Article

Clean Production and Profitability: An Eco-efficiency Analysis of Kenyan Manufacturing Firms

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Abstract

This study examines the linkage between the profitability of firms measured by return on assets (ROA) and environmental performance measured by eco-efficiency and also the impact of a good environmental management system (EMS) on profitability and eco-efficiency of firms. These environmental management practices were captured by the type of EMS a firm adopts that classified firms as either environmental leaders or environmental laggards. To achieve this panel data regression model with ROA as the dependent variable and eco-efficiency scores as the regressors was performed. The results suggest that there is a potential gain in the profitability of the firm by improving eco-efficiency in resource use. Furthermore, proactive firms are found to perform better than reactive firms in terms of profitability and eco-efficiency but firms that combine both proactive and reactive EMS perform even better, which shows the benefit of adopting commitment-based approaches alongside the compliance-based approaches to environmental management.

Keywords

eco-efficiency, environmental management systems, return on assets

JEL Classification: O14, Q53, Q55

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Introduction

Eco-efficiency starts from issues of economic efficiency that have positive environmental benefits while cleaner production starts from issues of environmental efficiency that have positive economic benefits. Hence, both link the goals of business excellence and environmental excellence by creating the bridge through which corporate behavior can support sustainable development, integrating economic growth, and environmental improvement (WBCSD, 1997). The concept of cleaner production was introduced by UNEP Industry and Environment in 1989. Cleaner production is the continuous application of an integrated preventive environmental strategy applied to processes, products, and services to increase eco-efficiency and reduce risks for humans and the environment, which aims at making more efficient use of natural resources (raw materials, energy, and water) and reducing the generation of wastes and emissions at the source (Zhongfan, 2008).

Eco-efficiency is a measure of environmental performance and hence an indicator of clean production. In analyzing the profitability of any entity, both the volume of output as well as the costs involved in producing that level of output are taken into account. While direct costs are easily reflected in prices, indirect costs present as external effects to the environment and are not easy to capture through prices. To correct such externalities, the government may impose some penalties, such as environmental taxes and other environmental policy tools that are attracted by poor environmental management, in order to force firms to internalize any externalities that arise from their operations. In this way, both the direct and indirect costs are reflected in the operational costs of the firm. In such a scenario, poor environmental practices by firms may have an impact on a firm's profit through increased operational costs while sound environmental practices may be a source of financial gain for the firm.

Literatures have shown that cleaner production is attractive in that, together with reducing the cost of production, there are benefits that accrue from the reduction of environmental contaminants that result from unclean production processes (see, for example, Phungrassami, 2008). Using an emissions-based index that reflects end-of-pipe strategies and an inputs-based index reflecting integrated pollution prevention, Wagner (2004) finds a predominantly negative relationship between environmental and economic performance for the emissions-based index; whereas, for the inputs-based index, no significant link is found. The results also show that for firms with pollution prevention–oriented corporate environmental strategies, the relationship between environmental and economic performance is more positive, thus making improvements in corporate sustainability more likely.

Evidence further shows that environmentally conscious companies have better financial performance than those companies that are categorized as not environmentally conscious (Ahmed, Montagno, & Firenze, 1998). More studies in the area have found a positive correlation between environmental concern and effort, and between effort and impact on performance characteristics such as operations efficiency, and company image and revenue (see, for example, Ahmed, Montagno, & Naffziger,

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2003). However, there is no evidence of such significant correlation between environmental effort and profit suggesting that this may be because firms think that investing in environmental efforts may offset the gain in revenue.

In literature, there are two main reasons why environmental management systems exist. First, a firm may establish an environmental management system (EMS) in order to comply with environmental regulations, in which case the EMS is said to be compliance based. Firms may establish EMS simply because they feel obliged to comply with the law of the land, or feel that they just want to do the right thing. For instance, Henriques and Sadorsky (1996) argues that government regulation, including regular inspections, high penalty, and reputation in case of the public disclosure are some of the most important factors affecting a firm's decision to invest in EMS. However, a firm may be driven by the need to improve quality of service responding to internal and external pressures, an approach known as commitment based. For instance, Shang, Lu, & Li (2010) argue that pressures from supply chain, customers, and communities played positive roles in engaging firms to improve environment management performance. It is also noted in literature that commitment and compliance-based approaches can coexist to the benefit of organizations wishing to move toward environmental sustainability (see, for example, Ramus & Oppegaard, 2007; Matuszak-Flejszman, 2009).

Other studies have looked at the motivation behind alternative public environmental policy, including both traditional environmental policy tools (direct regulation, market-based instruments, etc.) and incentives to introduce EMS and other programs that encourage environmental innovations. For instance, a study by Ytterhus (2004) concludes that the most important motivations with respect to the environmental practices were regulatory compliance, prevention or control of environmental incidents, corporate profile/image, and cost saving. Looking at the relationship between environmental practices and commercial performance, Ytterhus (2004) finds that firms having both a certified EMS and an environmental department did not differ significantly in economic performance compared to firms having neither a certified EMS nor an environmental department.

Klassen and Whybark (1999) develop a conceptual model of environmental management within operations. The model proposes that the general orientation of operations managers on environmental issues ranges from proactive to reactive, and this is intrinsically related to the investment pattern in environmental technologies. An empirical validation of the model is presented for a sample of plants from the furniture industry and identifies three distinct groups ranging from proactive to reactive. Proactive managers were seen to implement a balanced portfolio that included not only the expected pollution prevention strategies but also a sizable proportion of the traditional end-of-pipe controls and remediation. Contextual factors also differentiate among these three groups, thus suggesting options for senior management to assist plant managers to become more proactive and to improve environmental performance.

This article analyzes the linkage between eco-efficiency and a firm's profit. This is done by first seeking to establish the presence and nature of any relationship between

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the profitability of a firm and its level of eco-efficiency. Profitability is indicated by return on assets (ROA), which is a measure of a firm's operation performance while eco-efficiency is a ratio defined as value of output per unit of environmental effects. This is done for three inputs that are likely to have some environmental effects namely water, fuel oil, which is deemed as a dirty fuel, and electricity, which is considered as a clean fuel.

In order to relate a firm's EMS with its eco-efficiency and profitability, firms are classified according to the nature of the EMS in operation (Verbeke & Buysse, 2000). Firms that have no established EMS are said to be environmental laggards while those that have an EMS framework are said to be environmental leaders. Among the environmental leaders, firms whose EMS merely meet the minimum requirements of regulatory authorities, in this case adherence to environmental audit (EA) as required by the National Environmental Management Authority (NEMA)[1], are said to be reactive, while those that incorporate some voluntary actions such as clean production initiatives (CPI)[2] or ISO certification are said to be proactive. The eco-efficiency and profitability levels of these groups are compared to establish if there is any benefit for a firm to have an EMS and more so whether it pays for a firm to be environmentally proactive. It is important to note that some companies can have an ISO certification in order to respond, in appearance, to stakeholders' pressures without changing their internal practices. For example, it is argued that some of the most polluting companies have a certified EMS (see, for example, Boiral, 2007; Meyer & Rowan, 1977). We therefore took a careful assessment when making the difference between the leaders and the laggards, including considering other criteria based on the information reported by NEMA, when conducting monitoring.

A panel data eco-efficiency analysis is done for the firms in the sample using a 2-year panel data of Kenya's manufacturing firms from Regional Programme Enterprise Development (RPED) dataset for Kenya's manufacturing sector for the years 2001 to 2002. World Business Council for Sustainable Development define eco-efficiency as a concept that means improving the efficiency in the use of natural resources, while minimizing the negative environmental impact of pollution arising from the use of natural resources (WBCSD, 2000). After establishing whether the relationship exists for all firms, the study endeavors to separate firms in terms of whether they are environmental leaders or environmental laggards. The environmental leaders are further categorized into reactive or proactive depending on whether their EMS is voluntary or involuntary. This separation will help us to study the characteristics of each of these categories in relation to their profitability and eco-efficiency.

Modeling the Eco-Efficiency–Profitability Relationship

The analysis of the empirical relationship between eco-efficiency and profitability of firms involves an estimation procedure based on a panel data model, in which eco-efficiency is assumed to influence the profitability variable, which is the dependent variable. The basic panel data model is specified as follows:

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$$ROA_{it} = \alpha_t + X_{it}\beta + E_i\gamma + Z_{it}\lambda + \mu_{it} \quad (1)$$

Where all firms are indexed with a subscript i and all years are indexed with a subscript t ; ROA_{it} denotes return on assets and is the dependent variable that is a measure of profitability for firm i in period t . X_{it} represents the vector of eco-efficiency indicators that are time variant. E_i is a vector of dummy variables capturing different EMS. u_{it} is the stochastic error term.[3] Z_{it} is a vector of control variables.

In this analysis, a modified version of the empirical model by Guenster, Derwall, Bauer, and Koedijk (2005) is adopted and is specified as follows:

$$ROA_{it} = \alpha_i + \beta_i EE_{it} + \gamma_i EMS_i + \lambda_i Z_{it} + \mu_{it} \quad (2)$$

Where ROA_{it} denotes return on assets, EE_{it} is a vector of eco-efficiency scores, EMS is a vector of environmental management systems dummies, whether environmental leader or environmental laggard, proactive or reactive while Z_{it} is a vector of control variables. β, γ, and λ are vectors of coefficients to be estimated and u_{it} is the stochastic error term.

The first task of this analysis is to determine if there is any relationship between eco-efficiency and profitability for individual firms. This is achieved by estimating equation 2 first as a pooled ordinary least squares (OLS) model followed by fixed effects model estimation.

The second aspect of this analysis is to compare the mean ROA and mean eco-efficiency scores for various subsamples. The dataset is split into different subsamples; first environmental "leaders" and environmental "laggards" and then firms that are reactive in their environmental approach in that their EMS is channeled to adhere to some environmental regulations and those that are proactive in their environmental approach in that they are committed to environmental improvement. Further, proactive firms that are ISO certified are isolated from those that have adopted CPI.

Empirical Analysis

Summary Statistics

First, the descriptive statistics for the main variables used in this analysis are computed and reported in Table 1. The summary is done for the overall sample and also in years. The reported statistics reveal that the mean profitability ratio was 13% for the entire sample across the 2 years. However, on average, firms were more profitable in year 2001 than in year 2002 with an average profitability ratio of approximately 14% and 12% respectively. For eco-efficiency indicators, which in this analysis measures how efficient or productive the resource is, the eco-efficiency of water was 71% for the overall sample but was higher in year 2001 at 77% than in 2002, which was 65%. For the eco-efficiency of fuel oil, which is considered a dirty fuel, it was quite low and did not vary much across the years being 10% for the overall sample and 9%

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Table 1. Summary Statistics in Years for Main Variables.

Variable	Overall	2001	2002
Return on assets (ROA) (Value)	12.85	13.76	11.94
	(14.91)	(15.40)	(14.42)
Eco-efficiency of water (Liter)	0.710	0.766	0.654
	(1.766)	(2.188)	(1.206)
Eco-efficiency of fuel oil (Liter)	0.097	0.094	0.099
	(0.237)	(0.221)	(0.252)
Eco-efficiency of electricity (Kw)	0.044	0.040	0.048
	(0.091)	(0.075)	(0.057)
Environmental leaders dummy	0.715	0.703	0.726
	(0.452)	(0.459)	(0.448)
Environmental laggards dummy	0.285	0.297	0.274
	(0.452)	(0.459)	(0.448)
Proactive EMS dummy	0.098	0.102	0.094
	(0.298)	(0.304)	(0.293)
Reactive EMS dummy	0.609	0.593	0.624
	(0.489)	(0.493)	(0.486)
Small-scale enterprise dummy	0.174	0.169	0.179
Medium-scale enterprise dummy	0.464	0.458	0.470
Large-scale enterprise dummy	0.362	0.373	0.350
Pro-NEAP age dummy	0.813	0.814	0.812
Post-NEAP age dummy post-EMCA age dummy	0.119 0.068	0.110 0.076	0.128 0.060
N	235	118	117

Notes: EMS = Environmental Management System. NEAP = National Environmental Action Plan. EMCA = Environmental Management and Coordination Act .
Source: Computed from RPED dataset. The figures in parentheses are the standard deviation.

and 10% respectively for years 2001 and 2002. For the eco-efficiency of electricity, which is considered a clean fuel, the eco-efficiency indicator was only 4% for the overall sample, and 4% and 5% for the years 2001 and 2002 respectively. The drop in the general performance of the firms from 2001 to 2002 may be associated with political uncertainties, since 2002 was an election year.

It should be recalled that environmental productivity, which is used to measure eco-efficiency, is computed as value per unit of environmental effects. In this scenario, a high eco-efficiency indicator implies a decline in the denominator, which is the environmental effect indicated by the cost of the input. Therefore, the summary statistics are reasonable because for inputs that are expected to have a high environmental impact such as water and fuel oil, a high eco-efficiency indicator implies less of it is being used while for an input such as electricity that is expected to have a lower environmental impact, a lower eco-efficiency indicator means more is being used.

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In general, the magnitudes of the mean ROA show that the firms were slightly more profitable in the year 2001 than in the year 2002. For the eco-efficiency indicators, firms performed better in 2001 than in 2002 in the case of eco-efficiency of water but for the eco-efficiency of energy, firms performed slightly better in the year 2002 than in the year 2001. However, the eco-efficiency of fuel oil was very low which is indicative of inefficient use of fuel oil in production. In the case of eco-efficiency of electricity, the low eco-efficiency indicator is a positive sign in the sense that firms are using more of electricity than fuel oil to power manufacturing processes, which is a move toward clean production.

About 72% of the firms in the overall sample are environmental leaders, that is firms that have at least one form of environmental initiative, while 28% are environmental laggards, with no environmental initiative at all. More firms showed environmental leadership in 2002 than in 2001. Firms with a proactive EMS were only 10% with 61% having a reactive EMS in the overall sample. This implies that although firms that show environmental initiative are many, majority of the firms are motivated by the need to comply with regulations to avoid penalties and maintain their reputations in the face of their stakeholders. Very few firms seem to recognize the benefits of proactive EMS. Some of the benefits that can be enjoyed by the firms having EMS include generating mechanisms aimed at minimizing material, resource and energy consumption, possible growth of exports of the firm's products, and compliance with legal requirements, which will generally imply that firms have high potential of increasing profits. Looking at the distribution of the firms in terms of firm age, over 81% of the firms in the sample have existed for over 10 years before the first environmental plan; NEAP came into effect in 1994. Less than 10% of the firms came into operation after the establishment of the new environmental act, Environmental Management and Coordination Act (EMCA) in 1999. In the period between these two environmental legislations, only 12% of the firms were established. On the size of the firms in the sample, 17% of the firms are small-scale enterprises employing less than 20 employees, 46% are medium-scale enterprises while less than 36% are large-scale enterprises.

Estimating the Impact of Eco-efficiency on ROA

Estimation is done in several steps beginning from a pooled OLS model. Next is a panel data model, which is the fixed effects model. An instrumental model was found to be unnecessary after the diagnostics tests failed to find evidence of endogeneity. The next subsection presents the results of the pooled OLS model.

Pooled OLS Model. The analysis begins by estimating a pooled OLS model for ROA with only eco-efficiency indicators. Next, the dummy variables for EMS are included in the estimation. The same model is again estimated including all the control variables among them the age and size dummy variables. The results are reported in Table 2 alongside each other for comparison purposes.

Examining the results, in the baseline model that assumes that eco-efficiency is the only factor influencing ROA, the three eco-efficiency scores are all significant but the goodness of fit of the model is only 5%. In the model that controls only for the impact

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Table 2. Pooled OLS Estimation Results.

Variable	Model 1 only eco-efficiency scores	Model 2 Environmental dummies	Model 3 Control variables
Constant	11.59***	9.468***	4.940***
	(1.197)	(1.439)	(1.575)
Eco-efficiency of water	1.457**	1.307*	0.575
	(0.711)	(0.722)	(0.623)
Eco-efficiency of fuel oil	7.962*	7.348	4.554
	(5.293)	(5.252)	(3.541)
Eco-efficiency of electricity	−12.48***	−12.19***	−0.266
	(3.578)	(4.265)	(3.893)
Environmental leaders	—	−5.167***	−2.423*
	—	(1.461)	(1.578)
Proactive EMS	—	10.53***	7.928***
	—	(3.424)	(2.699)
Reactive EMS	—	8.119***	6.570***
	—	(1.540)	(1.811)
Capital intensity	—	—	−0.898**
	—	—	(0.368)
Labor intensity	—	—	3.419***
	—	—	(1.091)
R and D intensity	—	—	−5.530
	—	—	(6.935)
Leverage	—	—	−0.003
	—	—	(0.006)
SSE dummy	—	—	5.211*
MSE dummy	—	—	−2.627*
Pre-NEAP dummy	—	—	−1.325
Post-NEAP dummy	—	—	0.257
R^2	0.050	0.064	0.404

Notes: EMS = Environmental Management System. SSE = Small-Scale Enterprise. MSE = Medium-Scale Enterprise. NEAP = National Environmental Action Plan.
Source: From Pooled OLS estimation using Stata 10. The figures in parentheses are the standard errors. *denotes Significance level at 10% based on *t*-statistics. **denotes Significance level at 5% based on *t*-statistics. ***denotes Significance level at 1% based on *t*-statistics.

of the EMS, eco-efficiency of water and that of electricity are significant but eco-efficiency of fuel oil is not significant; however, this does not improve the goodness of fit much, which is now 6%.

However, in the model that controls for all other factors, all eco-efficiency indicators are insignificant but the goodness of fit improves significantly to 40%. Given the goodness of fit, the most appropriate pooled OLS model is the controlled model. Looking at the results, eco-efficiency is not a major determinant of a firm's profitability, since the impact of both the eco-efficiency of water and energy is not significant

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Table 3. Panel Data Results.

Variable	Fixed effects model	Pooled OLS
Constant	6.626***	4.940**
	(3.401)	(1.575)
Eco-efficiency of water	1.023	0.576
	(2.864)	(0.623)
Eco-efficiency of fuel oil	9.075	4.554
	(15.32)	(3.793)
Eco-efficiency of electricity	27.48	−0.266
	(38.17)	(3.893)
Capital intensity	−0.195	−0.898**
	(0.976)	(0.369)
Labor intensity	2.404***	3.419***
	(0.600)	(1.091)
R and D intensity	−12.37**	−5.530
	(5.518)	(0.006)
Leverage	−0.009	−0.003
	(0.016)	(0.006)
Pre-NEAP age dummy	5.750	−1.325
Post-NEAP age dummy	4.899	0.258
R^2	0.190	0.404

Notes: NEAP = National Environmental Action Plan.
The figures in parentheses are the standard errors.
***denotes* Significance level at 5% based on *t*-statistics. ****denotes* Significance level at 1% based on *t*-statistics.

The environmental leaders dummy is negative and significant at 10% level of significance, which implies that having an EMS impacts negatively on profits. This may be associated with the initial costs involved in setting up an EMS. However, when the environmental leaders are differentiated into proactive and reactive, the two dummy variables are now positive and significant. There is evidence of a proactive EMS having an advantage over a reactive EMS, since the coefficient of proactive EMS is bigger than that of the reactive EMS. Looking at the other control variables, capital intensity relates negatively with ROA and is significant. The coefficient of labor intensity is positive and significant. The age dummies are insignificant; however, for the firm size dummies, the coefficient of the SSE dummy is positive and significant while that of the MSE dummy is negative and significant.

Panel Data Model. Using pooled OLS in a panel data setting implies that the panel characteristics of the data are ignored. There is a potential danger of having standard errors that are understated and significance levels that are overstated, although the coefficients may be consistent. To ensure that the estimation results are efficient, a panel data model is estimated. The choice between a fixed effects model and random effects model is informed by the Hausman test. The calculated value of 17.24 is greater

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Table 4. Testing for Endogeneity Bias—Durbin–Wu–Hausman test.

H0	Test statistic	Critical value	*p*-value	Comment
All regressors are exogenous	0.69	13.84	0.406	Do not reject Ho
Eco-efficiency of fuel oil is exogenous	0.23	63.84	0.627	Do not reject Ho
Eco-efficiency of water is exogenous	0.47	13.84	0.492	Do not reject Ho
Eco-efficiency of electricity is exogenous	0.01	23.84	0.913	Do not reject Ho

than the critical value of 16.91 value and the *p*-value is 0.045, which is significant and makes a fixed effects model appropriate. A fixed effects model is estimated and results reported in Table 3.

The results of the fixed effects model show that the elasticities of ROA with respect to the eco-efficiency indicators for water and energy are all insignificant, which implies that eco-efficiency has no significant impact on the profitability of firms. This is consistent with the pooled OLS results after controlling for all the possible factors that are known to affect the profitability of firms.

It is important to rule out the presence of endogeneity bias in the model. This is a serious econometric problem which would render the estimated parameters inconsistent. In the presence of endogeneity bias, an instrumental variable estimation is imminent. In this analysis, the source of endogeneity bias is suspected to be between the dependent variable and the regressors, since both ROA and eco-efficiency indicators are value-based ratios. An attempt to avoid this bias is made in computing the variables in the sense that ROA uses total sales as the value measure while the eco-efficiency indicators use value added as the value measure. There is need to determine econometrically if there is any endogeneity bias that will justify the estimation of an instrumental variable model. The Durbin–Wu–Hausman statistic tests for the endogeneity between the dependent variable and eco-efficiency indicators whereby rejecting the null hypothesis would suggest that the eco-efficiency indicator is endogenous. This would justify an instrumental variable estimation. Table 4 presents the results of the Durbin–Wu–Hausman χ^2 tests.

In all the cases, the results of the Durbin–Wu–Hausman χ^2 test report a calculated χ^2 that is less than the critical value at 1 degree of freedom and 5% level of significance. The null hypothesis cannot be rejected, implying the absence of endogeneity problem. Therefore, the instrumental variables (IV) estimation is not necessary.

In this scenario, the results from OLS and fixed effects models are binding, which indicate that eco-efficiency has no significant impact on the profitability of firms in Kenya. This is contrary to earlier studies (see Guenster et al., 2005 & Mohn, 2006). There is evidence that both a proactive and reactive EMS impact positively on profits, which agrees with earlier findings by Ramus and Oppegaard (2007), who argue that

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Table 5. Mean and Standard Deviations for Environmental Leaders and Laggards.

Variable	Overall	Leaders	Laggards
Return on assets (ROA)	12.85	13.96	10.08
	(14.91)	(16.16)	(10.80)
Eco-efficiency of water	0.710	0.833	0.403
	(1.766)	(2.028)	(0.714)
Eco-efficiency of fuel oil	0.097	0.103	0.081
	(0.237)	(0.255)	(0.181)
Eco-efficiency of electricity	0.044	0.045	0.041
	(0.091)	(0.099)	(0.069)
Eco-efficiency of waste	0.003	0.003	0.004
	(0.013)	(0.013)	(0.012)
N	235	168	67

Source: Computed from RPED dataset. The figures in parentheses are the standard deviation.

commitment and compliance-based approaches can coexist to the benefit of organizations wishing to move toward environmental sustainability.

However, the fact that a proactive EMS seems to have a greater impact on profits than a reactive EMS is contrary to the findings by Ytterhus (2004), who argues that firms with an EMS did not differ in economic performance with firms that have no EMS.

This calls for further analysis that involves comparing both ROA and eco-efficiency indicators for different subsamples. To achieve this, a subsample of firms that are environmental leaders is compared with that for environmental laggards. The means and standard deviations of both ROA and eco-efficiency scores are reported in Table 5.

Before making any conclusion as to whether environmental leaders perform better than environmental laggards, we test the hypothesis that there is no statistical difference between the means. The null hypothesis is that the $H_0 : u_1 - u_2 = 0$ implying that there is no statistical difference between the means. The alternative hypothesis is $H_1 : u_1 - u_2 > 0$. The null hypothesis is rejected if the *p*-value is less than the significance level. A failure to reject the null hypothesis would mean that we cannot make conclusions from the observed means since they are not statistically different.

In the case of ROA, the calculated *t*-statistic is 2.146. Using the *t(66)*[4] distribution, estimated in Table D in Moore and McCabe (2006) by the *t(60)* distribution, we see that *P(t≥2.146)*[5] is between 0.02 and 0.01, indicating a significant difference between the means at the 0.05 level. In the case of eco-efficiency of water and eco-efficiency of waste, the calculated *t*-statistic is 2.402 and 5.882 respectively while the *p*-values are both significant at 0.05 level. In these three cases the null hypothesis is rejected, which implies that there is sufficient evidence to conclude that environmental leaders are more profitable than environmental laggards and they are more eco-efficient in the use of water and waste disposal.

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Table 6. Mean ROA and Eco-efficiency for Different EMS Types.

Variable	Proactive EMS	Anticipatory EMS	Reactive EMS
Return on assets (ROA)	17.38 (18.94)	17.74 (17.27)	13.55 (15.75)
Eco-efficiency of water	1.373 (4.513)	1.637 (5.100)	0.757 (1.273)
Eco-efficiency of fuel oil	0.156 (0.345)	0.196 (0.383)	0.096 (0.298)
Eco-efficiency of electricity	0.033 (0.063)	0.028 (0.067)	0.046 (0.104)
Eco-efficiency of waste	0.001 (0.002)	0.001 (0.002)	0.003 (0.015)
N	23	18	143

Source: Computed from RPED dataset. The figures in parentheses are the standard deviation.

Considering that a higher eco-efficiency indicator implies less of the input in use, the higher eco-efficiency indicator for water is good for the Kenyan firms and also in many other similar industries in developing countries where water is critical input in terms of environmental sustainability. However, environmental leaders seem to spend more on waste than environmental laggards. In the case of eco-efficiency of fuel oil and eco-efficiency of electricity, the *p*-value is greater than the significance level at 0.05 levels in which case the null hypothesis cannot be rejected. This reveals that there is insufficient evidence to conclude that environmental leaders are more eco-efficient than environmental laggards in the use of fuel oil and electricity.

There is a need to establish if there is any financial benefit in having a proactive EMS. To do this, we further subdivide the sample for environmental leaders into firms that are proactive in their EMS approach, where the EMS is commitment motivated, and those that are reactive in their approach, where the EMS is compliance motivated. An intermediate group of firms that are deemed to have an anticipatory EMS approach since they combine both reactive and proactive approaches is also included. Table 6 reports the means and standard deviation of proactive, anticipatory, and reactive firms.

Testing for statistical difference between the means of proactive and reactive firms, the results reveal that for ROA, the calculated *t*-statistic is 0.92. Using the *t(22)* distribution, from Table D in Moore and McCabe (2006), we see that the *p*-value is between 0.2 and 0.15, which is insignificant at the 0.05 level in which case we fail to reject the null hypothesis. The *p*-values for the test for statistical differences in the means of all eco-efficiency variables are all insignificant being all between 0.2 and 0.15. Hence, there is insufficient evidence to conclude that firms with proactive EMS are more profitable or more eco-efficient than firms with reactive EMS. However, eco-efficiency of waste is significant at 0.10 level. This implies that proactive firms spend more on waste disposal when compared to reactive firms.

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Table 7. Mean ROA and Eco-efficiency for ISO Certified and CPI Firms.

Variable	Proactive	ISO	CPI
Return on assets (ROA)	17.38 (18.94)	13.16 (12.19)	21.20 (22.86)
Eco-efficiency of water	1.373 (4.513)	0.598 (0.682)	1.988 (6.279)
Eco-efficiency of fuel oil	0.156 (0.345)	0.247 (0.445)	0.033 (0.029)
Eco-efficiency of electricity	0.033 (0.063)	0.029 (0.079)	0.032 (0.036)
Eco-efficiency of waste	0.001 (0.002)	0.0002 (0.0005)	0.002 (0.002)
N	23	13	12

Source: Computed from RPED dataset. The figures in parentheses are the standard deviation.

Examining the results for anticipatory firms, the eco-efficiency indicator for fuel oil is higher than those for proactive and reactive firms while the eco-efficiency of electricity is lower for anticipatory firms than that for proactive and reactive firms. This shows that firms that combine proactive and reactive approaches to environmental management perform better than those that choose either. This is consistent with the results due to Ramus and Oppegaard (2007). It is therefore not conclusive that there is a financial benefit in firms embracing proactive environmental management practices.

It is also important to establish if there is any financial benefit in a firm having an EMS that is internationally certified as opposed to an in-house EMS. To do this, we further isolate the firms that are ISO certified from those that have implemented CPI and compare their mean ROA and eco-efficiency scores. Recall that a proactive firm was defined as one that is

ISO certified, adopts either CPI or both. The results are reported in Table 7.

The results suggest that firms with internationally certified EMS seem to do better than those that adopt national standards in terms of eco-efficiency of fuel oil and electricity but for eco-efficiency of water, internationally certified EMS have no advantage over a national EMS standard. Further, internationally certified EMS has no advantage over a national EMS standard in terms of profitability.

However, testing for statistical difference between the means of ISO and CPI firms using the *t(11)* distribution from Table D in Moore and McCabe (2006), the results reveal that calculated *t*-statistic is 1.084 for ROA with a *p*-value between 0.2 and 0.15, which is insignificant at the 0.05 level. The calculated *t*-statistic for eco-efficiency of fuel oil is 1.740 with a *p*-value between 0.1 and 0.05, which is insignificant at the 0.05 level (but significant at 0.1 level). The *p*-values for eco-efficiency of water and eco-efficiency of electricity are insignificant being greater than 0.05. In all cases, the null hypothesis cannot be rejected at 0.05 level. Hence, there is insufficient evidence to

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conclude that firms with ISO certified EMS are less profitable or less eco-efficient than firms with national EMS standard. However, the *p*-value for eco-efficiency of waste is significant at 0.05 level, which implies that firms with ISO certified EMS spend more on waste disposal.

Conclusion

This article sought to explore the linkage between clean production and the profitability of firms by examining the relationship between a firm's profitability and its level of eco-efficiency, which is a measure of environmental performance. This was done by running a panel data regression model with ROA as the dependent variable and eco-efficiency scores as the regressors. It further sought to establish the impact of EMS on both eco-efficiency and profitability. These environmental management practices were captured by the type of EMS a firm adopts that classified firms as either environmental leaders or environmental laggards. For the environmental leaders, they were further classified as either proactive or reactive depending on their environmental management approach.

An increase in the eco-efficiency indicator that reflects the value per unit of environmental effects implies a fall in the amount of input in use. Another important aspect is that in interpreting the eco-efficiency indicator in relation to ROA, two aspects are worth noting. First, for environmental friendly inputs such as electricity, a lower eco-efficiency indicator, implying more of its use in production, is good for the firm since it would mean that clean fuel is being substituted for dirty fuel. Second, for environmentally detrimental input such as fuel oil and water, a higher eco-efficiency score, implying less of its use in production, is good for the firm since it reflects lower levels of pollution. For waste, a higher eco-efficiency indicator is good in the sense that it indicates that the cost of waste disposal is going down, implying less waste is being generated in the production process. While these results shows promising findings with regards to the use of the environmental resources, a big issue is whether that can be sustained more especially in Kenya and many other similar developing countries. Greater efforts are being made in these countries toward industrialization. A big problem is the energy and water sector to sustain the growing demand of water and electricity. Large percentage of the electricity is hydropower, which because of the persistent droughts is no longer secure source. Kenya, like many other countries in Eastern Africa, is now looking for other dirty sources such as fuel oil and coal to produce electricity.

The estimation results reveal that eco-efficiency of water, fuel oil, and electricity have no significant impact on the profit of a firm. The dummy variable for proactive EMS is positive and higher than that of reactive EMS that is also positive. This implies that although combining both proactive and reactive environmental management approach is beneficial to the firm, proactive approach will benefit the firm more. However, the benefit is only in terms of eco-efficiency of energy, which does not seem to translate into higher profits. There was evidence that on average, environmental

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leaders are more eco-efficient in the use of water than environmental laggards. Environmental leaders seem to spend more on waste disposal, which implies that they are more environmental conscious. This suggests that it is good for the environment when firms embrace good environmental management practices. Governments are therefore required to support those initiatives of the private firm, for example provision of good infrastructure that will reduce transportation and commutations costs, tax incentive, and so on. On average, proactive firms perform better than reactive firms in terms of energy eco-efficiency, but firms that combine both proactive and reactive EMS perform even better in terms of both energy eco-efficiency; however, this does not seem to have an impact on the profitability of the firm. Firms with international certified EMS have an advantage over those with national EMS in terms of energy eco-efficiency. In conclusion, good environmental management practices such as proactive EMS and ISO certification only seem to improve energy eco-efficiency but have no impact on the profitability of the firm. However, given the data constraints in this analysis, the government should establish a mechanism where environmental impacts are well quantified to aid in research.

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Notes

1. National Environment Management Authority (NEMA) is an institution created by the Environmental Management and Coordination Act (EMCA) in July 2002 to supervise and coordinate environmental management programs and initiatives.
2. This is an initiative of the Kenya National Cleaner Production Center (KNCPC) established in July 2000 by the Government of Kenya through the Kenya Industrial Research and Development Institute (KIRDI) and the United Nations Development Program (UNDP), whose mandate is to accelerate the adoption of Cleaner Production (CP) practices by Kenyan businesses through awareness raising, training, setting up of demonstration projects, information dissemination, and policy dialogue.
3. The errors are assumed to be identically and independently distributed, that is the observations are assumed to be serially uncorrelated across individuals and time and the errors are assumed to be homoskedastic, and the assumptions of the classical linear model are met. Under these conditions, OLS is an efficient estimation method.
4. The degrees of freedom are calculated using $t(k)$ distribution where k represents the *smaller* of $n_1 - 1$ and $n_2 - 1$ (see Moore & McCabe, 2006).
5. This is a one-tailed test where p is the probability that t lies to the right of the critical value.

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