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Assessment of Energy Efficiency Investment in Onitsha Business Cluster, Nigeria[1]

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Stephen K. Dimnwobi
(Corresponding Author)
Department of Economics, NnamdiAzikiwe University Awka, Nigeria
E-mail: stephenkcdim@gmail.com

Ebele S. Nwokoye
Department of Economics, NnamdiAzikiwe University Awka, Nigeria
E-mail: es.nwokoye@unizik.edu.ng

Clement I. Igbanugo
Department of Economics, University of Benin, Nigeria
E-mail: izuclems@gmail.com

Chukwunonso Ekesiobi
Department of Economics, ChukwuemekaOdumegwu Ojukwu University, Nigeria
E-mail: chukwunonsoekesiobi@hotmail.co.uk

Simplice A. Asongu
School of Economics, University of Johannesburg, South Africa
E-mails: asongus@afridev.org, asongusimplice@yahoo.com

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Research Department

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Stephen K. Dimnwobi, Ebele S. Nwokoye, Clement I. Igbanugo, Chukwunonso Ekesiobi & Simplice A. Asongu

Abstract

This paper empirically assesses energy efficiency (EE) adoption among firms by examining the factors that drive investment in energy efficiency in the Onitsha plastic cluster, South-East, Nigeria. Self-administered questionnaires were delivered to the selected enterprises. A total of 450 questionnaires were administered of which 423 were certified valid and utilized for the analysis. A Heckit model was developed and estimated. Gender, firm size, *Joneses* effect, and expected cost reduction benefits are the significant determinants of energy efficiency investment. However, firm structure, government incentives, regulatory requirements, and reduction of carbon emission are insignificant drivers of EE investment decisions in the Onitsha Plastic Cluster. This paper presents a foremost attempt at analysing the determinants of energy investment in a cluster in Nigeria.

Keywords – Energy Efficiency, Nigeria, Onitsha, Plastic, Cluster

1. Introduction

Similar to other developing countries, the Nigerian industrial sector is largely comprised of micro, small and medium scale enterprises (MSMEs). Energising this sector has been a challenge for the country given the energy-intensive nature of the manufacturing procedures of MSMEs (Naik and Bagodi, 2021). Aside from the residential sector, MSMEs are the major electricity consumers in Nigeria (Sule *et al.*, 2011; Nwokoye *et al.*, 2017). In comparison to large enterprises, MSMEs are less energy-efficient with worrying implications for energy availability and environmental sustainability (Maheshwari*et al.*, 2021; Naik and Bagodi, 2021). However, to adequately meet the increasing demand for energy in the sector, promoting efficient energy use is a peculiar challenge for most developing nations (Biswas *et al.*, 2018; Haider and Bhat, 2020; Dimnwobi *et al.*, 2022a). Consequently, energy efficiency (EE) is acknowledged to be a cost-effective method that improves competitiveness, economic productivity, and climate change mitigation (Fleiter *et al.*, 2012; Haider and Bhat 2018).

There is considerable evidence in the literature on the determinants of enterprise uptake of EE measures. However, most of these studies were conducted in transitional or developed economies (Abadie *et al.*, 2012; Costa-Campi *et al.*, 2015; Lutz *et al.*, 2017; Segarra-Blasco and Jove-Llopis 2019; Kalantzis and Revoltella, 2019), with a relatively lesser focus on Sub-Sahara African economies (particularly Nigeria). To our knowledge, except for Ndichu *et al.* (2015) that sampled 62 cassava-processing firms in Nigeria using descriptive statistics, Nigerian studies have centred on EE and consumption demand (Tajudeen, 2015), EE and cars (Arawomo and Osigwe 2016) among others.The positioning of the study also departs from a strand of entrepreneurship literature in Nigeria which has largely focused on inter alia: determinants of entrepreneurial emergence (Madichie *et al.*, 2008; Ekesiobi and Dimnwobi, 2020) and entrepreneurship within the family remit (Igwe *et al.*, 2018; Igwe *et al.*, 2020). Such scope and coverage limitation provides room for research attention and prompts this study with a focus on industrial clusters. Motivated by this, the study investigates the drivers of EE investment by firms in Nigeria using the Onitsha plastic cluster in Anambra State as a case study. This cluster is comprised of firms that deal in a variety of plastic-related products and is considered the most energy-intensive cluster in Nigeria.

This study provides additional insights on EE adoption by firms through the inclusion of a factor not considered by previous studies - the *Joneses effect*. This is a non-economic factor that influences the decision-making of all economic agents. It recognizes the possibility of other socialization agents, such as peers and media, which might influence EE decisions. This allows the investigation of the degree to which enterprise EE measures uptake is influenced by this factor. The inclusion is further justified by studies that acknowledge the importance of this variable in technology uptake and embracing cleaner energy, especially in developing countries (Nwokoye *et al*., 2019; Mundaca and Samahita, 2020). Also, unlike previous studies, we uniquely utilized the Heckman Two-Step Selection model to control for selection bias. Therefore, this study presents a foremost empirical contribution highlighting the determinants of investments in energy efficiency by firms in Nigeria.

The remainder of this paper is as follows: Section two presents the related literature. After describing the methodology in the third section, the presentation of the result is contained in the fourth section. Section five concludes the study and makes major recommendations.

2. Literature Review

2.1. Empirical Literature

The literature is awash in theories on technology adoption. For instance, the theory of reasoned action (TRA), is a well-known socio-psychological theory that states that an individual’s or organization’s perceptions and attitudes influence their intentions and behaviours (Fishbein and Ajzen, 1975). Based on this assumption, several studies have utilized the TRA to explain the antecedents of a variety of pro-environmental behaviours. Similarly, Rogers’s innovation model demonstrates that adopters do not always adopt or reject an invention based on their knowledge of its existence. Instead, people go through a mental process to weigh the benefits and drawbacks or risks before rejecting or accepting the innovation (Rogers, 2003). The decision to invest in technology can also be explained using a utility or profit maximization framework. The utility maximization model proposes that choice sets of economic agents are contingent on expected derivable utility. On the other hand, the profit maximization approach proposes that the choice sets of economic agents are contingent on the amount of profit or benefits that are expected to accrue to them (Rosenzweig and Foster, 2010).

In this study, we are particularly interested in unearthing the determinants and not the barriers to investment in EE by firms. De Groot *et al* (2001) for instance, surveyed 135 Dutch firms across nine industrial sectors. Applying discrete choice models, they underlined the achievable cost savings through the efficient utilization of energy and the requisite policy implementation like fiscal and subsidies arrangements as the influential factors driving EE uptake. In a case study involving eight Swedish manufacturing industries, Rohdin and Thollander (2006) revealed that the presence of ambitious staff, energy prices increases, and firm-wide strategic policy on energy centred on removing less EE equipment drives EE uptake. Confirmation of these findings is found in later studies by Rohdin *et al* (2007) and Thollander and Ottosson (2008) which concentrated on the Swedish foundry industry and Swedish pulp and paper industry, respectively. Similarly, Hasanbeigi *et al* (2009) interviewed energy experts and firms in the industrial sector of Thailand. They found that production cost reductions, product quality enhancements, as well as staff safety and health improvements, are the topmost drivers of EE.

Abadie *et al* (2012) analysed the driving factors influencing SMEs' EE investment in the United State of America using the logit model. The study reported investment costs and payback time as the most influential. Zhang *et al* (2013) utilized the structural equation model to study the willingness to implement EE practices by firms in China. They found that the effect of social pressure and perceived attitudes on a firm's willingness to adopt EE is positive and significant, while the effect of perceived behavioural control on a firm's EE adoption was negative though significant. Cagno and Trianni (2013) highlighted the significance of allowances, external pressures like energy price increases, and the introduction or raising of fees on both consumed resources and pollutant emissions in the adoption of EE measures. Additionally, the willingness of firms to adopt EE is hinged on whether it can offer long-term benefits, enhance productivity, and the presence of ambitious staff within the firm. Costa-Campi *et al.* (2015) investigated the determinants of EE uptake in Spain using the logit model. They found that firm size, focus on foreign markets, and tangible assets investment were significant to EE investments while research and development investments per worker are insignificant. Ndichu *et al.* (2015) focused on two sub-Saharan African countries (Nigeria and Kenya) to assess the motives for the uptake of EE in agro-industrial sectors. The study reported government incentives, environmental regulation, government policies, energy regulatory requirements, and the desire to lower costs as the key determinants. Cantore (2016) applied the logit model and utilized samples from firms in Moldova, the Philippines, and Vietnam.

The study established that organizational factors of firms as well as internal management enhances a firm's drive to invest in energy-efficient technologies.

Also, Gerstlberger *et al.*(2016) applied a logit model usingthe European Manufacturing Survey 2009 data and found the importance of process and product innovation in adopting EE measures. Similarly, in Slovenia, Hrovatin *et al.*(2016) utilized probit models and found that export orientation, market share, energy cost, an expectation of future demand by the manager, and foreign ownership influence the decision to embrace EE measures. Solnørdal and Thyholdt (2017) used the logit model to investigate the drivers of EE investments by Norwegian manufacturing firms. Educational attainment, firm size, and collaboration with competitors as well as research institutes and universities were found to positively influence EE investments. Lutz *et al.* (2017) assessed the drivers of EE in the German manufacturing sector using a stochastic energy demand frontier analysis. The most significant variables discovered were firms that are innovative and export their products as well as those that are mindful of the environment. Ackah (2017) revealed that energy consumption by firms has been inefficient and the reduction in energy consumption witnessed in Ghana's SMEs is engendered by blackouts and not efficiency.

Hassen *et al.* (2018) applied a generalized ordered probit model to data from 8174 Ethiopian enterprises to investigate the predictors of EE technologies and practices adoption by MSMEs. They found that the larger the enterprise, the more probable the enterprise will embrace EE practices and technologies. They further revealed that clustered enterprises are more likely to utilize EE technologies. Biswas *et al*. (2018) surveyed 429 enterprises in India and the study concludes that partaking in EE workshops, competition with bigger firms, the firm's age, and awareness of various government schemes and programmes are very influential in the decision to deploy EE technologies. Segarra-Blasco and Jove-Llopis (2019) employed the probit model on8,213 European SMEs data and found that the major motivations include cost-saving, environmental awareness, public support, and firm age and size. Employing the propensity score matching method and the logit model, Kalantzis and Revoltella (2019) appraised if SME's energy audits encourage EE measures and found that energy audits facilitate investments in EE measures. In India, Haider *et al.* (2019) underlined a firm's age, size as well as financial performance as the significant variables that influence EE adoption. Cunha *et al.* (2020) utilized an online survey from Portuguese MSMEs and established that enterprises with an energy manager as well as energy management systems that have conducted an energy audit are more likely to adopt EE measures. Likewise, Macharia *et al* (2021) discovered that adopting EE measures in Kenyan firms is significantly influenced by top managers' experience, exporting status, female ownership, and research and development

2.2. Theoretical Framework

In technology adoption literature, the decision to invest in technology options is widely explained using a utility or profit maximization framework. According to Caswell and Zilberman (1985) and Green et al. (1996), the utility optimization framework proposes that economic agents' choice sets are contingent on expected utility derivable from that choice. Given that, the utility is not directly observable; the economic agents' actions are noticed through their various choices. On the other hand, the profit maximization method proposes that economic agents' choice sets are contingent on the number of benefits or profits that they are supposed to receive (Rosenzweig and Foster 2010). Thus, firms are keen to make the required investments in EE premised on the expected utility maximization from achieving their strategic objectives, including profit maximization, environmental protection, and sustainability, among others.

To start with, suppose a firm's strategic objective is profit maximization. First, it is assumed that firms' decision to invest in EE activities or technologies is made based on firms' expectation of positive net profit, or other benefits in physical or monetary terms. Second, firms invest in EE measures only when the expected profit from the utilization of such activities or technology is significantly greater than other technology options. Finally, firms are rational and maximise their expected profits.

Firm *j* decides which EE technology or activity *k* to adopt for any given production process by assessing the likely profits under each of the *k* EE technology while taking into consideration the production requirements, the type of device, and the firm's characteristics (Green et al. 1996; Genius et al 2013). Each production method faces constant returns-to-scale technology (Caswell and Zilberman 1985). The expected per unit profits, $\Pi_{j,k}$, of the j^{th} firm utilizing EE technology *k* are composed of two independent elements:

$$\Pi_{j,k} = \Omega_k' X_j + \varepsilon_{jk} \quad (1)$$

Where Ω'_k is the non-stochastic vector of coefficients to be estimated and X_j is the vector of observed variables associated with the j^{th} firm and k^{th} measures. The unobserved characteristics are denoted ε_{jk} so that if the j^{th} firm is selected at random, then ε_{jk} is a random variable (Caswell and Zilberman 1985).

Let k_1 and k_2 represent a firm's expected profits for two production technology choices. The linear expected profit model could then be specified as:

$$\Pi_{k1} = \Omega'_{k1} X_j + \varepsilon_{k1} \text{ and } \Pi_{k2} = \Omega'_{k2} X_j + \varepsilon_{k2} \qquad (2)$$

Where Π_{k1} and Π_{k2} are expected profits of EE technology k_1 and k_2 respectively, X_j is the vector of explanatory variables that influence the perceived desirability of the technology option, Ω'_{k1} and Ω'_{k2} are parameters to be estimated, and $\varepsilon_{k1}, \varepsilon_{k2}$ are error terms assumed to be independently and identically distributed (Greene 2003; Gujarati 2004). In the case of choice of EE technologies, if a firm decides to use option k_1, it follows that the expected profit from option k_1 is greater than the expected profit from other k^{th} options (say k_2):

$$\Pi_{k1}(\Omega'_{k1} X_j + \varepsilon_{k1}) > \Pi_{k2}(\Omega'_{k2} X_j + \varepsilon_{k2}),\ k_1 \neq k_2 \qquad (3)$$

Thaler (2015) and Fonseca *et al.* (2016) contend that contrary to the neoclassical economic doctrine, firm investment decisions could be anchored on several strategic objectives other than profit maximization. In their view, investment decisions could be driven by stakeholders' interests, ecological and sustainability concerns. Suppose we denote other factors that drive firm investment decision as R, then the probability that a firm will invest in technology option k among the basket of technology options could then be defined as:

$$prob(Y = 1/X) = prob(\Pi_{k1} + R_{k1} > \Pi_{k2} + R_{k2}) \qquad (4)$$

Such that

$$prob(\Omega'_{k1} Z_j + \varepsilon_{k1} - \Omega'_{k2} Z_j - \varepsilon_{k2} > 0/Z) \text{ and } prob(\Omega^* Z_j + \varepsilon^* > 0/Z) = F(\Omega^* Z_j)$$

Where $X, R \in Z$, P(.) is a probability function, $\varepsilon^* = \varepsilon_{k1} - \varepsilon_{k2}$, $\Omega'^* = \Omega_{k1} - \Omega_{k2}$ and $F(\Omega^* Z_j)$ represents a cumulative distribution function ε^* evaluated at $\Omega^* Z_j$. According to Greene (2003) and Gujarati (2004), the exact distribution of F depends on the distribution of the random disturbance term, ε^*.

3. Methodology

3.1. Study Area

The study population consists of all firms in the Onitsha plastic cluster. Onitsha, in Anambra State, South-East Nigeria, is home to the largest market in West Africa (the Onitsha main market) and one of the largest clusters in Nigeria (the Onitsha plaster cluster) (Ekesiobi and Dimnwobi, 2020; Nwokoye *et al.* 2022). Although there are five well-known industrial clusters in Nigeria: Kano (Leather) in Kano state, Otigba (ICT) in Lagos State, Nnewi (Automotive) and Onitsha (Plastic) in Anambra state, and Aba (Shoe) in Abia State (Ekesiobi *et al*. 2018; Nwokoye *et al.* 2022), it is no coincidence that three out of the five clusters are located in the South-eastern part of Nigeria, a region with a rich history of trade, manufacturing, and commerce (Ekesiobi and Dimnwobi, 2020; Nwokoye *et al.* 2022). Also, the industrial and commercial activities in the region are buoyed by the existence of a traditional apprenticeship system of Igbo origin (Igwe *et al*. 2018; Nwokoye *et al.* 2022), which has spawned a slew of Igbo businesses in Nigeria and beyond.

The Onitsha plaster cluster consists of firms that deal in a range of products like plastic film extrusion, plastic waste recycling, plastic injection, polythene bag making, pipe extrusion, and plastic blow moulding among others. The selection of the Onitsha plastic cluster is contingent on these reasons: first, the cluster is the most energy-intensive among other industrial clusters in Nigeria and produces a commodity (plastics) which is a popular household item in Nigeria. It is estimated that only 30% of Nigerian plastic needs are met locally while the rest is imported (Obioha 2019). Second, the cluster is situated in Onitsha, a city recognised as one of the biggest commercial hubs in West Africa alongside Lagos state, making the products of the cluster readily available to consumers. Third, unlike other clusters and from observed experience in various clusters in Nigeria, the cluster is gradually embracing EE measures. It is therefore ideal to pinpoint the factors that drive these EE investments and pave the way for adoption by firms within and outside clusters in Nigeria.

3.2. Sampling Procedure

Since the firms in the cluster are similar in size, the study employed a random sampling method in the firms' selection as well as the selection of the respondents. The interest of the study is to draw information from owners or managers of the 450 firms sampled. Before administering the questionnaire, the researchers visited the cluster to meet with stakeholders and explain the study objectives and seek their cooperation. The enumerators engaged are graduate students familiar with the local language and trained about the survey purpose, the target audience, the survey process, and how to approach every step of the exercise.

3.3. Data Collection

Primary data from firms in the Onitsha plastic cluster were collected between the 5th of February 2018 and the 29th of March 2018 using a structured questionnaire. Each question is followed by options, ranging from dichotomous to multiple-choice options. While no question on the dependent variable is ordinal, the questions meant to generate the explanatory variables are either purely categorical or utilize rating scales (including ordinal and interval scales). Appropriate statistical procedures were employed to validate the technique and ensure that the questionnaire achieves content, criterion, and construct validity. For example, the questionnaire was reviewed by experts, particularly, energy economists (members of the Nigeria Association of Energy Economics). The design of the questionnaire also draws significantly from literature, thereby guaranteeing convergent validity. A pilot study for the reliability test (including test-retest and Cronbach alpha test) was conducted in another clime (particularly, the Nnewi Industrial cluster) using 40 respondents. The results obtained show that the questionnaire is reliable and consistent.

3.4. Data Analysis

The choice of estimation procedure and technique is one of the most difficult phases in the research process. As noted by Fowler (2013), the validity and reliability of research outcomes are largely contingent on the estimation technique and other techniques adopted under the research method. Most literature on determinants of energy efficiency utilises discrete choice estimation procedures such as logit (Costa-Campi *et al*., 2015; Solnørdal and Thyholdt, 2017) and probit (Abadie *et al*., 2012; Hrovatin *et al*., 2016). However, given the nature of the sampling process involving firms or households, Heckman (1979) and Lemba *et al*. (2013) argue that the possibility of sample selection bias may undermine estimations using pure logit or probit procedure. In this regard, we utilize the Heckman selection model as developed by Heckman (1979). The Heckman selection model or Heckit model has been used in similar studies by Adeoti (2009) and Lemba *et al.* (2013). Heckman's framework is an alternative to maximum likelihood methods for estimating the parameters of a selection model. The Heckit model contains a second equation, known as the selection equation, in addition to the one to be estimated, which defines whether an observation makes the sample non-random. Let R_j represent the probability of a firm engaging in energy-efficient activities, assuming that:

$$R*_j = \eta' z_j + \mu_j \tag{5}$$

Where z_j is the vector of covariates. The variable R_j^* is not observed, but we observe if a firm engages in energy efficiency activities, so that:

$$R_j = 1 \text{ if } R_j^* > 0 \text{ and } R_j = 0 \text{ if } R_j^* \leq 0$$

Suppose D_j represents firm's investment in energy-efficient technology such that:

$$D_j = \beta' X_j + \varepsilon_j \tag{6}$$

Where X_j is a vector of variables that affect D_j. μ_j and ε_j are error terms that follow a bivariate normal distribution such that:

$$\begin{bmatrix} \mu_j \\ \varepsilon_j \end{bmatrix} \sim N \begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix} \tag{7}$$

In Equation (7), σ and ρ are scale parameter and correlation coefficient respectively. Also, Equation (7) shows that the variance ε_j has been normalized to 1 since this variance is not identified in this model.

Suppose R_j and z_j are observed for a random sample of firms but D_j is observed only when R_j= 1 (that is when the firm invests in energy efficiency options), then

$$\mathrm{E}(D_j / R_j = 1) = \mathrm{E}(D_j / R_j^* > 0) = \mathrm{E}(D_j / \mu_j > -\eta' z_j)$$

$$\begin{aligned} &= \beta' X_j + \mathrm{E}(\varepsilon_j / \mu_j > -\eta' z_j) \\ &= \beta' X_j + \rho \sigma_\varepsilon \lambda_j (\alpha_\mu) \end{aligned} \qquad (8)$$

Where

$$\lambda_j(\alpha_\mu) = \frac{\phi(\alpha_\mu)}{1-\Phi(\alpha_\mu)} = \frac{\phi(-\alpha_\mu)}{\Phi(-\alpha_\mu)} = \frac{\phi(\eta' z_j / \sigma_\mu)}{\Phi(\eta' z_j / \sigma_\mu)} \qquad (9)$$

And ϕ, Φ are the standard normal density function and the standard normal distribution function respectively. The function $\lambda_j(\alpha_\mu)$ is called the inverse Mills ratio (Greene 2008). Given that X_j is correlated with $\lambda_j(\alpha_\mu)$, a least-squares regression of D_j on X_j, omitting the term $\lambda_j(\alpha_\mu)$, would produce an inconsistent estimator of β. Equation (5) is the selection equation while Equation (8) is the outcome equation. The first stage of the Heckit framework involves estimating Equation (5) using the probit model. Then the inverse ratio is estimated as defined in Equation (9). The second step is to estimate the outcome equation (Equation 8) using OLS. Note that the inclusion of $\hat{\lambda}$ in Equation (8) allows parameters β to be consistently estimated by least-squares regression of D on X and $\hat{\lambda}$. Also, z and X are covariates such that $z \subset X$.

4. Results and Discussion

4.1 Socio-Economic Characteristics of the Surveyed Firms

Tables I and II show the summary statistics of the socio-economic characteristics of the firms. Categorical variables are summarized in Table I. There is gender disparity in the participation in industrial activities in the industrial layout. About 82% of the respondents are males. All firms in the industrial cluster are domestic and mostly sole proprietorship in nature (about 70%). 69.7% of the firms export some of their goods to foreign economies. However, none of the firms surveyed has a functional Research and Development (R&D) department although about 24% engage in R&D. Again, none of the firms has an EE policy. Firms in the cluster do not organize EE training.

Table 1. Summary of categorical variables

Categorical variables			
Definition of Variable	Categories	Observation	(%)
Gender (Firm Owner)	1=Male	347	82
	0=Female	76	18
Education (Firm Owner)	1=Tertiary	196	46.3
	0=Pre-Tertiary	227	53.7
Firm's Ownership Type	1=Domestic	423	100
	0=Foreign	0	0
Firm Structure	1=Sole Proprietorship	298	70.4
	0=Partnership and Company	125	29.6
Export of Goods	1=Yes	128	30.3
	0=No	295	69.7
R & D	1=Yes	102	24.1
	0=No	321	75.9
Functional R & D Department	1=Yes	0	0
	0=No	423	100
Meter	1=Prepaid	0	0
	0=Postpaid	423	100
Meterization	1=Charges Following Readings From The Meter	54	12.8
	0= Charges Are Arbitrary	369	87.2
energy efficiency awareness	1=Yes	263	62.2
	0=No	160	37.8
energy efficiency policy	1=Yes	0	0
	0=No	423	100
energy efficiency training	1=Yes	0	0
	0=no	423	100
Generating Set	1=Yes	423	100
	0=no	0	0

Source: Field Survey, 2018

Table II describes the continuous variables obtained in the survey. On average, each firm spends about ₦[2]100, 000 per month, ₦24,000 per month, and ₦92,000 per annum on operating costs, electricity, and R&D respectively.

[2]The monetary variables are reported in the country's local currency which is Naira (₦). As at the time the survey was conducted, one dollar is equivalent to 360 naira.

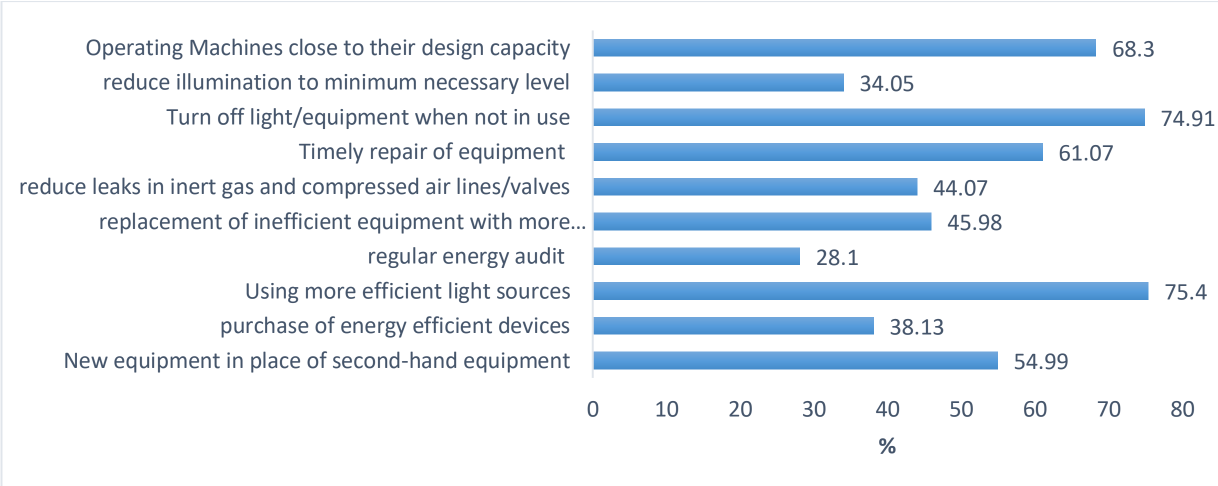
Table II. Description of continuous variables

	Observation	Mean	standard deviation	Minimum	maximum
Age	423	34	5.63	18	68
Firm existence(Years)	423	6	2.03	2	13
average monthly operating costs	423	₦100,000	₦50,030.50	₦40,000	₦220,000
electricity costs	423	₦24,000	₦12,222.31	₦13,230	₦43,045
R & D annual budget	89	₦92,000	₦61,042.79	₦49,000	₦320,000
age of self-generating set (Number of Years)	423	3	2.02	1	7
Staff Strength	423	6	3.11	4	15

Source: Field Survey, 2018

Figure 1 shows that firms engage in various efficiency-enhancing activities such as using a more efficient light bulb (75%), turning off light or equipment (75%), and operating machines to full design capacity (68.3%). Other energy efficiency-enhancing activities and decisions include replacing overstayed devices with new ones (55%), replacing inefficient devices with efficient ones (45%), reducing leaks in inert gases (44%), timely repair of equipment (61%) as well as the purchase of energy-efficient devices. Our finding corroborates Zhang *et al* (2013) who note that the energy efficiency behaviour of firms involves adhering to certain routine behaviour (e.g. timely repair of equipment, reducing leaks in inert gases, turning off lights or equipment when not in use) and investing in new technologies (e.g. investing in a more efficient lightbulb, investing in energy-efficient devices, among others).

Figure 1. Energy efficiency-enhancing activities of the firms in Onitsha plastic cluster (in percent)

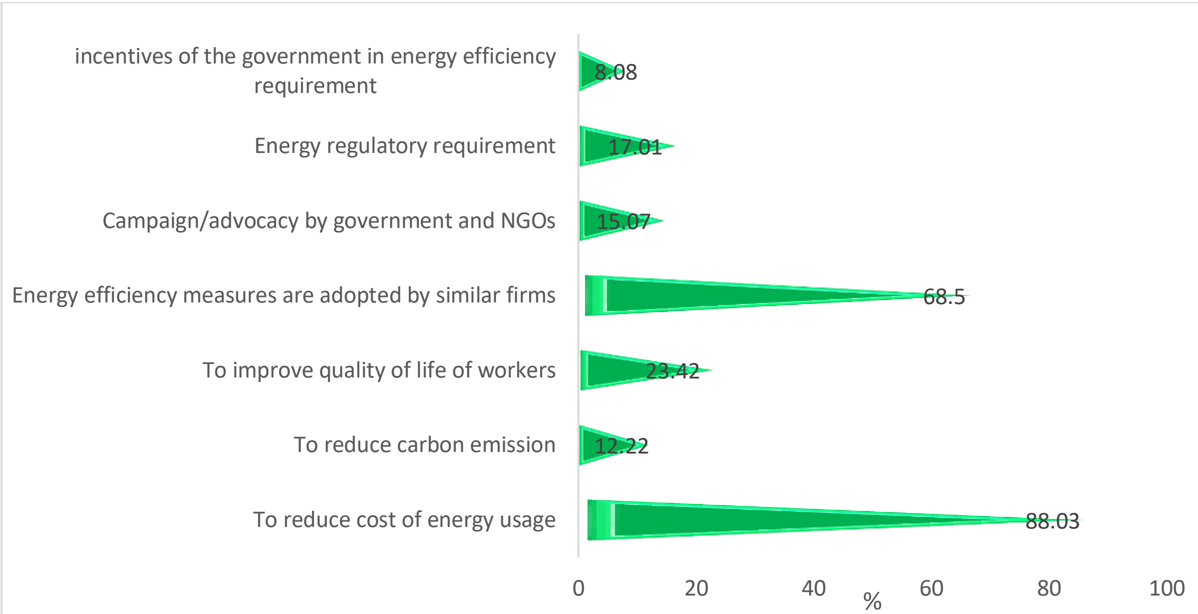


Source: Field Survey, 2018

Figure 2 summarises the reasons for energy efficiency investments. Firms may invest in EE measures to reduce the cost of energy consumption (88%), reduce carbon emission (12.22%), adhere to regulatory requirements (17.01%), or benefit from government incentives (8%). Also, about 68.5% of the respondents indicate that EE adoption behaviour was influenced by the adoption behaviour of other firms, especially the need to be like other firms. The desire to "keep up with the Joneses" otherwise known as the Joneses effect (Cheung and Sengupta, 2010)appears to be a strong factor in the adoption of energy efficiency behaviour. *Joneses* effect is a bandwagon choice effect that arises when the decision of firm j is induced by the decision of firm r $(j \neq r)$. This, in a way, is akin to the prediction of the Institutional Theory of Adoption (DiMaggio and Powell, 1983; Kostova *et al.*, 2008). As firms attempt to keep up with the Joneses, over time, they converge in organisational pattern, structure, culture, and characterization. This attribute could be seen as a pivotal feature in achieving targeted adoption. Other reasons indicated for firms' engagement in EE behaviour include the need to improve the quality of life of workers (23.42%); and campaign/advocacy by government and NGOs (15.07%).

From the foregoing, energy efficiency activities are not innate but driven by the need to save energy costs, reduce carbon emissions, adhere to government regulations as well as "keep up with the Joneses".

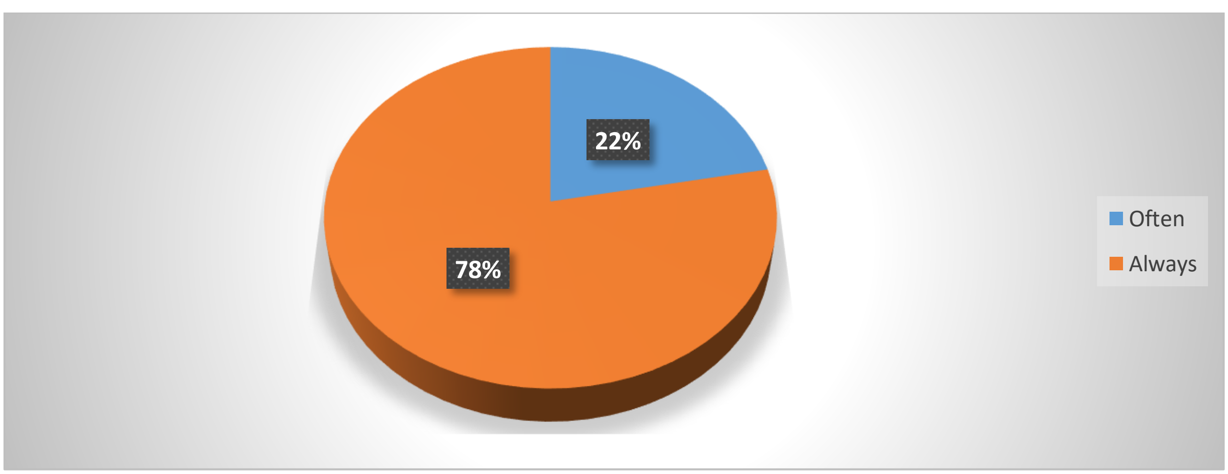
Figure 2. Reasons for energy efficiency investments (Responses in percent)



Source: Field Survey, 2018

Figure 3 indicates that most firms (78%) depend on self-generated electricity (using a private generating set or plant). This is an indication that the supply of electricity from the national grid could be grossly inadequate. Dimnwobi *et al*.(2022b) affirm that businesses in Nigeria do not depend on the national grid due to frequent outages which may last for several days. This is likely to impose further constraints on firms' performance, including adoption behaviour (Nwachukwu and Ezedinma, 2014; Adewuyi and Emmanuel, 2018).

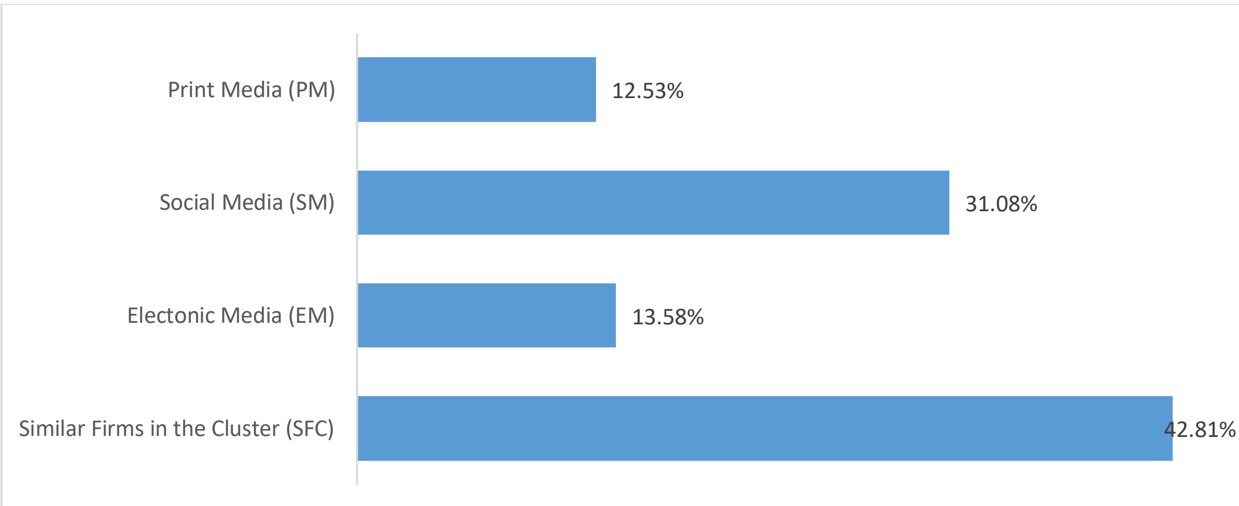
Figure 3. Frequency of use of private power generating sets



Source: Field Survey, 2018

Figure 4 shows that there are several sources of awareness of energy efficiency investment. About 42.81% of the respondents obtained information about EE investment from similar firms in the cluster. Another 31.08% learnt about EE investment from social media. Also, 12.53% and 13.58% said that they learnt about EE investment from print media and electronic media respectively.

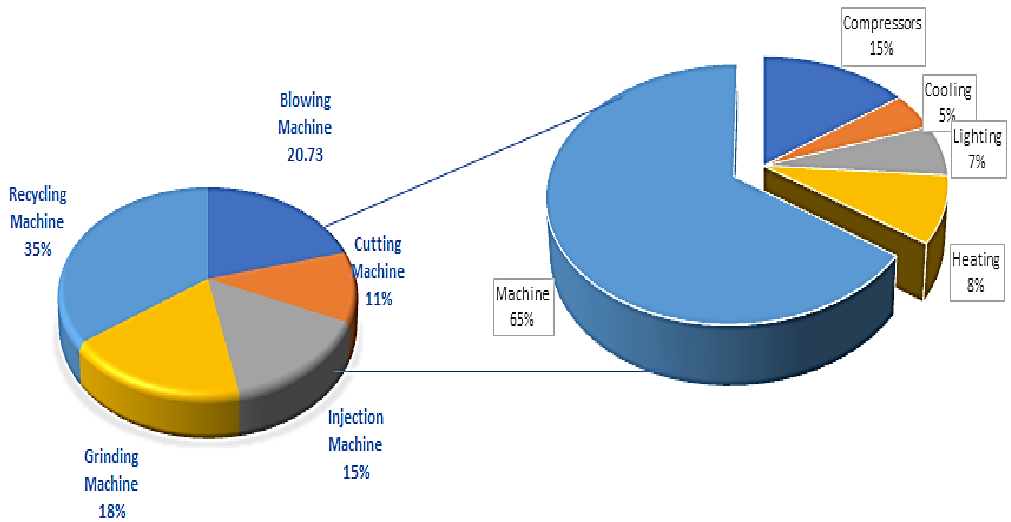
Figure 4. Sources of awareness



Source: Field Survey, 2018

As shown in Figure 5, the energy requirement for the plastic clusteris for compressors, cooling devices, lighting devices, heating devices, and operating machines. Energy consumption by operating machines is estimated at 65%. About five main operating machines were identified namely recycling machine, blowing machine, cutting machine, injection machine, and grinding machine. Energy consumption varies depending on the machine's activities and manufacturer.

Figure 5. Energy consumption of firms in the cluster



Source: Field Survey, 2018

4.2 Likelihood of Engaging in Energy Efficient Activities

To estimate the outcome equation in the Heckman framework, we first estimate the selection equation. The selection equation estimates the likelihood of a firm engaging in EE activities. All continuous variables including age, age square, firm size, staff strength, and firm structure are logged.The parameter estimates of the probit models derived from the first stage of the Heckman model as shown in Table III indicate that the models have good fits with their explanatory variables, as the chi-square statistics are significant at the 1% level. The result shows that gender, age, firms structure, duration of firms existence, and meterization enhance the likelihood of a firm engaging in energy efficiency investment. Further, the results show that corporations and partnerships are more likely to invest in energy-efficient options than sole proprietorships. Particularly, the marginal effect indicates that the likelihood that sole proprietorships will invest in energy-efficient options may decline by 1.37%. Similarly, new firms are more likely to engage in EE investment than older firms. The marginal effect also shows that the likelihood that older firms will invest in energy-efficient options may decline by 2.56 percentage points. Also, those that are using prepaid meters are more likely to invest in energy-efficient options than firms that are using post-paid meters.

Table III. Probit regression predicting the likelihood of engaging in energy-efficient activities

	Coefficient	**Standard error**	**Marginal effect**	**Standard error**
Gender	0.00442***	0.00119	0.001105***	0.000297
Log(age)	0.06397***	0.00982	0.015976***	0.002452
Log(age-square)	0.03501	0.09251	0.00875	0.02312
Log(firm size)	-0.00949	0.07202	-0.00237	0.018005
Firm structure	-0.0549***	0.00691	-0.01371***	0.001726
Education	0.01391	0.05322	0.003477	0.013304
Log(staff strength)	-0.10922	0.12908	-0.02722	0.032174
Log(firm existence)	-0.10281***	0.01883	-0.02563***	0.004695
Meterization	-0.04137***	-0.01592	-0.01034***	-0.00398
Constant	0.07618***	-0.00129	0.019017***	-0.00032
Fixed Effect				
Energy efficiency investment options			Yes	
LR	-318.77		-108.82	
X2	510.82		312.09	
Obs	423		423	

, **, and * indicate significant at 10%, 5% and 1% level respectively.*
(…) indicates the standard errors
Source: Field Survey, 2018

4.3. Determinants of Investment Behaviour of Firms in Onitsha Plastic Cluster

From the first-stage estimation, the inverse mill ratio was estimated as specified in Equation (9). The inverse mill ratio enters the outcome equation (or the second stage of the Heckman model) as an explanatory variable. Table IV presents the result of the second stage of the Heckman model. The Heckit second stage is estimated using the OLS procedure. The "coefficient of the inverse Mills ratio variable (lambda)", gotten from the Heckman procedure is statistically significant, which suggests that its addition was essential to prevent sample selection bias. The result shows that as the firm owner's educational level rises, the tendency to invest in energy efficiency would also increase by 30.2%. This result corroborates Duro *et al.* (2010), Solnørdal and Thyholdt (2017), and Hassen *et al.*(2018) claim that education, whether formal or informal, is critical for the adoption of energy efficiency options. The coefficients for gender (0.429), firm size (0.432), *Joneses* effect (0.114), and expected cost reduction benefits (0.010) indicate that gender, firm size, Joneses effect, and expected cost reduction are significant determinants of EE investment in the cluster. Our findings on firm size agree with the outcomes of past studies (Costa-Campi *et al.,* 2015; Solnørdal and Thyholdt 2017; Hassen *et al.,* 2018). The participation of bigger corporations in a competitive global ecosystem can be attributable to the importance of size in our findings. Given the expected relative increase in energy consumption and energy expenditure by big firms, it can be presumed that these realities can provide a compelling attraction to embrace EE practice. Also, the sheer size and resources available to bigger firms can enable them to leverage better networks, capital, and organization required to implement EE undertakings (Hrovatin *et al.*, 2016).

Similarly, our study agrees with results from previous studies which showed that cost reductions emanating from lower energy consumption drive EE investments in Sweden (Thollander and Ottosson, 2008),in Thailand (Hasanbeigi *et al*., 2009) and Slovenian (Hrovatin *et al*., 2016). Schleich (2007) observes that cost savings are the key driver of energy efficiency behaviour in most developing countries. The study argues that, unlike developed countries that are concerned about environmental quality, developing countries respond much more to cost savings than environmental quality. Notice that the coefficient for carbon emission as a determinant of energy efficiency is not significant. This suggests that our finding corroborates Schleich (2007). As also enumerated by Schleich (2007), cost savings due to energy efficiency is estimated at €100 billion per annum globally. This implies that energy efficiency would translate to improved competitiveness for firms and reduced vulnerability to energy price hikes.

Table IV. Determinants of energy efficiency investment (Heckman Second-Stage)

	Coefficient	Standard Error
Education	0.30212***	0.07794
Gender of Firm Owner	0.42891***	0.14802
Log(Firm Structure)	0.08523	0.08503
Log(Age)	0.55332***	0.13455
Log(Firm Size)	0.43212***	0.08641
Government Incentives	0.04082	0.05183
Regulatory Requirements	0.03109	0.02223
Joneses Effect	0.11398***	0.02290
Carbon Emission	0.04901	0.03178
Cost Reduction	0.01048***	0.00136
Cost of Acquisition	-0.58012***	0.11580
Awareness	0.04289	0.03473
Policy	0.05098	0.05109
Log(Age X Joneses Effect)	0.09239	0.09217
Log(Firm Size X Joneses Effect)	0.08212	0.06674
Log(Education X Joneses Effect)	0.57032***	0.14321
Log(Firm Structure X Joneses Effect)	-0.07891***	-0.00410
Constant	0.61289***	0.10213
Fixed Effect		
Energy efficiency investment options	Yes	
@LOG(SIGMA)	-0.481**	
	(0.215)	
SIGMA	0.627***	
	(0.076)	
RHO	-0.969***	
	(0.019)	
R2	0.79	
F-stat	89.01	
Obs	329	

, **, and * indicate significant at 10%, 5% and 1% level respectively.*
(…) indicates the standard errors
Source: Field Survey, 2018

On the other hand, according to Flood and Marion (2002) and Cheung and Sengupta (2010), the *Joneses* effect is one non-economic factor that influences the decision behaviour of all economic agents including households, firms, and government. Every investment decision involves risks and most risk-averse firms would be reluctant to try something new. However, once there is evidence that another firm is already benefitting from such a decision; other firms would quickly realign their investment decision accordingly. DiMaggio and Powell (1983) and Kostova *et al* (2008) argue that this kind of bandwagon behaviour driven by the Joneses effect could lead to convergence to an industry-wide characterization or isomorphic collective rationality that legitimizes institutional adoption behaviour.

Also, the coefficients (and standard errors) of government incentives, regulatory requirements, and reduction of carbon emission are 0.041 (0.052), 0.031 (0.022), and 0.049 (0.032), respectively. This indicates that the variables are not significant drivers of energy efficiency investment decisions in the Onitsha Plastic Cluster. The findings on government incentives do not align with the earlier findings of Prasanna *et al* (2018) and Hong *et al.* (2019).However, it could be indicative of the dearth of such incentives. On climate considerations, our results also contradict other studies like Damigos *et al*. (2020) and López-Bernabé *et al*. (2021). Also, the findings on regulatory requirements do not support the results obtained by previous studies such as Wang *et al.* (2020) and Han and Chen (2021). Similarly, in a study conducted in three cities in Nigeria (Lagos, Benin City, and Abuja), Uyigue *et al.* (2009) concluded that there is no evidence that government energy departments have trained business leaders in those cities on energy-saving activities. This suggests that the government may be doing little or nothing to drive EE investment in the region. There is limited concern and commitment to the reduction of carbon emissions among Nigerian firms, especially in the cluster. This could be driven by a low level of awareness on one hand, and bias that climate change compliance behaviour is prohibitive in terms of costs (Dimnwobi *et al*., 2022b). This bias could be strengthened by a lack of climate change education. It could also be reinforced by the dearth of enforceable environmental regulatory codes that could influence the behaviour of firms.

Also, the cost of acquisition harms firms' EE investment decisions in the industrial cluster. As cost increases by 1 percent, the tendency to invest in energy efficiency options declines by 0.58 percent. Similarly, in a study of determinants of energy efficiency investment in the US, Abadie *et al* (2012) obtained evidence that investment costs and payback time are critical for deciding on energy efficiency investment among US firms. The result also shows investment decision arising from the *Joneses* effect is not significantly influenced by age. That is, both young and old business owners make energy investment decisions based on the *Joneses* effect. The result also suggests that both small and large firms make investment decisions based on the *Joneses* effect. Contrarily, education and firm structure amplify the *Joneses* effect on firms' EE investment decisions.

5. Conclusion and Policy Implication

The findings of this study suggest that investment in EE in the Onitsha plastic cluster is low. Most firms do not have a functional R&D department which may constitute a constraint to ascertaining energy-saving options. This is also worsened by the non-conduct of energy audits by the firms. It was also found that there is a dearth of operational government policy, programs, and regulations aimed at increasing investment in industrial EE options. Investment decisions by firms are rarely made based on an estimated cost-benefit analysis. Also, the study found that gender, firm size, joneses effect, and expected cost reduction benefits are significant determinants of energy efficiency investment. However, firm structure, government incentives, regulatory requirements, and reduction of carbon emission are insignificant drivers of EE investment decisions in the Onitsha Plastic Cluster.

The findings of this study have serious policy implications. Energy is a major input for firms with huge costs implications. This implies that firm competitiveness could largely depend on minimizing energy costs. Firms that engage in energy efficiency are expected to achieve substantial cost reduction and less vulnerability to energy price hikes. Although the initial cost of acquiring energy-efficient devices could be high, the cost reduction gains more than offset the cost of investment (Schleich, 2007). The implication of the EE behaviour of the firms in the cluster is that energy price shocks could have larger-than-expected effects on the firms. Thus, to reduce vulnerability and enhance firms' resilience, energy efficiency options that promote costs reduction should be prioritized by both firms and the government. Rawls's principle of justice and Hartwick's sustainability criterion, emphasize that the future generation has equal and just claims on the environment. The findings show that there are policy and behavioural gaps in pursuing the climate change agenda. This implies worsening environmental degradation in the Nigerian environmental space as well as heightening the danger of global warming. Thus, it is required that corporate policy prioritizes the reduction of carbon emissions and improvement of environmental quality. The next step entails the mainstreaming of energy efficiency advocacy in the popular apprenticeship practice in the region. Given recent government pronouncements on climate change and the basic necessity for businesses to cut their energy expenses, the training of apprentices on energy efficiency and carbon emission reduction should be a top priority moving ahead. Currently, Nigeria does not have a clear and implementable energy roadmap. The findings of this study suggest that development policies should incorporate a sustainable energy roadmap that does not only focus on achieving energy efficiency but also guarantees environmental sustainability and reduction in CO_2 emission in line with the global mandate (Dimnwobi *et al*., 2021). The energy roadmap should have deliverable targets and timelines. The government (through the Ministry of Power) should also establish and deploy specially designed measures for the provision of appropriate and quality information on proven EE practices to promote EE investment in the industrial layout and other similar agglomeration of firms across the country.

In addition, the concern of policymakers should transcend the employment and revenue opportunities in the Onitsha plastic cluster to include judicious utilisation of limited energy supply (like the uptake of EE measures). To achieve this, the government needs to embark on an energy audit program in the cluster. A holistic and detailed energy audit in the cluster is necessary to ascertain energy-saving options available to the firms, and how to effectively explore such options with minimal or no initial loss. More so, one of the findings of this study is that the Joneses effect is a strong determinant of energy efficiency adoption behaviour. In other words, to promote the adoption of energy efficiency behaviour in clusters in Nigeria, a targeted buy-in strategy could be adopted. This involves identifying the pilot firms in each cluster (these firms to be treated as the Joneses could be the key cluster players) and supporting them to adopt certain targeted energy efficiency behaviours. Sooner or later, other firms in the clusters would begin to converge with the Joneses. Also, given that firms' inertia in going into EE investment is exacerbated by huge implementation costs, efforts should be made towards providing subsidies, tax exceptions, and other incentives that would encourage industrial EE investment. Financial institutions could also support EE investment in the cluster through special credit portfolios that target such investments. By doing this, the objective of the country's latest energy policy (NREEEP) will be easily achieved.

While this paper proposes modest contributions to the literature on firm EE behaviour, it still possesses certain limitations to be taken into cognisance by future studies. Firstly, several factors like religiosity, monetary and fiscal incentives, among others, could be incorporated as vital determinants of firm EE investment. Secondly, given the relevance of the study findings for the plastic cluster in South-East Nigeria, generalising the findings for other clusters and the entire country are however limited by scope and sample size. Thus, further studies should be conducted to address these issues to broaden the scope and context of this study for improved generalizability.

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