# Clean production and Employment Outcomes: An Eco-efficiency Firm Level Analysis in Kenya

Erick Maiko Akama[§], Razack Lokina[†] & Beatrice Kalinda Mkenda[‡]

**Abstract**

This study explores the correlation between environmental performance and employment outcomes in the manufacturing industry in Kenya. Specifically, the study seeks to achieve three primary goals: first, to examine the impact of eco-efficiency on various types of employment outcomes; second, to examine the effect of adopting an Environmental Management System (EMS) on employment outcomes; and lastly, to compare the impact of using either a commitment-based approach (proactive firms) or a compliance-based approach (reactive firms) on different types of employment outcomes. The study uses a 2-year panel data of Kenya's manufacturing firms from the Regional Programme Enterprise Development (RPED). Analysis is done using a pooled panel regression model that utilizes eco-efficiency scores as explanatory variables and employment outcomes as the dependent variable. The study findings indicate that by improving eco-efficiency in resource allocation, there is a potential gain in employment outcomes – though this gain varies depending on the type of employment outcome being considered. Moreover, proactive firms were found to perform better than reactive firms in employment outcomes, implying that adopting a commitment-based approach towards environmental management is more beneficial for manufacturing firms in terms of bolstering their employment outcomes.

**Key words:** Eco-efficiency; employment; environmental performance; Environmental Management System; proactive firms; reactive firms; environmental leaders; laggard.

**JEL Classification Codes:** O44; Q56; E24.

[§] School of Economics, University of Dar es Salaam; maikoakamaerick@gmail.com; https://orcid.org/0000-0001-6284-1276

[†] Professor and Deputy Vice Chancellor, University of Dodoma, razack_lokina@yahoo.co.uk; razack.lokina@udom.ac.tz, https://orcid.org/0000-0001-7180-5541

[‡] Senior Lecturer & Dean, University of Dar es Salaam School of Economics, bkmkenda@googlemail.com; https://orcid.org/0000-0001-5788-0369

## 1. Introduction

The traditional approach of end-of-pipe technologies, which involves treating pollutants after they have been generated, is no longer sustainable. Instead, as the world continues to grapple with the effects of climate change, there is a growing need for manufacturing industries to adopt cleaner production methods (Khalili *et al*., 2015; Maiurova *et al*., 2022). Clean production is a concept that has been gaining traction in recent years. It refers to the process of producing goods and services in an environmentally sustainable manner (Bjørnbet *et al*., 2021; Orlins & Guan, 2016). It revolves around reduction of waste, resource conservation and minimization of pollution.

While the benefits of clean production are well documented[1], there is still much debate about its impact on employment outcomes (Orlins & Guan, 2016). In many of the developing countries, there is a hesitancy to switch from end-of-pipe technologies to cleaner production methods (Ghazinoory, 2005). The main concern is that this shift might lead to job losses and reducing effect on the people's welfare (Ghazinoory, 2005; Frijns & Van Vliet, 1999). However, in light of the growing concern for environmental sustainability and the pressing need for measures to counteract environmental degradation, it has become widely recognized that eco-efficiency (a component of clean production) is a crucial element to achieving sustainability objectives. By eco-efficiency, we refer to the ability of firms to produce goods and services while minimizing any environmental harm.

Based on the complexity of the issue, it is clear that empirical investigation is needed to fully understand the impact of clean production on employment outcomes. This investigation can help to identify which industries are most likely to be affected by clean production and which ones are likely to benefit. Equally, they can help to identify the skills and training needed for workers to transition into new jobs in emerging industries. Finally, empirical investigations can help policymakers to develop targeted policies and programs to support workers during the transition to a cleaner economy.

Previous studies have mostly focused on analyzing the effect of eco-efficiency on firm performance. Yet, little research has been conducted on how eco-efficiency influence employment outcomes. To address this gap, our study aimed to explore the correlation between eco-efficiency and different types of employment outcomes in Kenya. Specifically, we investigated how Environmental Management Systems (EMS) adopted by firms impact employment outcomes, as well as examining the differences between proactive and reactive firms in terms of commitment to eco-efficiency and its effect on employment. Further, existing empirical evidence have primarily focused on developed countries with high technological capabilities. Understudies are low technical capacity countries like Kenya where end-of-pipe technologies predominate. Thus, in this study, we explore association between clean productions technologies (as opposed to the traditional end-of-pipe technologies) and employment outcome in Kenya. In specific, we examine

[1] First and foremost, it helps to protect the environment. By reducing waste and pollution, clean production can help to preserve natural resources and prevent environmental degradation. In addition, clean production can also lead to cost savings for businesses. By using resources more efficiently, businesses can reduce their operating costs and improve their bottom line. Finally, clean production can also help to improve the health and well-being of workers. By reducing exposure to harmful chemicals and pollutants, workers can enjoy a safer and healthier work environment.

different employment outcome (skilled, permanent, part-time and causal employment) between two types of firms: environmental leader[2] and environmental laggards[3].

The subsequent sections of this manuscript are arranged as follows: Section 2 presents the overview of relevant literature to establish the general framework in which our investigation is based. Section 3 presents the methodology and the data to be used. Next, in Section 4, presents the estimation and discusses the outcomes of our estimation, and finally, in Section 5, we summarize our findings.

## 2. Literature review

From the principles of neoclassical economic theory, a well-functioning market system must operate based on an optimization model to ensure efficiency. Any deviation from this objective would result in an inadequate resource allocation that would ultimately lead to reduced social satisfaction. However, the conceptual framework employed by neoclassical economists overlooks the significant impact that environmental factors have on production processes and consumer preferences. By failing to incorporate the adverse effects of pollution and other externalities into market transactions, this model overlooks the true impact that these factors have on overall societal welfare. In an effort to address these limitations, Pigou (1932) sought to modify the neoclassical model by emphasizing the importance of mitigating externalities in order to optimize societal welfare. However, neoclassical economists continue to view regulations aimed at controlling externalities as costly constraints that can ultimately reduce firms' profits, resulting in potential cutbacks in hiring and cost-cutting measures.

Cahuc & Malherbet (2004) and Oelkers & Cole (2008) provide the most recent theoretical framework linking environmental performance and employment through their model. The authors take into account pollution emissions as a production factor, which can affect both the environment and the labor market. Their model suggests that firms that invest in environmental performance are likely to experience increased productivity and competitiveness, resulting in a positive impact on employment. Furthermore, the authors argue that policies aimed at reducing pollution emissions can also have positive effects on employment by stimulating innovation and promoting the development of new technologies.

Although limited empirical evidence on the nexus between clean production initiatives and employment outcomes exists in low technological capacity economies such as Kenya, evidence from high technical capacity economies have concentrated on impact of environmental regulations rather than impact of clean production initiatives on employment outcomes. Further, these studies have remains highly inconclusive. For instance, Curtis (2016) found a small negative impact of the nitrogen oxides cap-and-trade program on manufacturing employment, with impacts primarily occurring through decreased hiring rates, rather than increased separation rates. Sheriff *et al.*, (2016), on the other hand found negative impacts of ozone regulations on employment at electric utilities, with no accompanying changes in electricity generation, possibly indicating labor-saving technical change.

[2] These are firms that have Environmental Management Systems (EMS)
[3] These are firms without Environmental Management Systems (EMS)

Further, Greenstone (2002) and Walker (2011, 2013), suggest that countries subjected to stringent air quality regulation had a likelihood of generating fewer manufacturing vacancies as compared to non-regulated countries. However, because they identified employment impacts by comparing regulated to similar non-regulated areas, environmental performance impact on employment was likely overstated and thus biased (Greenstone, 2002). Dissou and Sun (2013) on the other hand specified a wage curve to examine the welfare and employment implications of different ways of recycling revenues from a carbon cap-and-trade system. They found relatively small effects on employment for low- and high-skilled workers across scenarios, noting that this is unsurprising given that carbon-intensive industries tend to use relatively more capital than labor.

Additionally, Kahn and Mansur (2013) examined differences in adjacent counties over an extended period (1998-2009). Their research reveals that energy-intensive sectors tend to locate in low-priced electricity areas while polluting industries tend to favor areas with fewer regulations. This results in decreased employment opportunities in highly regulated areas. However, the effects are generally minor for the typical manufacturing industry with an 8 percent increase in electricity prices resulting in a decrease of 3.8 percent in employment within Ohio and a 0.3 percent decrease in California.

In conclusion, both theoretical and empirical literature are inconclusive on the impact of clean production on employment outcomes. Contrary to the neoclassical economists who argue that clean production has a counterproductive impact on employment outcomes, some scholars have found evidence of a positive relationship between clean production and employment (see, Cahuc & Malherbet (2004) and Oelkers & Cole (2008)). However, to the best of our knowledge, limited studies have been conducted in low technical capacity countries like Kenya. This is a crucial gap in the literature as these countries are often dominated by a trade-off between environmental protection and economic growth. The limited studies that have been conducted in low technical capacity countries suggest that the impact of clean production on employment outcomes may differ from what has been observed in high-income countries. Factors such as lack of access to technology, inadequate infrastructure, and limited human capital may affect the ability of firms to adopt clean production practices and subsequently impact their ability to create jobs. Therefore, it is essential to examine the impact of clean production on employment outcomes in low technical capacity countries like Kenya. Our contribution aims to fill this gap by providing empirical evidence on the relationship between clean production and employment outcomes in Kenya.

## 3. Methodology

### 3.1 Theoretical framework

The study's theoretical framework is developed from the classical Cobb-Douglas production function facing a given firm. The production model assumes that the output of a firm is dependent on various inputs like capital and labour. To extend this model, we have incorporated pollution inputs as another significant factor for production, as depicted in equation 1.

$$Y_{it} = W_{it}^{\alpha} L_{it}^{\beta} T_{it}^{\gamma}, \qquad 0 < \alpha, \beta, \gamma < 1 \tag{1}$$

Where $Y_{it}$ is the output of the i$^{th}$ polluting firm in period t; $W_{it}$ denotes the pollution input for i$^{th}$ firm in period t; $L_{it}$ denotes the labor input for i$^{th}$ firm in period t and T represents all other inputs (including capital) for the i$^{th}$ firm in period t, while α, β, and γ are the pollution-elasticity, labor-elasticity and other factors' elasticity, respectively. From this background, let's assume that the main objective of the Kenyan manufacturing firms is profit maximization, then an individual firm's objective function at any given time is to choose the level of W to maximize profit (π).

$$Max(\pi_{it}) = \left[P_{it}W_{it}^{\alpha}L_{it}^{\beta}T_{it}^{\gamma} - (C_iW_{it} + V_iL_{it} + Q_iT_{it})\right] \quad (2)$$

Where $P_{it}$ denotes the price of output made by i$^{th}$ firm in period t. V represents the price of labor for firm i, Q denotes the price of other input factors for the firm, and $C_i$ is the price of pollution input for the firm. As environmental regulations become more stringent, the costs associated with pollution are likely to rise, thereby contributing to an increase in $C_i$. Note that we assume that there is a positive relationship between $C_i$ and the intensity of environmental regulations. Taking partial derivative for equation 2 above, with respect to W, L and T, we obtain the following.

$$\partial\pi/_{\partial W_{it}} = \alpha P_{it}W_{it}^{\alpha-1}L_{it}^{\beta}T_{it}^{\gamma} - C_i = 0 \quad (3)$$

$$\partial\pi/_{\partial L_{it}} = \beta P_{it}W_{it}^{\alpha}L_{it}^{\beta-1}T_{it}^{\gamma} - V_i = 0 \quad (4)$$

$$\partial\pi/_{\partial T_{it}} = \gamma P_{it}W_{it}^{\alpha}L_{it}^{\beta}T_{it}^{\gamma-1} - Q_i = 0 \quad (5)$$

Since$^{\partial\pi}/_{\partial T_{it}} = 0\ at\ optimal$, equation 5, we can be re-written as

$$\gamma P_{it}W_{it}^{\alpha}L_{it}^{\beta}T_{it}^{\gamma-1} - Q_i = 0 \quad (6)$$

Or simply as

$$\frac{T_{it}^{\gamma}}{T_{it}} = \frac{Q_i}{P_{it}W_{it}^{\alpha}L_{it}^{\beta}}$$

$$T_{it}^{\gamma} = \frac{Q_iT_{it}}{P_{it}W_{it}^{\alpha}L_{it}^{\beta}} \quad (7)$$

Substituting this value of $T_{it}^{\gamma}\ in\ equations$ 3 we have

$$\alpha P_{it}W_{it}^{\alpha-1}L_{it}^{\beta}\left(\frac{Q_iT_{it}}{P_{it}W_{it}^{\alpha}L_{it}^{\beta}}\right) = C_i$$

$$Q_i = \frac{\gamma W_iL_{it}}{\propto T_{it}} \quad (8)$$

Equally, substituting $T_{it}^{\gamma}$ $in\ equations$ 4 we have

$$\beta P_{it} W_{it}^{\alpha} L_{it}^{\beta-1} \left(\frac{Q_i T_{it}}{P_{it} W_{it}^{\alpha} L_{it}^{\beta}}\right) = V_i$$

Or

$$Q_i \quad = \quad \frac{\gamma V_i L_{it}}{\beta T_{it}} \tag{9}$$

Solving equation 8 and 9, the labour demand as a function of environmental regulation is given in equation 10 below.

$$\frac{\gamma W_i L_{it}}{\propto T_{it}} = \frac{\gamma V_i L_{it}}{\beta T_{it}}$$

Thus

$$L_i = \frac{\beta}{\alpha V_i} CW \tag{10}$$

Equation 10 is the labour demand for the firm facing environmental regulations. Note that measurement of the relationship between regulatory stinginess and employment growth is based on the assumption that when environmental regulations are tightened, each firm faces a proportional rise in costs and thus reduce its initial labour employment. This can be represented as:

$$\frac{\partial L_i}{\partial C_i} = \frac{\beta}{\alpha V_i} W_i \left(I - [-\left(\frac{C}{W}\right) * \left(\frac{\partial W}{\partial C}\right)]\right)$$

Letting

$$\theta_{WC} \quad = \quad -\left(\frac{C}{W}\right) * \left(\frac{\partial W}{\partial C}\right)$$

$$\frac{\partial L_i}{\partial C_i} = \frac{\beta}{\alpha V_i} W_i (I - \theta_{WC}) \tag{11}$$

Where, $\theta_{WC}$ represents the price elasticity of pollution inputs. In this case, C is the intensity of environmental regulations. Note that when regulations are tightened, firm will reduce expenditures on pollution. That means that $\frac{\partial W}{\partial C} < 0$. We add a minus sign in Equation (11) to make sure that $\theta_{WC}$ is non-negative. Equation (11) can be decomposed into two parts. First, $\frac{\beta W}{\alpha V_i}$ represents the employment change caused by the change in the relative price between C and Li, and we can call it the substitution effect. The second, $(\frac{\beta W}{\alpha V_I})\ \theta_{WC}$ represents the employment change caused by the change of firm's production scales under the regulations, and we call this change the scale effect. Increasing regulatory stringiness will simultaneously create both substitution effect and scale effect. However, the substitution effect is initially smaller than the scale effect, then bigger with the increase of investment in pollution prevention. That is to say, environmental regulations will increase an individual's employment probability when the regulatory stringency reaches a given level.

### 3.2 **Modeling the eco-efficiency –employment relationship**

We begin from the assumption (based on the theoretical framework) that eco-efficiency, which is a measure of clean production, influences employment. We specify the basic panel data model, as

$$EMP_{it} = \alpha_0 + \alpha_i EES_i + \alpha_i E_i + \beta X_{it} + \sigma Z_{ijt} + \mu_{it} \qquad (12)$$

Where subscript i and t denotes an individual firm and year respectively; $EMP_{it}$ is the employment outcome and dependent variable. It is a continuous variable that is proxied by (i) Total number of employee of individual firm at period t (ii) Number of permanent employee of individual firm at period t (iii) Number of temporary/causal employee of individual firm at period t (iv) Number of skilled employee of individual firm at period t (v) Number of part-time employee of individual firm at period t; $E_i$ is the dummy capturing different types EMS assumed by the firm (that is whether a firm is an environmental leader, environmental laggard proactive or reactive); $X_{it}$ is a vector of time invariant eco-efficiency score; $\sigma Z_{ijt}$ is a vector of control variables while $\mu_{it}$ is the stochastic error term. $EES_i$ is a vector of time invariant eco-efficiency score of inputs of interest such as water, electricity and fuel. We define eco-efficiency as product value of output per unit of environmental influence. The product value is proxied by quantity of goods produced to customers. For environmental influence we used the aspects of product consumption that include: Energy consumption; Water consumption and electricity consumption

### **3.3 Data and its processing**

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. Classification of firms as either environmental laggard or environmental leaders follow closely the classification given by Verbeke & Buysse, (2003) but with caution given that some firms may have an ISO certification in order to respond, in appearance, to stakeholders' pressures without changing their internal practices. Notably, it has been argued that some of the most polluting firms have a certified EMS (Boiral, 2007; Meyer & Rowan, 1977). We therefore took a careful assessment when making the difference between types of firms, including considering other criteria based on the information reported by NEMA, when conducting monitoring. Further, we sub-divide environmental leaders into (i) Reactive firms (firms who's 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) and (ii) Proactive (those that incorporate some voluntary actions such as clean production initiatives (CPI) or ISO certification). We then compare the employment under compliance-based approach and commitment approach. We then carry out two levels of analysis: In the first step is to determine if there is any correlation between eco-efficiency and employment outcomes for individual firm. This is done by estimating equations 12 using the pooled Ordinary Least Square (OLS) after testing the poolability test. It will then be followed by random effect method for robustness checks.

## 4.0 Results

### 4.1 Descriptive statistics

The descriptive analysis is conducted on two levels: at the overall sample and individual years. According to the summary statistics presented in Table 1, the mean firm-level total employment across the two-year period for was 275 workers. However, on average, each firms hired more employees in 2001 (around 277 workers) than they did in 2002 (around 274 workers). The findings further indicates that the mean number of permanent workers in the overall sample was 151, with 2002 having a higher number of permanent workers (153) than 2001 (which had an average of 150 workers). Additionally, the overall mean number of part-time workers was about 123 for the overall sample with 2001 employed more part-timers (about 126 workers) than 2002 (with 120 workers). For the skilled workers, the results showed that the mean number for the e overall sample was approximately 41 workers, and 2002 had more skilled workers (42 workers). Finally, regarding casual workers, the mean number of the overall sample was approximately 22 workers, while the mean numbers of casual workers for 2001 and 2002 were 21 and 23 workers, respectively.

The efficiency of energy (fuel and electricity) and water resource use are proxied by eco-efficiency indicators. According to result in Table 1, the average eco-efficiency of fuel across the overall sample was around 55.53%. However, a comparison of fuel eco-efficiency between the two time periods shows an improvement from 46.45% in 2001 to 66.76% in 2002. This signifies that a lower quantity of fuel was used in 2002 as compared to 2001 to produce the same level of output. Since fuel is categorized as a 'dirty' source of energy, an increase in its eco-efficiency denotes a reduction in fuel use required to generate equal output levels. Consequently, the environmental impact of fuel reduced during the recorded two-year period.

Additionally, the result reveals that water resources had an overall eco-efficiency rate of around 1.04%. The findings further indicate that this rate declined from 6.25% in 2001 to roughly 3.75% in 2002. This decrease in water's eco-efficiency suggests that the environmental impact related to its use in production worsened during those two periods, with more water utilized per unit output in 2002 than in 2001. As for electricity's eco-efficiency, the data shows an average of 29.05% for the sample size. Nevertheless, a stark difference was observed over time: electricity's eco-efficiency was considerably lower in 2001 at 28.28% but significantly higher in 2002 at 29.92%. Considering electricity is widely perceived as "clean" energy, its increase in eco-efficiency denotes an improvement in environmental sustainability.

Approximately 69% of the firms in the overall sample were found to be environmental leaders, while approximately 31% were environmental laggard. The distinction was based on whether a firm had taken up an environmental management initiative (EMS) or not. Those firms with at least one EMS initiative were classified as environmental leaders, while those without were regarded as environmental laggard. Environmental leaders remained fairly the same between 2001 and 2002. We further disaggregated environmental leaders into proactive (those that initiated voluntarily) and reactive (those whose EMS merely meet the minimum requirements of regulatory authorities). The results show that reactive firms accounted for approximately 53%, while proactive firms accounted for approximately 47%, with no significant variation during the two study periods.

During the study period, approximately 49% of the firms in the study had at least a double shift, while approximately 51% had a single shift. However, there was a slight improvement in the labour shift from 49.12% in 2001 to approximately 49.29% in 2002. The average age of the firm was approximately 36 years, with a majority (75.26%) of the firms being domestically owned. State-owned firms accounted for 8.83%, while foreign-owned (African) and foreign-owned (rest of the world) firms accounted for 6.36% and 15.90%, respectively. The rest of firm ownership accounted for 18.02%. Approximately 29.18% of these firms were from the garment industry, while the metal and non-metallic industries accounted for 16.19% and 11.03%, respectively. The rest of the industry formed less than 10% of the overall sample.

**Table 1: Summary statistics**

| Variable | Observation | overall | 2001 | 2002 |
|---|---|---|---|---|
| Total employment | 526 | 275.0513 | 276.5589 | 273.5437 |
| | | (686.0132) | (706.1864) | (666.5738) |
| • Permanent workers | 524 | 151.7385 | 150.4122 | 153.0649 |
| | | (347.4055) | (346.669) | (348.799) |
| • Part-Time workers | 526 | 123.1749 | 126.1749 | 120.1749 |
| | | (545.7989) | (577.1493) | (513.6249) |
| • Skilled workers | 483 | 41.87371 | 41.25306 | 42.51261 |
| | | (118.5382) | (117.5072) | (119.8345) |
| • casual workers | 481 | 22.45946 | 21.89627 | 23.025 |
| | | (55.15239) | (55.22916) | (55.18481) |
| Eco_fuel | 302 | .5553119 | .4644926 | .6676586 |
| | | (8.952667) | (8.537275) | (9.472357) |
| Eco_water | 328 | .0103536 | .0624656 | .0374919 |
| | | (.8533373) | (1.210265) | (.2275062) |
| Eco_electricity | 341 | .2904977 | .2828209 | .299182 |
| | | (2.410023) | (1.834479) | (2.934305) |
| Environmental leader (1/0) | 549 | .6867031 | .6861314 | .6872727 |
| | | (.464257) | (.4649128) | (.4644495) |
| Environmental laggard (1/0) | 549 | .3060109 | .3065693 | .3054545 |
| | | (.4612546) | (.4619126) | (.4614394) |
| • Proactive (1/0) | 356 | .4719101 | .4719101 | .4719101 |
| | | (.499913) | (.5006185) | (.5006185) |
| • Reactive (1/0) | 353 | .5325779 | .5280899 | .5371429 |
| | | (.4996458) | (.5006185) | (.5000493) |
| Labour shift (1/0) | 565 | .4920354 | .4911661 | .4929078 |
| | | (.5003796) | (.5008076) | (.5008385) |
| Age of Firm | 152 | 36.26316 | 35.77632 | 36.75 |
| | | (28.95503) | (29.03175) | (29.06275) |
| Ownership (1/0) | | | | |
| • State-owned (1/0) | 283 | | .0883392 | |
| | | | (.2842903) | |
| • Domestic owned (1/0) | 283 | | .7526502 | |
| | | | (.4322361) | |

| | | |
|---|---|---|
| • Foreign_owned(African) (1/0) | 283 | .0636042 (.2444789) |
| • Foreign_owned(rest of world) (1/0) | 283 | .1590106 (.3663338) |
| • Other ownership(1/0) | 283 | .180212 (.3850448) |
| Industry (1/0) | | |
| • Paper (1/0) | 562 | .0782918 (.2688696) |
| • Garments (1/0) | 562 | .2918149 (.4550026) |
| • Metals and machinery(1/0) | 562 | .1619217 (.3687072) |
| • Non-metallic and plastic materials(1/0) | 562 | .1103203 (.3135677) |
| • Chemicals and pharmaceutics(1/0) | 562 | .0996441 (.2997918) |
| • Construction(1/0) | 562 | .0640569 (.2450725) |
| • Food (1/0) | 562 | .0355872 (.1854236) |
| • Wood and furniture(1/0) | 562 | .0676157 (.2513089) |
| • Leather (1/0) | 562 | .0177936 (.1323183) |

**4.12 Pre-estimation tests**

We begin by addressing potential cross-sectional dependency common among firm-level panel data. Cross-sectional dependence can arise from various sources such as similar responses from individual firms to a shock or interdependent preferences. To test for cross-sectional dependence, we utilized tests proposed by Friedman (1937) and Frees (1995, 2004), as well as the parametric testing procedure suggested by Pesaran (2004). The null hypothesis of independent error terms across cross-sectional units was tested against the alternative of cross-sectional dependence. Based on the results from the test statistics shown in Table 2, it is evident that the probability values of both Pesaran's and Friedman's tests are large. Also, the value obtained from Frees' test is smaller than all critical values from the Frees' Q distribution. Therefore, we conclude that there is substantial evidence to fail to reject the null hypothesis and confirm that the error terms are independent across cross-sectional units.

**Table 2: Cross-sectional dependence using Friedman's test, Frees test and Pesaran test**

| Cross sectional dependence Test | Pr Value |
|---|---|
| 1. *Pesaran's test* | |
| ▪ Pesaran's test of cross sectional independence = 61.922, | Pr = 1.0000 |
| 2. *Frees test* | |
| • Frees' test of cross sectional independence = 0.467 | |
| • Critical values from Frees' Q distribution | |
| ▪ alpha = 0.10 : 0.2828 | |
| ▪ alpha = 0.05 : 0.3826 | |
| ▪ alpha = 0.01 : 0.5811 | |
| 3. *Friedman's test* | |
| ▪ Friedman's test of cross sectional independence = 66.745, | Pr = 1.0000 |
| ▪ Average absolute value of the off-diagonal elements = 0.034 | |

**4.13 Poolability test**

To determine whether to use pooled OLS and fixed effect models, a Chow's poolability test is utilized. Result in Table 3 result in failing to reject the Null hypothesis of all fixed effects are jointly zero against the alternative of at least some fixed effects are jointly different from zero (P=1.000) .This confirm that the pooled OLS model is an appropriate fit for our data.

**Table 3: Chow's Poolability test**

| | |
|---|---|
| Sigma_u | 42.322433 |
| Sigma_e | 41.301835 |
| rho | .51220275 (fraction of variance due to u_i) |
| F test that all u = 0 F(21,685789) = 0.00 | Prob > F = 1.0000 |

**4.13.2 Estimating the impact of eco-efficiency on employment**

The primary aim of this study was to analyse the effect of eco-efficiency on various types of employment in the manufacturing firms of Kenya. In order to achieve this, we utilized pooled OLS estimation as suggested by Chow's poolability test, found to be suitable for our data. The baseline regression result, presented in Table 4, assumed that only eco-efficiency influences employment decisions by firms. Result in Table 4 reveals that all three eco-efficiency measures (namely water, fuel and electricity), significantly influence the employment outcomes within the Kenyan manufacturing firms. However, the limited explanatory power of less than 2% (as shown by R squared of less than 0.02) signifies a weak goodness of fit across all five employment outcomes. Intuitively, implying that there are other relevant variables influencing employment decisions by firms in Kenya.

**Table 4: Effect of eco-efficiency on employment outcome of Kenyan manufacturing**

| | (Model 1) | (Model 2) | (Model 3) | (Model 4) | (Model 5) |
|---|---|---|---|---|---|
| VARIABLES | Overall employee | Permanent employee | Part time employee | Skilled employee | causal employee |
| Eco-efficiency of water | -91.30*** | -58.62*** | -32.49*** | -11.69*** | -13.22*** |
| | (0.125) | (0.0787) | (0.0571) | (0.0276) | (0.0233) |
| Eco-efficiency of electricity | 4.606*** | 1.674*** | 2.939*** | 0.752*** | -0.366*** |
| | (0.0390) | (0.0200) | (0.0195) | (0.00321) | (0.00152) |
| Eco-efficiency of oil | 26.84*** | -4.922*** | 31.90*** | -10.94*** | 0.894*** |
| | (0.122) | (0.0671) | (0.0661) | (0.0201) | (0.0212) |
| Constant | 219.3*** | 141.4*** | 77.56*** | 38.76*** | 22.95*** |
| | (0.125) | (0.0860) | (0.0571) | (0.0301) | (0.0180) |
| R-squared | 0.006 | 0.003 | 0.018 | 0.007 | 0.004 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the second phase of our analysis we controlled for the impact of environmental management systems (EMS) and other control variables. Interestingly, we found that all eco-efficiency factors (namely, water, electricity, and fuel) continued to be statistically significant in influencing employment outcomes. The improved goodness of fit (of R squared between 0.175 and 0.379 in Table 5) implied that the appropriate pooled model for our data set is the one with control variables.

**Table 5: Effect of eco-efficiency and other controls on employment outcome of Kenyan manufacturing**

| VARIABLES | (1) Overall employee | (2) Permanent employee | (3) Part time employee | (4) Skilled employee | (5) causal employee |
|---|---|---|---|---|---|
| Eco-efficiency of water | 882.8*** | 506.1*** | 386.4*** | -613.9*** | 167.8*** |
| | (3.266) | (2.278) | (1.293) | (2.572) | (0.564) |
| Eco-efficiency of electricity | 3.144*** | 1.074*** | 2.061*** | -1.240*** | 0.121*** |
| | (0.0198) | (0.0137) | (0.0108) | (0.00973) | (0.00333) |
| Eco-efficiency of oil | -21.36*** | -18.52*** | -2.447*** | -20.45*** | -19.27*** |
| | (0.431) | (0.343) | (0.173) | (0.0929) | (0.0843) |
| Type of EMS (1/0) | | | | | |
| • Environmental leader | 103.8*** | 97.08*** | 6.284*** | 5.761*** | 26.02*** |
| | (0.405) | (0.310) | (0.215) | (0.136) | (0.0656) |
| • Environmental laggard | -150.8*** | -135.4*** | -15.17*** | -46.55*** | -28.34*** |
| | (0.389) | (0.296) | (0.211) | (0.122) | (0.0657) |
| • Proactive | 377.6*** | 235.1*** | 142.6*** | 35.54*** | 18.50*** |
| | (0.566) | (0.450) | (0.243) | (0.0983) | (0.0837) |
| • Reactive | -377.6*** | -235.1*** | -142.6*** | -35.54*** | -18.50*** |
| | (0.566) | (0.450) | (0.243) | (0.0983) | (0.0837) |
| Industry (1/0) | | | | | |
| • Paper | -128.4*** | -98.93*** | -29.70*** | 9.887*** | 8.795*** |
| | (1.017) | (0.838) | (0.389) | (0.0923) | (0.0722) |
| • Garments | -18.91*** | -30.27*** | 9.399*** | 52.07*** | 22.10*** |
| | (0.956) | (0.749) | (0.453) | (0.158) | (0.0989) |
| • Metals and machinery | -136.9*** | -60.27*** | -78.10*** | 66.26*** | 12.29*** |
| | (0.988) | (0.817) | (0.410) | (0.295) | (0.0689) |
| • Non-metallic and plastic materials | 206.2*** | 159.1*** | 46.17*** | 89.31*** | 53.25*** |
| | (1.222) | (1.021) | (0.490) | (0.318) | (0.164) |
| • Chemicals and pharmaceutics | -283.7*** | -155.5*** | -128.7*** | 1.021*** | -2.972*** |
| | (1.063) | (0.892) | (0.460) | (0.110) | (0.0886) |

| | | | | | |
|---|---|---|---|---|---|
| • Construction | -124.6*** | -69.15*** | -55.44*** | 32.45*** | 3.535*** |
| | (0.974) | (0.816) | (0.391) | (0.184) | (0.0704) |
| • Food | -240.3*** | -134.2*** | -105.9*** | -33.43*** | 12.73*** |
| | (1.019) | (0.885) | (0.457) | (0.184) | (0.0788) |
| • Wood and furniture | -4.338*** | -64.12*** | 60.59*** | 23.51*** | 29.46*** |
| | (1.251) | (0.874) | (0.622) | (0.148) | (0.0681) |
| Labour shift | | | | | |
| • Single | -88.80*** | -47.23*** | -40.35*** | -15.56*** | 14.59*** |
| | (0.591) | (0.412) | (0.315) | (0.196) | (0.0785) |
| Ownership structure | | | | | |
| • Domestic | -199.7*** | -80.79*** | -120.5*** | 36.58*** | -19.67*** |
| | (0.643) | (0.417) | (0.366) | (0.183) | (0.128) |
| Number of customers | 2.184*** | -0.148*** | 2.358*** | -0.632*** | 0.359*** |
| | (0.0193) | (0.0124) | (0.0110) | (0.00431) | (0.00293) |
| Number of competitors | 0.170*** | 0.118*** | 0.0512*** | -0.00963*** | 0.00572*** |
| | (0.000911) | (0.000661) | (0.000381) | (0.000134) | (7.12e-05) |
| Formal firm training | 249.8*** | 160.9*** | 89.12*** | 50.89*** | 24.19*** |
| | (0.502) | (0.332) | (0.256) | (0.118) | (0.0674) |
| Worker compensation | 293.8*** | 173.6*** | 123.5*** | 45.00*** | 51.22*** |
| | (0.768) | (0.472) | (0.345) | (0.138) | (0.131) |
| Constant | -114.9*** | -107.3*** | -10.05*** | -83.33*** | -73.29*** |
| | (1.075) | (0.873) | (0.506) | (0.276) | (0.225) |
| R-squared | 0.379 | 0.322 | 0.288 | 0.175 | 0.306 |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5 shows that eco-efficiency plays a crucial role in determining employment outcomes for manufacturing firms in Kenya. Improvements in the eco-efficiency of water or electricity have a positive effect on overall employment, including permanent, part-time, and causal employment. A Plausible, both eco-efficiency of water and electricity may involve everything from installing energy-efficient lighting to implementing water-saving measures. By reducing the amount of resources a firm uses, improvement in these eco-efficiencies can help lower costs and improve profitability. Additionally, improvement in these eco-efficiencies can help firm meet regulatory requirements and enhance their reputation among customers who are increasingly concerned about sustainability. All these have the potential to increase a firm's employment outcome.

However, improvements in the eco-efficiency of water or electricity was found to have a negative impact on skilled employees. Plausibly, these improvements in the eco-efficiency in water and electricity could possibly be attributed to automated technologies that considerably reduce the need for human intervention. An example of this is the installation of smart meters in households, which has led to a decrease in demand for meter readers, resulting in a loss of jobs. In contrast, we found that the eco-efficiency of fuel - a dirty energy source - has a negative influence on all employment forms in Kenyan manufacturing firms.

The environmental leader dummy is found to be positive and statistically significant in influencing all types of employment among manufacturing firms in Kenya. For instance, holding all other factors constant, additional environmental leaders increased overall employment by approximately 104 employees, permanent employment by approximately 97 employees, part-time employment by approximately 6 employees, skilled employment by approximately 6 employees and causal employment by approximately 26 employees. Intuitively, this implies that an additional adoption of environmental management systems by one more firm in Kenya positively and significantly increased all forms of employment.

Interestingly, when the environmental leader is disaggregated into proactive (commitment-based) and reactive (compliance-based) dummies, the proactive dummy is found to be positive and significant in all types of employment, while the reactive dummy is found to be negative and significant in all types of employment. This is evidence that the commitment-based approach improves employment outcomes, while the compliance-based approach discourages employment outcomes among manufacturing firms in Kenya.

More interestingly, we found that both being an environmental laggard and a reactive firm have a negative and significant impact on employment outcome. However, the impact of the reactive dummy is found to be greater than that of the environmental laggard. Intuitively, this is evidence that command and control (through compliance) could have an undesirable employment outcome result rather than not having it in the first place.

For other control variables, we found that the dummy for industry had a significant influence on employment outcome. For instance, both overall employment and permanent employment were negatively influenced by all industries except the non-metallic & plastic materials industry. For part-time employment, we found that the paper industry, metal & machinery industry, chemical & pharmaceutics, construction and food industry had a negative influence, while industries such as garments, non-metallic & plastic materials and wood & furniture were found to have a positive influence. In regard to skilled employment, we found that all industries had a positive impact, except for employment in the food industry. Similarly, all industries were found to have a positive and significant impact on casual employment except in the chemical and pharmaceutical industries.

For the labour shift dummy, the study findings reveal that having a single shift had a negative and significant influence on all types of employment except for causal employment, in which it has a positive and significant impact. Equally, being a domestically owned firm significantly reduced all types of employment outcomes except skilled employment. This implies that domestic firms were more biased towards skilled employees than towards other employees.

Number of customers was found to have a significant impact on employment outcome. Specifically, an increase in the number of customers was found to have a positive impact on overall employment and part-time and causal employment but a negative impact on permanent and skilled employment. Equally, the number of competitors of the firm was found to have a significant impact on employment. However, the direction of impact was not uniform across all forms of employment. For instance, while an additional competitor was good for overall, permanent, part-time and causal employment, it was found to have a negative impact on skilled employment. For firms offering formal training, the study found that formal training had a positive and significant impact on all types of employment. Overall and permanent employment have the greatest impact. Equally, the finding reveals that offering workers compensation had a positive and significant influence on employment outcome for all types of employment

## 5. Conclusion

The study concludes that there is enough evidence to support the impact of eco-efficiency of environmental inputs such as water, oil and electricity on employment outcome among manufacturing firms in Kenya. The study found out that there was high eco-efficiency score of fuel (the dirty energy) and low eco-efficiency score of electricity, implying that firms were substitution more dirty energy for clean energy in their manufacturing process. Further, the study found enough evidence to support commitment-based approach as the best approach to improve both the environment performance and employment outcome. However, evidence is against compliance-based approach as it was found to have a negative impact on employment. Of interest, being environmental laggard was found to have a less impact on employment outcome than compliance-based approach. Hence, based on these findings, we recommend the following policy interventions in an attempt to improve environmental impact of the environment and employment outcomes among the manufacturing firms in Kenya. We thus recommend that the government and manufacturing stakeholders should adopt a commitment-based approach towards environmental management initiatives; that there is a need for an elaborate formal training and worker's compensation among manufacturing firms and lastly, there is need for both government and manufacturing firms to comprehensively work towards a formula of increasing the labour shifts in the country

**Acknowledgement**

This work was supported by the African Economic Research Consortium (AERC) through their scholarship programme. We thank anonymous reviewers and editors of this journal for useful comments that enriched the content of this paper. The views expressed herein are those of the authors and do not necessarily reflect the views of the African Journal of Economic Review.

**References**

Abubakar, F. H. (2018). *An investigation into the drivers, barriers and policy implications of circular economy using a mixed-mode research approach* (Doctoral dissertation, University of Sheffield).

Almeida, C. M. V. B., Agostinho, F., Giannetti, B. F., & Huisingh, D. (2015). Integrating cleaner production into sustainability strategies: An introduction to this special volume. *Journal of Cleaner Production*, *96*, 1–9.

Bjørnbet, M. M., Skaar, C., Fet, A. M., & Schulte, K. Ø. (2021). Circular economy in manufacturing companies: A review of case study literature. *Journal of Cleaner Production*, *294*, 126268.

Boiral, O. (2007). Corporate greening through ISO 14001: a rational myth?. *organization science*, *18*(1), 127-146

Bonilla, S. H., Silva, H. R., Terra da Silva, M., Franco Gonçalves, R., & Sacomano, J. B. (2018). Industry 4.0 and sustainability implications: A scenario-based analysis of the impacts and challenges. *Sustainability*, *10*(10), 3740.

Buysse, K., & Verbeke, A. (2003). Proactive environmental strategies: A stakeholder management perspective. *Strategic management journal*, *24*(5), 453-470.

Cahuc, P., & Malherbet, F. (2004). Unemployment compensation finance and labor market rigidity. *Journal of Public Economics*, *88*(3-4), 481-501.

Curtis, E. M. (2018). Who loses under cap-and-trade programs? the labor market effects of the nox budget trading program. *Review of Economics and Statistics*, *100*(1), 151-166.

Dissou, Y., & Sun, Q. (2013). GHG mitigation policies and employment: A CGE analysis with wage rigidity and application to Canada. *Canadian Public Policy*, *39*(Supplement 2), S53-S65.

Frijns, J., & Van Vliet, B. (1999). Small-Scale Industry and Cleaner Production Strategies. *World Development*, *27*(6), 967–983.

Ghazinoory, S. (2005). Cleaner production in Iran: Necessities and priorities. *Journal of Cleaner Production*, *13*(8), 755–762.

Greenstone, M. (2002). The impacts of environmental regulations on industrial activity: Evidence from the 1970 and 1977 clean air act amendments and the census of manufactures. *Journal of political economy*, *110*(6), 1175-1219.

Herrendorf, B., Rogerson, R., & Valentinyi, Á. (2014). Growth and Structural Transformation. In *Handbook of Economic Growth* (Vol. 2, pp. 855–941). Elsevier.

Herrmann, C., Blume, S., Kurle, D., Schmidt, C., & Thiede, S. (2015). The positive impact factory–transition from eco-efficiency to eco–effectiveness strategies in manufacturing. *Procedia CIRP*, *29*, 19-27.

Kahn, M. E., & Mansur, E. T. (2013). Do local energy prices and regulation affect the geographic concentration of employment?. *Journal of Public Economics*, *101*, 105-114.

Khalili, N. R., Duecker, S., Ashton, W., & Chavez, F. (2015). From cleaner production to sustainable development: The role of academia. *Journal of Cleaner Production*, *96*, 30–43.

Kusi-Sarpong, S., Bai, C., Sarkis, J., & Wang, X. (2015). Green supply chain practices evaluation in the mining industry using a joint rough sets and fuzzy TOPSIS methodology. *Resources Policy*, *46*, 86–100.

Maiurova, A., Kurniawan, T. A., Kustikova, M., Bykovskaia, E., Othman, M. H. D., Singh, D., & Goh, H. H. (2022). Promoting digital transformation in waste collection service and waste recycling in Moscow (Russia): Applying a circular economy paradigm to mitigate climate change impacts on the environment. *Journal of Cleaner Production*, *354*, 131604.

Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American journal of sociology*, *83*(2), 340-363.

Nabavi-Pelesaraei, A., Rafiee, S., Mohtasebi, S. S., Hosseinzadeh-Bandbafha, H., & Chau, K. W. (2019). Comprehensive model of energy, environmental impacts and economic in rice milling factories by coupling adaptive neuro-fuzzy inference system and life cycle assessment. *Journal of cleaner production*, *217*, 742-756.

Oelkers, E. H., & Cole, D. R. (2008). Carbon dioxide sequestration a solution to a global problem. *Elements*, *4*(5), 305-310.

Orlins, S., & Guan, D. (2016). China's toxic informal e-waste recycling: Local approaches to a global environmental problem. *Journal of Cleaner Production*, *114*, 71–80.

Pigou, A. C. (1932). The effect of reparations on the ratio of international interchange. *The Economic Journal*, *42*(168), 532-543.

Pinto, J. T. (2019). *Sustainable Resource Management in European Steel Supply Chains* (Doctoral dissertation, Thesis. University of Clermont-Auvergne).

Sheriff, G., Ferris, A. E., & Shadbegian, R. J. (2019). How did air quality standards affect employment at US power plants? The importance of timing, geography, and stringency. *Journal of the Association of Environmental and Resource Economists*, *6*(1), 111-149.

Stocker, A., Gerold, S., Hinterberger, F., Berwald, A., Soleille, S., Morgan, V. A., & Zoupanidou, E. (2015). The interaction of resource and labour productivity. *A scoping study. Sustainable Europe Research Institute (SERI) bio by Deloitte on behalf of European Commission, DG Environment*.