995	[−10.6471, 10.0995]

TABLE 18 Estimated Coefficients of EQRTNS

Coeff.	Value	Std. error	White	*t*-stat.
Φ_1	−0.16415	0.07467	0.05620	−2.92049
Φ_2	−0.13837	0.08764	0.06800	−2.03484
Φ_3	−0.16484	0.10162	0.07764	−2.12321
Φ_4	−0.35923	0.14963	0.10898	−3.29611

tervals are also shown in table 17. Our estimates –10.0995, –8.052812 and –10.0995, which constitute small values in the EMSINT-EQRTNS threshold distribution. The estimations were for the following firm categories: 'low emitting firms,' 'medium emitting firms,' 'high emitting firms' and 'very high emitting firms.' Regression slope coefficients, standard errors, the standard errors and *t*-stat for four regimes are reported in table 18. And our estimated model from the findings is written as:

$$\begin{aligned}&\text{if } q_{it-1} \leq -10.0995,\\ &\text{if } -10.0995 < q_{it-1} \leq -8.0528,\\ &\text{if } -8.0528 < q_{it-1} \leq -10.0995,\\ &\text{if } q_{it-1} > -10.0995.\end{aligned}$$

TABLE 19 ENGINT Threshold Effect on MVE/S

F1	220.0344
P-value	0.01
Critical values	30.13489, 48.46399, 164.3896
F2	269.3122
P-value	0.00
Critical values	25.12891, 33.27547, 45.46908
F3	315.7607
P-value	0.00
Critical values	19.46946, 23.50075, 34.30394

NOTES CVS at 10%, 5% and 1%.

TABLE 20 ENGINT-MVE/S Threshold Estimate

Estimate	95% Confidence Interval
0.0009	[0.0009, 0.0010]
0.0006	[0.0006, 0.0006]
0.0011	[0.0001, 0.0017]

In the first regime (low emitting firms) where EMSINT ratio is less than –10.0995, the estimated coefficient Φ1 is –0.16415, indicating that EQRTNS decreases by –0.16415 with 1% increase in EMSINT ratio. In the second regime (medium emitting firms) where EMSINT ratio is between –10.0995 and –8.052812 the estimated coefficient Φ2 is –0.13837, indicating that EQRTNS decreases by –0.13837 with 1% increase in EMSINT ratio. In the third regime (high emitting firms) where EMSINT is between –8.052812 and –10.0995 and coefficient Φ3 is –0.16484. This similarly shows that EQRTNS decreases by –0.16484 with 1% increase in EMSINT ratio. In the last regime (very high emitting firms) where EMSINT ratio exceeds –10.0995 and estimated coefficient Φ4 is –0.35923. This equally shows that EQRTNS decreases by –0.35923 with 1% increase in EMSINT ratio. The results generally indicate that improvement in EMSINT is inimical EQRTNS growth.

The study similarly determined the number of thresholds in the carbon input intensity (ENGINT)–Market value of equity deflated by sales (MVE/S) relationship estimating equation (4) and sequentially allowing for zero, single, double, and triple thresholds. Our test statistics F1, F2 and F3, critical values, and bootstrap *p*-values are all reported in table

TABLE 21 Estimated coefficients of MVE/S

Coeff.	Value	Std. error	White	*t*-stat.
Φ_1	−58.098	56.150	44.265	−1.313
Φ_2	−1493.025	388.485	10.491	−1.809
Φ_3	1165.510	449.053	351.348	3.317
Φ_4	136.104	164.413	82.185	1.656

19. The null hypothesis (HO) is rejected at 0.01 in the single threshold F1, double threshold F2, and triple threshold F3, with bootstrap *p*-values of 0.01, 0.00, and 0.00 respectively. We thus conclude that a three threshold is contained in the relationship.

Table 20 shows the estimations, which are 0.00068, 0.00093 and 0.00110, and these are small in ENGINT-MVE/S distribution. The estimations represents the following firm clusters: 'low energy usage firms,' 'medium energy usage firms,' 'high energy usage firms' and 'very high energy usage firms.'

Table 21 reports the regression slope coefficients, standard errors, the standard errors and *t*-stat and for four regimes. And our estimated model from the findings is expressed as:

if $q_{it-1} \leq 0.00068$,
if $0.00068 < q_{it-1} \leq 0.00093$,
if $0.00093 < q_{it-1} \leq 0.00110$,
if $q_{it-1} > 0.00110$.

In the first regime (low energy usage firms) where ENGINT ratio is less than 0.00068, the estimated coefficient Φ1 is –58.098, indicating that MVE/S decreases by –58.098 with 1% increase in ENGINT ratio. In the second regime (medium energy usage firms) where ENGINT ratio is between 0.00068 and 0.00093 the estimated coefficient Φ2 is –1493.025. This indicates that MVE/S decreases by –1493.025 with 1% increase in ENGINT ratio. In the third regime (high energy usage firms) where ENGINT ratio is between 0.00093 and 0.00110, the coefficient Φ3 is 1165.510. This however shows that MVE/S increases by 1165.510 with 1% increase in ENGINT ratio. In the last regime (very high energy usage firms) where ENGINT exceeds 0.00110 the estimated coefficients Φ4 is 136.104. This again shows that MVE/S increases by 136.104 with 1% increase in ENGINT ratio. The results suggest that the relationship between ENGINT and MVE/S varies in accordance with different changes in ENGINT, with ENGINT showing a linear relationship (inverse U-shape).

TABLE 22 EMSINT Threshold Effect on MVE/S

F1	261.0626
P-value	0.01
Critical values	48.13166, 111.6253, 204.607
F2	210.1656
P-value	0.00
Critical values	31.67894, 40.76298, 58.78185
F3	1534.627
P-value	0.00
Critical values	117.333, 185.4831, 533.403

NOTES CVS at 10%, 5% and 1%.

TABLE 23 EMSINT-MVE/S Threshold Estimate

Estimate	95% Confidence Interval
0.0005	[0.0005, 0.0005]
0.0006	[0.0006, 0.0006]
0.0005	[0.0005, 0.0005]

The study finally determined the number of thresholds in the carbon output intensity (EMSINT)–market value of equity deflated by sales (MVE/S) relationship by estimating equation (4) sequentially and allowing for zero, single, double, and triple threshold. Our test statistics, F1, F2 and F3, critical values, and *p*-values are all reported in table 22. The null hypothesis (HO) is rejected at 0.01 in each of the three cases, i.e. single threshold F1, double threshold F2, and triple threshold F3, with *p*-values of 0.01, 0.00 and 0.00, in each of the regression relationship. We therefore conclude that the relationship contains a three threshold.

Table 23 contains the estimates, which are 0.00053, 0.00055, and 0.00061; these values are small in the EMSINT-MVE/S distribution. Our classes of firms as exhibited by point estimates are 'low emitting firms,' 'medium emitting firms,' 'high emitting firms' and 'very high emitting firms.' Table 24 reports the regression slope coefficients, standard errors, the standard errors and *t*-stat and for four regimes. In addition, we expressed the estimated model from the findings as:

if $q_{it-1} \leq 0.00053$,
if $0.00053 < q_{it-1} \leq 0.00055$,
if $0.00055 < q_{it-1} \leq 0.00061$,

TABLE 24 Estimated Coefficients of MVE/S

Coeff.	Value	Std. error	White	*t*-stat.
Φ_1	−126.2427	51.6465	48.4104	−2.6078
Φ_2	476.1397	343.8062	198.8222	2.3948
Φ_3	−3515.8567	177.9356	84.9313	−41.3965
Φ_4	−121.7860	196.2598	84.9824	−1.4331

if $q_{it-1} > 0.00061$.

In the first regime (low emitting firms) where EMSINT ratio is less than 0.00053, the estimated coefficient Φ1 is −126.2427, indicating that MVE/S decreases by −126.2427 with 1% increase in EMSINT ratio. In the second regime (medium emitting firms) where EMSINT ratio is between 0.00053 and 0.00055, the estimated coefficient Φ2 is 476.1397. The result indicates that MVE/S increases by 476.1397 with 1% increase in EMSINT ratio. In the third regime (high emitting firms) where EMSINT ratio is between 0.00055 and 0.00061, the coefficient Φ3 is −3515.8567. This indicates that MVE/S decreases by −3515.8567 with 1% increase in EMSINT ratio. In the last regime (very emitting firms) where EMSINT ratio exceeds 0.00061, the estimated coefficients Φ4 is −121.7860. This also shows that MVE/S decreases by −121.7860 with 1% increase in EMSINT ratio.

Discussions and Conclusion

Our results showed a decline in the financial performance, measured by return on asset and return on sale by −0.08868 and −3.0147 respectively as energy usage intensity ratio exceed 0.00093. On the contrary, when energy usage intensity ratio is in the range of 0.00017–0.00093, these firms are able to maximise return on asset and return on sale. With return on asset showing an increase of 0.29772, and return on sale of 0.2413. Market value of equity deflated sale (MVE/S) on the other hand increases when energy usage intensity ratio exceeds 0.00093, and a higher increase when energy usage intensity ratio is in the range of 0.00093–0.00110. Equity returns also at its highest when energy usage intensity ratio exceeds −6.555347. The results again showed that return on asset exhibited the highest performance when the emissions intensity ratio is above 0.00053, showing an increasing of 0.51799. Return on sale also showed an increase of 1.0841738 when emissions intensity ratio is between the range of 0.00044–0.00061. Similarly, Market value of equity deflated sale showed an improvement at the point when the emissions intensity ratio is in the range of 0.00053–0.00055. A decline in equity returns is minimised when emissions intensity ratio is between −10.0995 and −8.052812.

The study has demonstrated the importance of threshold analysis in determining financial implications of carbon emissions reduction. Which it's believed could contribute to internal corporate carbon policy through the application of threshold analysis to help determine the level of carbon reduction that might be economically feasible and/or worthwhile to maintain a permissible level of carbon at a tolerable economic level for a firm's economic capacity. The threshold assessment should be able to direct management as to what level they should swing into action regarding carbon abatement management.

The assessment could also inform policy on carbon reduction investment commitments, and signal management as to where to stop or continue with carbon improvement activities and investments, to help enhance internal policy on carbon reduction in a more sustainable competitive manner. Given the controversies surrounding the carbon emissions reduction effect on corporate financial performance much work remains to be done to help understand the dynamics and fundamentals of the carbon emissions reduction effect on firms' general financial performance.

Conventional managerial performance evaluation is normally based on financial and other non-financial measures which excludes environmental variables such as greenhouse gas and fossil energy consumption. But results from this study makes it evident that managerial performance evaluation needs transformation to include environmental ratios such as, emissions intensity, energy usage intensity to the traditionally adopted internal managerial performance measures against divisional investment and/or earnings.

As climate change policies trigger unprecedented emergence in internal corporate carbon policies, and companies are increasingly developing ambitious carbon reduction agendas in all activities. Yet, one of the setbacks amongst others is how to determine which of the corporate activities that have significant influence on corporate carbon levels (Kjaer et al. 2015). The findings support the stakeholder and institutional theories as the results indicated the extent to which firms manage fossil-energy resources to create balance between environmental responsibility and financial gains to preserve their legitimacy. The results further seemed to indicate why companies institute integrated and multifaceted programmes and activities in the attempt to enhancing corporate interaction with the natural environment.

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