Investing in the cheapest form of energy: efficiency practices of SMEs in rural Ghana.

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Abstract

Efficiency has been identified as the cheapest and cleanest source of fuel. Whilst effort has been made in the advanced countries to promote technology and efficiency, little is known about efficiency in emerging economies in Africa. The purpose of this study is to identify the energy efficiency practices of SMEs in rural Ghana and also examine the barriers to energy efficiency practices. First, a descriptive analysis was used to examine the barriers and energy efficiency indicators. Finally, autometrics is used to examine the relationship between energy efficiency and productivity at the aggregate level. The study finds that lack of information on energy efficiency practices is the most important barrier to energy efficiency. On the practices, methods such as putting off electrical appliances when not in use or when closed, using new electrical appliances and using less appliances to achieve the same goal are some of the common ones adopted by SMEs in rural Ghana. The study recommends that the Ghana Energy Commission should intensify its energy efficiency education and extend this to rural areas.

Key words

Efficiency, Small and Medium Scale Enterprises (SMEs), autometrics, Energy Consumption

1.0 Introduction

Small and Medium-Sized Enterprises (SMEs) in developing countries face the hydra-headed challenge of energy access, power outage, access to finance and access to market. These challenges adversely affect productivity, hinder their competitiveness and stifle growth. Thus, in order for SMEs to preserve competitiveness, they need to be energy efficient, insofar as energy efficiency reduces cost of production through reduced energy bill (Worrell et al., 2003). At the national level, energy efficiency is the cheapest way of reducing energy-related carbon emissions. At firm level, energy efficiency can be a key means of enhancing productivity growth (Jorgenson, 1984, Thollander at al., 2007). Further, environmental policies that seek to curb carbon emissions have positive health effects due to improved air quality. In this regard, the Johannesburg Plan of Implementation (UNDESA 2002) called on all countries to develop policies and measures that contribute towards reduction of carbon emissions. Energy efficiency can lead to improvement in energy security, and ensure a firm's profitability and competitiveness (Gbonney, 2009). A major drawback is that most of these studies are either carried out in developed economies or at the aggregate level. Further, energy efficiency gains are constrained by the market mechanism and rely upon the extent to which the energy market can be restructured (Jaffe and Stavins, 1994). Indeed, imperfect competition, asymmetric information and incomplete market, among other inhibitors, can hinder the viability of energy price changes as a major efficiency tool. More generally, economic, behavioural and organisational barriers to energy efficiency gains are identified (Sorrell, 2007). This calls for SME-specific initiatives, behavioural changes, and policy intervention and gender empowerment. Considering gender empowerment and SMEs' productivity, Orser et al. (2010)

identify two main viewpoints. The liberal feminist view point propounds that the size of SMEs and other structural factors account for the difference between the performance of female and male-managed SMEs. The social feminist viewpoint asserts that, even after controlling for the structural factors, a residual gender impact still affects the SMEs' performance. In Africa, the UNDP sponsored 'fruits of the Nile' in which solar dryers have been distributed to women groups in rural areas in Uganda has led to increased fruits export (Okalebo and Hankins, 1997). According to Clancy and Dutta (2005), gender dimension of productive uses of energy is driven by the fact that in most developing countries, women are usually found working in micro and small-sized enterprises in rural sector. Therefore, lack of adequate energy supplies for these activities affects women's ability to operate these micro-enterprises profitably and safely. Clancy and Dutta (2005) suggest that energy contributes about 25% of the total cost of inputs of SMEs in rural areas. Thus, reducing energy consumption through efficiency could lead to cost savings and profitability. Taken together, the role of gender in explaining performance differences in SMEs is inconclusive. Thus, a holistic examination of the effects on productivity growth of gender and energy efficiency practices, especially in rural areas, is warranted.

In 2011, Ghana grew at an astonishing rate of 14.4%, one of the highest in the World, and it attained middle income status (Aiyar et al., 2013). In order to sustain such growth, various measures have been undertaken by policy makers, businesses and researchers. First, the government recently established a fund (Youth Enterprise Support Fund) to help the youth start businesses. Second, researchers and policy makers are calling on the government to remove energy price subsidies. The removal of such subsidies will increase energy prices. The cheapest way to offset the impact of energy prices on a firm's performance is through energy efficiency (Patterson, 1996). To this end, the Energy Commission of Ghana encourages energy efficiency practices through education and other measures such as ‘swapping old freezers for a new one’, and the replacement of 40W fluorescent lamps with energy efficient 36W fluorescent lamps.

Though these policies are well taken, they mostly target household energy consumption. Even at the household level, to the best of my knowledge, there is no study that attempts to evaluate the effects of such energy efficiency policies on energy consumption and productivity in both the rural and urban areas. Gbonney (2009) is perhaps an exception. He finds that energy efficiency activities undertaken by the Energy Foundation in Ghana within the residential and business sectors have yielded significant monetary savings for consumers. However, Ghonney's study makes a critical untested assumption that the impact of energy efficiency practices in Accra can be generalised and extended to other regions in Ghana, thus neglecting the potentially important effect of geographical location.

In an attempt to fill the aforementioned gaps, this research builds on the following aims. First, we examine the impact of the energy efficiency practices of SMEs is different in rural and urban areas. Second, we aim at identifying the main catalysts and inhibitors to the effectiveness of energy efficiency practices. Third, we investigate the role of women entrepreneurship on the energy efficiency practices and the performance of SMEs in rural and urban areas. Fourth, we aim at assessing whether and, if so, how such efficiency measures enhance productivity. Fifth, we study whether the choice of energy efficiency strategy is driven by geographical location. To this end, we divide our sample into the coastal region and the Savannah region. Seventh, building upon the findings from this study, energy efficiency practices will be designed for rural and urban Ghana to boost productivity and economic growth. Specifically, both direct (e.g. reduced energy bill) and indirect benefits (e.g. employment creation) of the designed energy efficiency practices to SMEs in Ghana will be identified in this study. Seventh, based on the effects of women entrepreneurship on the energy efficiency practices and the performance of SMEs, programmes of women education, training and empowerment will be proposed. Eight, findings of this study will be used to tackle social and demographic issues, such as unemployment and the rural-urban migration.

1.2 Motivation of study

According to Shipley and Elliot (2001), SMEs (i) often face difficulties in obtaining the necessary information on new and already existing energy technologies, and (ii) lack the capital and technical expertise to invest in energy-efficient technologies. These difficulties are amplified by less energy policy attention directed at non-energy intensive SMEs (Ramirez et al., 2005). Though rising energy prices are necessary for energy efficiency, Bertoldi et al. (2005) suggest that it is not always effective. Energy-efficient technologies have may advantages including lower maintenance costs, increased productivity and safer working conditions. Despite these advantages, the effect of energy efficiency on firm productivity in developing economies has received little attention. Further, how gender and geographical location of an SME account for the differences or similarities in SME performance have not been studied. In the absence of a formal energy efficiency program targeted at SMEs in both rural and urban areas, this study to seek answers to the following questions

1.3 Research Objectives

1. What is the relationship between energy intensity and productivity growth in SMEs in rural Ghana?

2. What types of energy efficiency strategies are implemented by SMEs in the rural areas in Ghana?

3. What factors promote or inhibit the implementation of these efficiency measures?

4. Does geographic location (coastal or Savannah) influence the choice of energy efficiency strategy?

5. Which energy efficiency measures are recommended by the Energy Commission of Ghana and how successful have these been?

1.4 Significance of Study

Since 1997, the government of Ghana has experimented with various energy efficiency strategies through Ghana Energy Commission. This study seeks to look at how these efficiency interventions have impacted rural SMEs and study the barriers that prevent effective implementation of the measures. This study will help design appropriate energy efficiency measures for rural Ghana and recommend ways by which barriers to efficiency can be overcome. It will also help to understand how rural SMEs perceive energy efficiency so as to revise or improve the communication strategies of Ghana Energy Commission.

2.**Literature Review**

This chapter provides an overview of the regulatory framework of energy efficiency in Ghana and an analysis of empirical studies on energy efficiency, productivity and SMEs. The chapter ends with a literature summary and the identification of the gaps in the literature.

2.1 Energy Efficiency

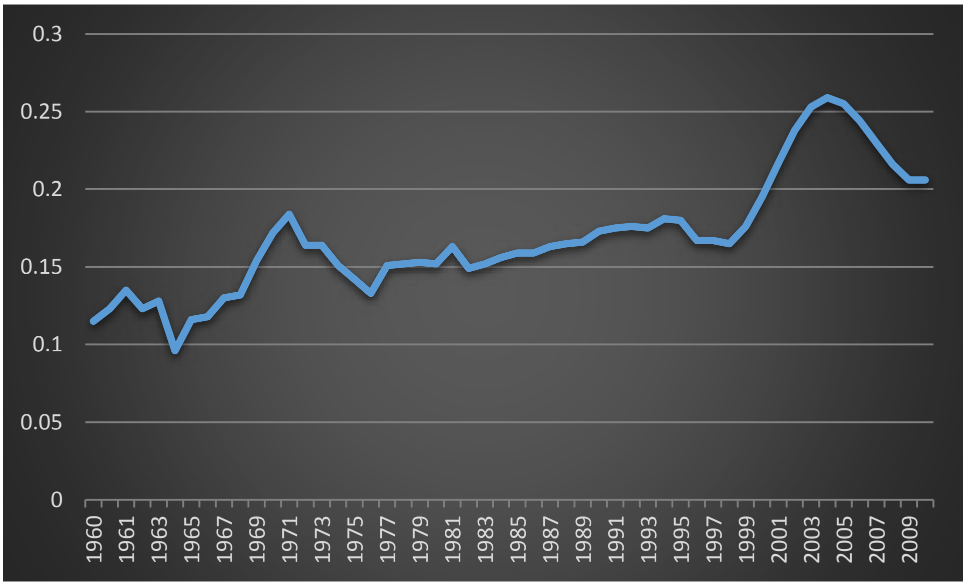
According to the neoclassical economics theory, a production function represents the relationship between the maximum amount of output that can be obtained from a given energy and other inputs (Sorrell, 2007).

Energy productivity is essential to the environment and economic growth. First, it is the cheapest way to reduce global emission of green gases (Mckinsey, 2007).According to the IEA (2006), an additional dollar spent on more efficient electrical equipment, appliances or buildings systems avoids more than two dollars in investment in electricity. Secondly, energy saved through productivity measures can also be used in other sectors of the economy. Energy efficiency has been found to be one of the main ways of reducing the impact of the trade-off between reduction in energy consumption and economic growth. For instance, Dan (2002) found that there has been a gradual decline in energy consumption in China since 1978 despite increasing growth and attributed this to energy efficiency.

After the oil price shocks in 1973/74 and 1979/80, average productivity in energy use has increased due partly to the replacement of energy-inefficient capital with efficient ones (Berndt, 1990). The efficiency can be embodied in the capital or can be disembodied in the form of experience. Bendt (1990) asserts that as one operates a production process, experience is accumulated through learning which leads to a decreasing unit cost which is independent of the capital stock. He indicates further that, increase in energy productivity usually follow energy price shocks with considerable time lag. This means major changes in energy use can occur through learning and as the capital stock is replaced with more energy efficient ones.

2.2 Total Factor Productivity in Ghana

Figure 1. TFP (in current US dollars)



Source: UNIDO, 2015

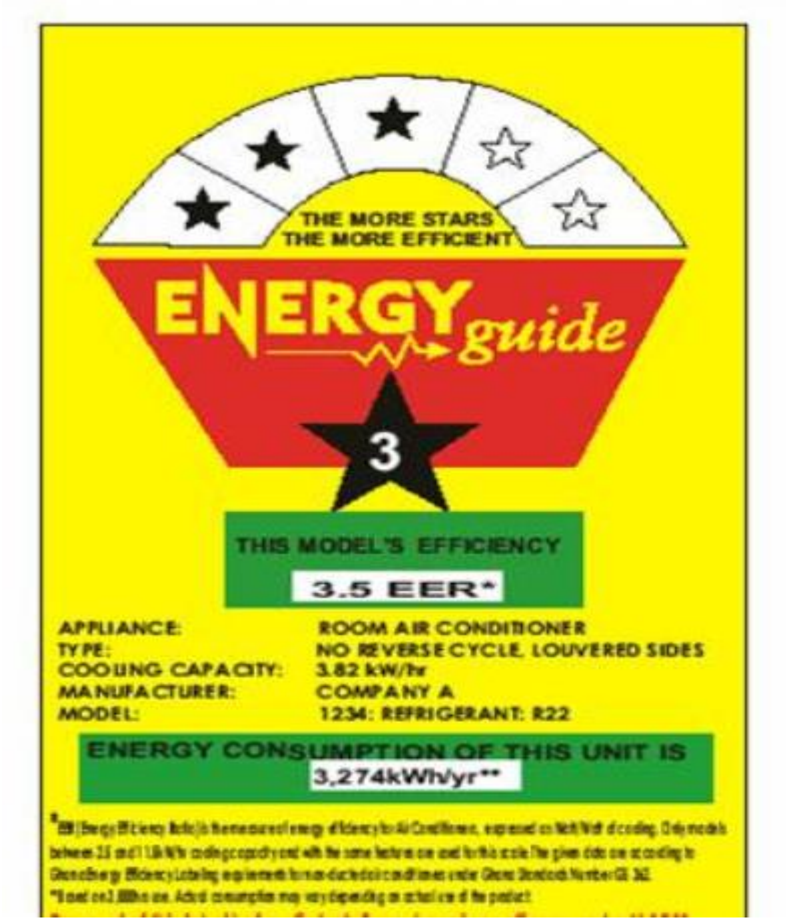
Figure 1 shows the productivity trend of Ghana from 1960 to 2010. It shows an increasing trend until 2004 when it began to fall. This can be explained by several factors such as the power crises and the increase in government spending after the HIPC programme. There was high increase in productivity from 1997, probably after the establishment of the Energy Commission in 1997.

2.1Regulatory Framework for Energy Efficiency in Ghana

According to Gbonney (2009), if energy efficiency policies are rightly initiated and well implemented, it can help countries to meet increased demand for energy at least cost and also minimise the environmental consequences of energy consumption. Based on this assumption, policy makers in the energy sector have a number of strategies and tactics to encourage energy efficiency and demand side management. In 1997, the Ghana Energy Commission was established by an Act of Parliament (Act 541). The purpose of the EC is to among other things promote the development of renewable energy resources and enhance energy efficiency. In the same year, the Ghana Energy Foundation, a public-private organization was created with the mandate to develop energy efficiency mechanisms and promote energy efficiency among consumers. Gbonney (2009) indicates that although the Ghana Energy Foundation has made some progress, most of its activities have been limited to the residential sector.

: Electrical appliances imported, produced or used in the country should have energy efficiency labels. This measure is supported by the Legislative Instrument 2005 (LI 1815).

Figure 1. Sample label



Source: Energy Commission

2.2 Demand Side Management of Energy

In 1999, Ghana Energy Foundation conducted a study on the energy efficiency practices of Ghana Textile Manufacturing Company and finds that the company saved 207,000KWh in electrical efficiency translating into 3,519 Ghana Cedis (1.6 Cedis was 1 dollar).

DSM includes all activities that are performed on the consumption side of an energy system, ranging from exchanging old incandescent light bulbs to compact fluorescent lights (CFLs) up to installing a sophisticated dynamic load management system. Whilst many studies suggest that DSM is “utility driven” in the past, it might move a bit towards a “customer driven” activity in the near future (Palensky and Dietrich, 2011). The authors perform a sequential Monte Carlo simulation to assess the impact of stochastic grid component outages and how far DSM can help in these cases. The correlation and sensitivity of the component capacity variation to the expected shortage of available transmission capacity is identified as well as the contribution of DSM to transmission capacity. Such centralized structures are sometimes complemented (if not replaced) by flat and freely organized market-driven mechanisms (Mohsenian-Rad et al, 2010). Depending on the timing and the impact of the applied measures on the customer process, DSM can be categorized into the following:

1. a) Energy Efficiency (EE).
2. b) Time of Use (TOU).
3. c) Demand Response (DR).
4. d) Spinning Reserve (SR).
5. According to Zhou et al (2008), DSM helps to reduce electrical related accidents, promotes customer satisfaction and reduces operational cost.

With the continuous growth rate in electricity demand in the country, it can be deduced that the utilities have a lot of work to do by increasing investment and the supply side. Despite this, the government is strongly looking at demand side management as a means of checking consumption trends and reducing power consumption. In some few years to come, consumer households will be equipped with smart metering and knowledgeable appliances. This would be a start for consumers to better monitor their electricity consumption and control loads in private households (Sebastian, et al, 2011).

Concerns raised about DMS are not new. The concept surfaced for a study in the 1908s when the need for solutions to influence consumer use of electricity was raised. DSM was considered even before this year regardless of the different kinds of utilities or geographical regions a country has. In a broader perspective, the main DMS techniques which have been implemented are as follows; (1)the use of night time storage heaters and electricity heating(Strabac, 2008); (2) adaptation of low limiters(those which can be switched off when demand is above a specific threshold); (3) reduction of price base on electricity usage , desirable time slots and curve flattering through the activation of program(Dincer, 2002); (4) the inclusion of smart appliances which manage their own running; (4) smart metering and feedback updates; (5) the use of frequency regulation to manage generators and loads (Mohsenian-Rad. et al,2010).

One factor which constraints and limits the application of DMS approaches is the existence of stand-alone micro grids. For instance, the demand curve which shows the match between demand and solar generation during periods must be flattening. The opposite of this strategy must be applied to the normal grid. During wind generation, the localised and stochastic nature of the wind demands the application of control strategies and accurate load management to allow for the management of fluctuations and intermittency which can create system failures. The cooperation between power management strategies and demand side management leads to high efficiency and optimized performance (Wu, et al, 2011).

Another strategy which can be implemented for demand side management is load shifting. This has been proposed for the management of micro grids. However, there is lack of proper definition for DMS in relation to stand alone grids which focuses on the optimisation of power generation management (Deindl., et al, 2008). In order to effectively apply DMS strategies effectively, a load control network must be built.

2.3 Energy Efficiency Practices in Ghana

The Ghana Shared Growth and Development Agenda (2010-2013) confirms the status of secure and reliable supply of high quality energy services in all sectors of the economy as a prerequisite for Ghana's development. This notwithstanding, Ghana suffers from recurrent power crisis which has led to the loss of a significant amount of output in the country. According to Braimah and Amponsah, (2012) this loss in output is a build-up of time lost in production and joblessness created as a result of lack of alternative sources of power to bridge the gap between the supply and demand. ISSER (2013) estimates that, the contributions from the electricity sub sector to GDP in 2011 and 2012 was at a level of 0.5% and in the same way, its share of total industrial GDP in 2012 totally declined to 1.8%.

According to Gyamfi (2007) and Adom et al. (2012), the electricity problem in Ghana could be solved easily only if attention is given to the demand side of electricity in the country and this study therefore pays attention to the demand side of electricity consumption in Ghana.

Adom et al. (2012) and Adom and Bekoe (2012) were the only authors whose study tried to estimate the demand dynamics for electricity in Ghana. However the authors' inability to measure the impact of certain significant factors of demand and the price of electricity weakened their analysis.

The following short term DSM strategies have been proposed by the government to increase energy efficiency in the country (Ofosu-Ahenkora, 2007).

1. The Intensification of Energy Efficiency Education
2. The Implementation of Mandatory Efficiency Standards for Room Air Conditioners and Compact Fluorescent lamps
3. The Supply and injection of 6million CFLs by government expected to reduce peak demand by 200-240MW – *cost of this option is US$60/MW capacity compared to US$1,000/MW for SCGT.

3.0 METHODOLOGY

The objective of this study is in three fold. First, the study seeks to identify the energy efficiency practices of SMEs in rural Ghana. Second, the barriers to energy efficiency implementation are ascertained. Finally, the relationship between energy intensity and enterprise productivity is studied. In order to achieve these objectives, 15 industries were selected from 4 regions. The four region are the Central, Eastern, Greater Accra and Volta regions. The choice of the industry and regions was dictated by energy consumption rate, energy access rate and the choice of electric utility provider. Based on the classification of the Regional Project on Enterprise Development, the study categorises small enterprises as those with 5 to 29 employees and 30 to 99 employees as medium enterprises (Regional Enterprise Development, 2008).

The study uses a survey conducted from November 2014 to March, 2015 in 5 out of the ten regions of Ghana with questionnaires. The essence of the study is to identify energy efficiency practices of Small and Medium Scale Enterprises in rural Ghana and ascertain whether these practices influence productivity. 200 questionnaires were distributed but 160 were completed.

In measuring the relationship between energy efficiency and productivity, two methods are employed. First, *autometrics* is employed to test for this link at the aggregate level. Hendry and

Krolzig (2005) suggest that model selection is a vital step in empirical research especially where a there is inconclusive arguments over the choice of variables that affect a given phenomenon. Since different set of factors can potentially influence the productivity, it will be important to have an econometric approach that automatically select the significant factors based on some predefined criteria. In Africa for instance, Bhattacharyya and Timilsina (2009) suggests that due to factors such the transition from traditional sources of energy to modern commercial ones and the economic structure, productivity functions may be the same as of those specified for developed countries. The automatic variable selection works by first specifying a general model based on based on previous findings, geographic and demographic characteristics, technological and economic trends. A misspecification test, lagged forms, significance levels and the desired information criterion is then set. This will allow valid inference from the specification (Hendry and Krolzig, 2005). This step is followed by the elimination of insignificant variables.

In order to ascertain the relationship between energy efficiency and productivity, a general unrestricted model (GUM) consisting of all predictors is specified. *Autometrics* then uses a tree-search to remove insignificant variables to select the final model (Pellini, 2014).

According to Patterson (1996), energy intensity can be broadly define as:

$$EI = {}^{Output}\!\!\diagup_{Energy}\, input \qquad (1)$$

This means that, energy intensity at the aggregate level can be summed up as the GDP divided by energy consumption (Ang, 2006). Therefore the more goods and services a country produces with a given amount of energy, the higher its energy efficiency. With regards to productivity, the study uses Total Factor Productivity (TFP) as a proxy. This is because, Zaman et al (2011) highlights that the strong relation between energy productivity and capital use indicates that energy efficiency may be augmented by optimizing capital use. Data on observed total factor productivity was from 1971 to 2010 was collected from the UNIDO global productivity database. The TFP is calculated using *growth accounting* and is obtained by attributing the excess of the sum of labour and capital contribution to economic growth to productivity. For instance, using a *Hicksian growth accounting,* we assume that the change in income, is as a result of the changes in capital (k), labour (l), productivity (A) and other factors (X) such as health, energy and quality of inputs.

$$\Delta Y = \Delta A + \Delta k^{\alpha} + \Delta l^{\beta} + \Delta X^{\rho} \quad \text{.......(2)}$$

Therefore, productivity becomes:

$$\Delta A = \Delta Y - \alpha \Delta k - \beta \Delta l - \rho \Delta X \quad \text{.......(3)}$$

Where A is a Hicksian

We begin by specifying a GUM error correction model saturated with impulse indicator and step dummies.

$$\Delta A_t = \beta_o + \beta_i t + \Delta\beta_{A-1} A_{t-1} + \Delta\beta_{EE} EI_{i,t} + \Delta\beta_{y-1} Y_{t-1} + \Delta\beta_{EC} EC_t + \Delta\beta_{EC-1} EC_{t-1} + \Delta\beta_{Ed} ED_t + \Delta\beta_{ed-1} ED_{t-1} + \Delta\beta_{co2} CO2_t + \Delta\beta_{co2-1} CO2_{t-1} + \sum_{i=1}^{T} \delta_i I_{i,t} + \sum_{i=1}^{T} \delta_i S_{i,t} + \varepsilon_t \quad (4)$$

Where t is the linear trend, $I_{i,t}$ are Impulse indicator dummy and $S_{i,t}$ are the step dummies. For all dummies, i is the index for indicator where as t is the index for time. For instance, $I_{2008,t}$ means impulse indicator dummy variable for 2008 which assumes the value 1 for 2008 and 0 prior to 2008.In order to enhance the robustness of the model, a battery of misspecification tests are used to evaluate it. EI is energy intensity, Y is GDP, EC is electricity consumption, CO2 is energy related carbon emissions, ED is education. These tests include the AR test (Breusch and Godfrey, 1981) where the null hypothesis state no correlation in the residual. Again, the ARCH test (Engle, 1982) where the null states that is serial correlation is employed. Other vital tests include the normality test (Bera and Jarque, 1982) which test normality in the residual, the hetero test (Breusch and Pagan, 1979) which test for homoscedasticity in the residual and finally, Reset test (Ramsey, 1974) which test for linearity in the functional form of the regression.

Secondly, at the micro (SMEs) level, two stage least squares are employed for the cross-sectional data.

Productivity = f(number of employees, energy prices, energy monitoring, gender, location, cost of fuel for generator, type of bulb use, acquisition of new energy using appliances)……(5)

In the absence of a suitable proxy, monthly turnover of SMEs is used to represent productivity. This function is estimated through a two stage least squares in SPSS. Following the work Agbola and Ankrah (2013), chi squares and correlation tests are used to examine the relationship between the variables. Objectives 1 and 2 will be analysed with descriptive statistics.

3.2 Description of Data

Data for the study will be collected through questionnaire and energy audit. The essence of using energy audit is to minimise the impact of Social Desirability Biases. That is when respondents behave and say things that may not be the fact on the ground (Brace, 2004). The sample size for the study is 160 SMEs in rural and urban areas as defined by the Ghana Population Census. The purpose of concentrating on both the rural and urban areas is to allow for comparison and also suggest geographic specific energy efficiency policies. The coastal zone of Ghana, which comprises the Western, Central, Greater Accra, Volta and Eastern

Regions, is generally humid and provides home to most energy intensive SMEs. Four regions were selected. These are Central, Eastern, Greater Accra and Volta. The data for this study will be collected from two main sources. Secondary data will be sourced from academic journal articles, textbooks and academic cases. Key literature sources on SMEs in Ghana, barriers to SMEs to SMEs performance and productivity and the relationship between energy efficiency practices and productivity will be reviewed.

Primary data will be collected from respondents with questionnaires, observation and interviews. The questionnaires will be pre-tested to ascertain whether the respondents understand the questions asked and whether they are consistent with the objectives set out by the study. Numbers will be assigned to the qualitative variables for the purpose of understanding the relationships among the variables. Parametric (Bonferroni) and non-parametric tests (Mann-Whitney and Chi-square tests) will be used to test for non-response bias between the respondents and the non-respondents. These primary data will be supplemented by data from the Ghana Statistical Service. The respondents will be divided into four categories as suggested by Frazer (2005). These are food and fisheries (cold stores, livestock, fishery), chemical processing (energy, fertilizer manufacturing, transportation), metal works (mining, mineral processing, metal works) and textiles and garments. This categorisation will help undertake comparative analysis and make industry recommendations after the study.

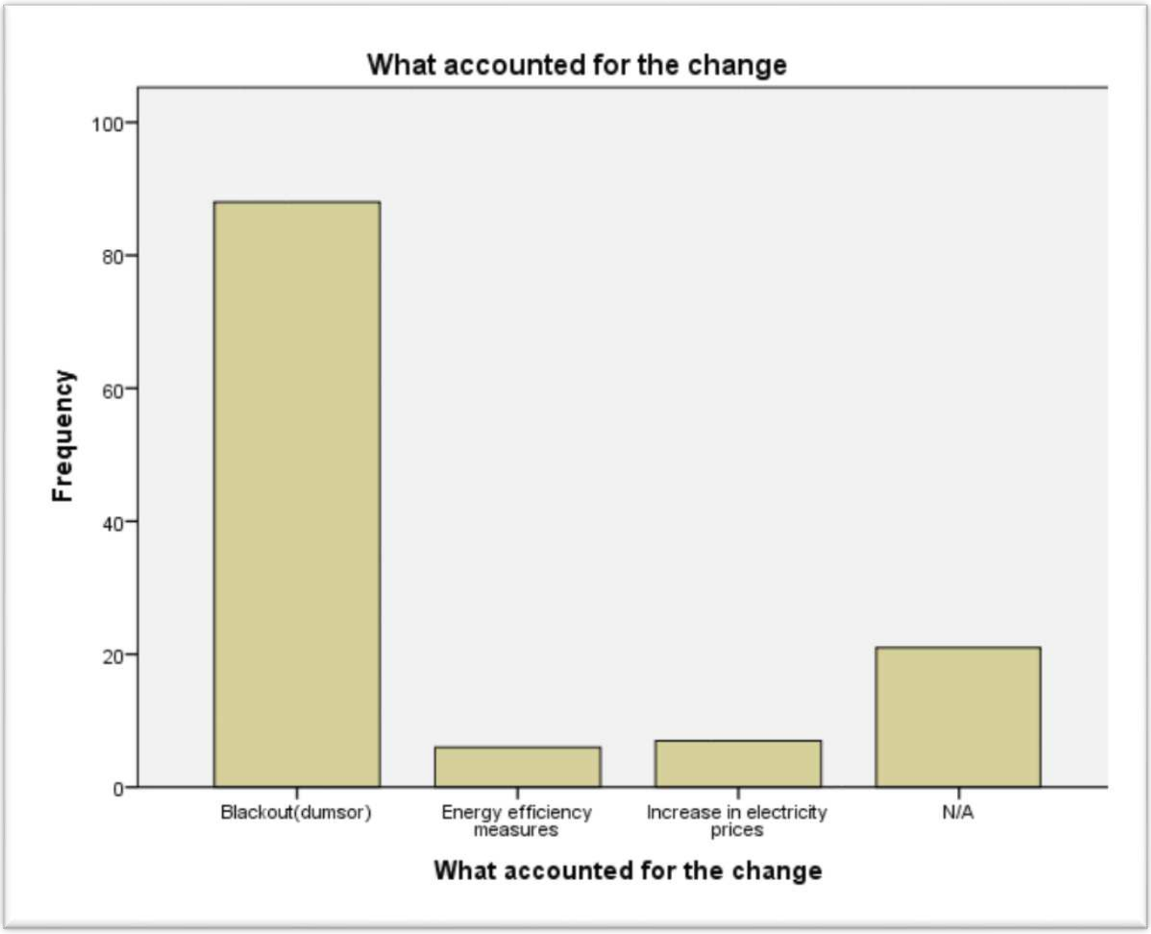
4.0 Analysis and Discussion

This chapters provides an overview of the results, findings and the discussion of the results.

4.1 Descriptive Analysis

The study seeks to examine the energy efficiency practices of SMEs in rural Ghana. The results indicate that about 60% of the SMEs studied have recorded a reduction in the electricity consumption over the past 6 months. However, 72% of these attributed the reduction in electricity consumption to blackouts (unreliable power supply).

Figure 2. Reasons for reduction in electricity consumption



According to figure 2, the principal cause of reduction in electricity consumption over the past 6 months has been blackouts according to 72% of those sampled. The study further finds that second most important driver of reduction in electricity consumption has been increases in prices. This confirms the findings of Ackah et al (2014) and Adom et al (2012) who find that price is a major driver of electricity consumption in Ghana. 5.7% of the respondents attributed the reduced electricity consumption to electricity price increases. Finally, only 4.9% indicated that their reduced consumption is as a result of energy efficiency. This finding has two important policy implications. First, policy makers can use price as a tool to achieve energy efficiency and climate change measures. Second, Ghana Energy Commission, the main body charged with enhancing energy efficiency should adopt more pro-rural mechanisms and medium to target and educate rural SMEs.

On where the respondents first heard about energy efficiency, 53% indicated radio and television whilst 36.8% indicated that they use their instinct in deciding whether they should adopt energy efficiency or not. Despite the effort of successive governments to encourage Ghanaians to use energy saving bulbs, by distributing 5000 bulbs in 2007, about 54% of the respondents use the incandescent ('onion') bulbs has been found to be inefficient. The International Energy Agency (IEA) estimates that the compact florescent light (energy saving bulbs) uses less than one-third to one-fifth energy of the incandescent bulbs. It is recommended that subsequent distribution of the energy saving bulbs should consider SMEs in rural areas.

Figure 3. Reasons for energy efficiency behaviour

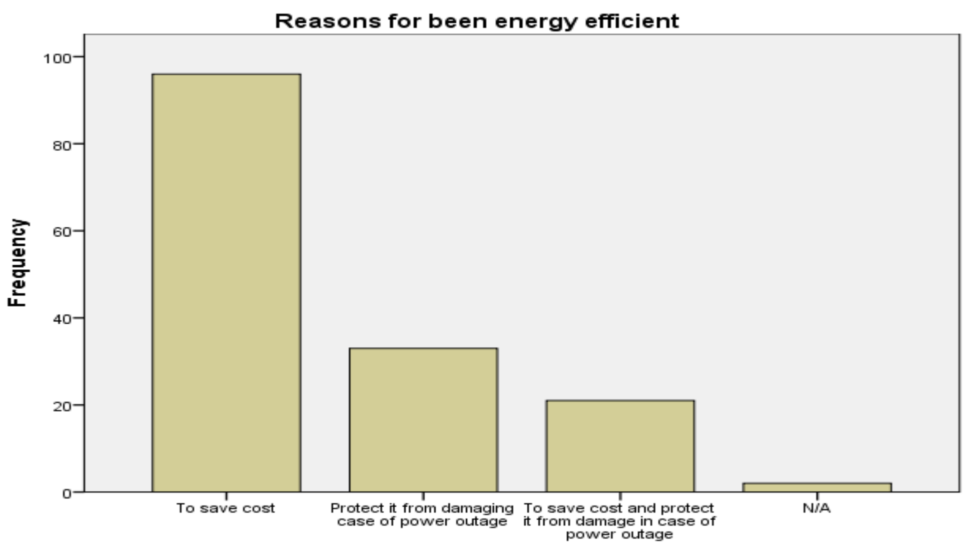


Figure 2 shows the reasons for energy efficiency behaviour of the respondents. According to the findings, 63.2% of the respondents indicated that saving cost is the number one reason for being efficient. Further, 21.7% indicated that they are efficient, for instance by putting electrical appliances when closing to save such equipment from been damaged when there is power outage.

Figure 4. What three things do you do to save energy?

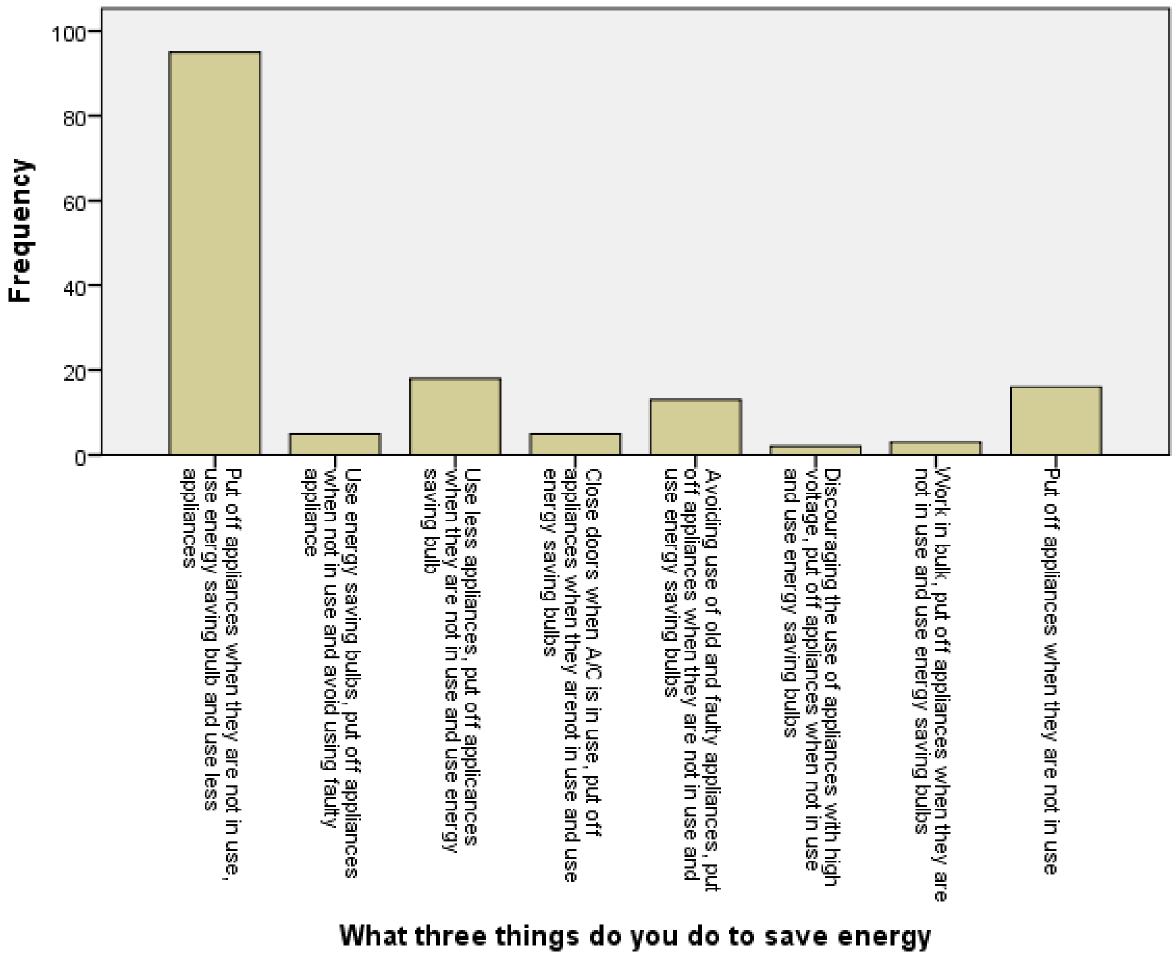
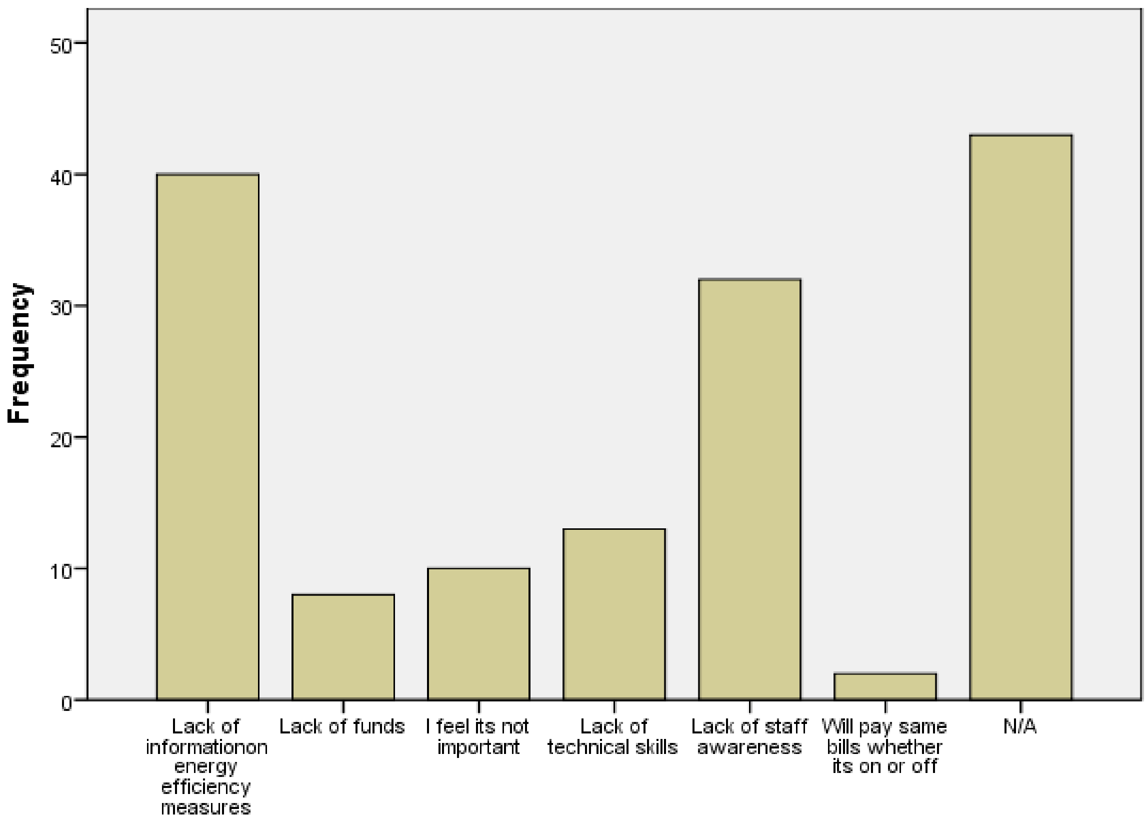


Figure 5.0 shows the three things SMEs in rural Ghana do to conserve energy. According to the findings, 60.5% put of their appliances when they close, 11% use less appliances to

consume less whilst 8.3% of the respondents avoid the use of old or second hand electrical appliances.

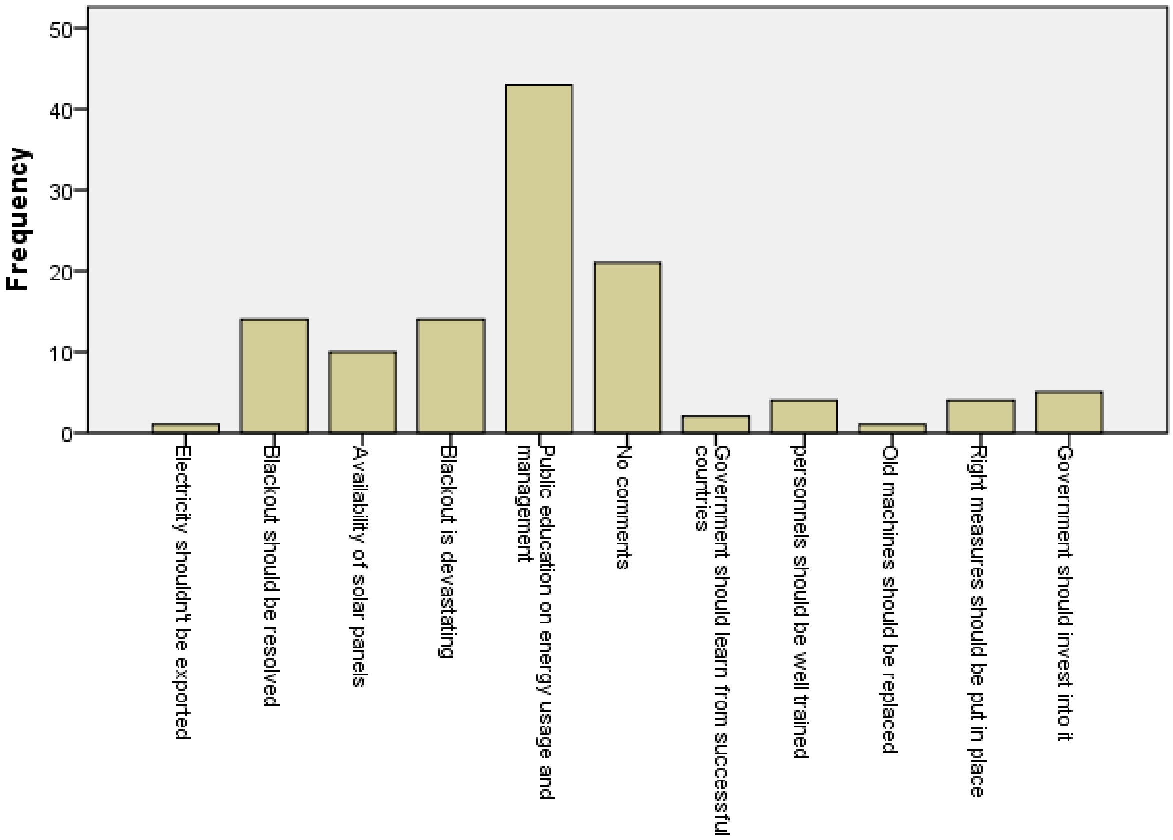
Figure 5. Barriers to energy efficiency



The three most important barriers are lack of information on energy efficiency measures, lack of staff awareness and lack of technical skills. These barriers fall under the institutional and organizational barriers highlighted by Weber (1997). These requires the energy commission to look at its communication strategy and device means of training SMEs in energy efficiency measures. Whilst commendation effort is being made by the Ghana Energy Commission and Ghana Energy Foundation to promote energy efficiency, most of these efforts seem to be concentrated in urban cities. In addition, the medium used by the Energy Commission such as

TV 3 and metro TV do not have nationwide coverage depriving rural SMEs of knowing energy efficiency measures.

Figure 6 Recommendations to enhance energy efficiency



According to figure 6, 26.4% of the respondents called for public education on energy usage and management whilst 8.4% called on the government to resolve the power crises. Whilst public education is ongoing, effort should be made to include rural areas. In addition, the provision under the Renewable Energy Act (2011) that calls for subsidized solar panels should be operationalised to allow rural SMEs minimise the impact of the power crises on sales and energy efficiency efforts.

4.2 Relationship between energy efficiency indicators and productivity (Regression analysis)

The regression analysis shows that the number of employees, monitoring and targeting of energy consumption and adjusting energy consumption to price changes affect monthly turnover. Whilst number of employees explains 0.985% of variations in monthly turnover, price changes explains 0.31% in sales. This notwithstanding, monitoring and targeting have an indirect relationship with monthly turnover (see Appendix B).

4.3 Relationship between energy efficiency and productivity (autometrics)

The output of the general unrestricted model shows that there is a relationship between energy intensity, energy related carbon emissions and productivity.

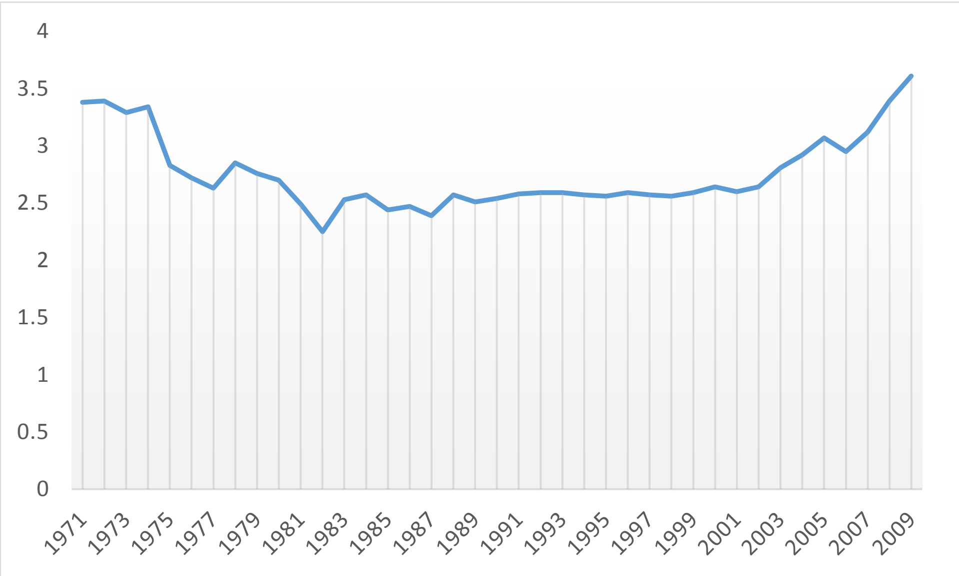
Table 2.0 Output from autometrics

	Coeeficents	Std. Error				
A(-1)	0.817	0.0407				
EI	-0.284	0.06475				
CO2(-3)	0.049	0.0145				
Sigma		0.01917				
Observations		37				
AR 1-2 test F(2,32)		0.999416				
Normality test Chi 2(2)		2.1353				
Hetero test F(6,30)		0.55116				

*Coefficients are significant at 5%. The table presents the preferred model after performing diagnostic tests and eliminating all insignificant variables.

Energy Intensity means the amount of energy that is used to obtain a unit of output, usually GDP (IEA, 2007). This means that when energy intensity increases, energy efficiency diminishes. According to figure 3, Ghana's energy intensity from 1971 to 1983, and increased between 1983 and 1985 and remained constant until 2001. The increased trend after 2001 can be attributed to inefficiency in energy consumption, increased share of heavy industrial manufacturing companies, structural changes and obsolete technology (Ma and Stern, 2008).

According to table 2, any 1% increase in energy intensity leads to 0.284% reduction in productivity. This confirms the findings of previous studies that show an indirect relationship between energy intensity and productivity (Zhang, 2003).



In terms of energy related carbon emissions, the lag values have a direct relationship with productivity. This implies that as consumers become aware of previous emissions as a result of energy use, they minimise their input use. Finally, the lag dependent variable has positive relationship with the current value of productivity.

Figure 4. Underlying productivity trend

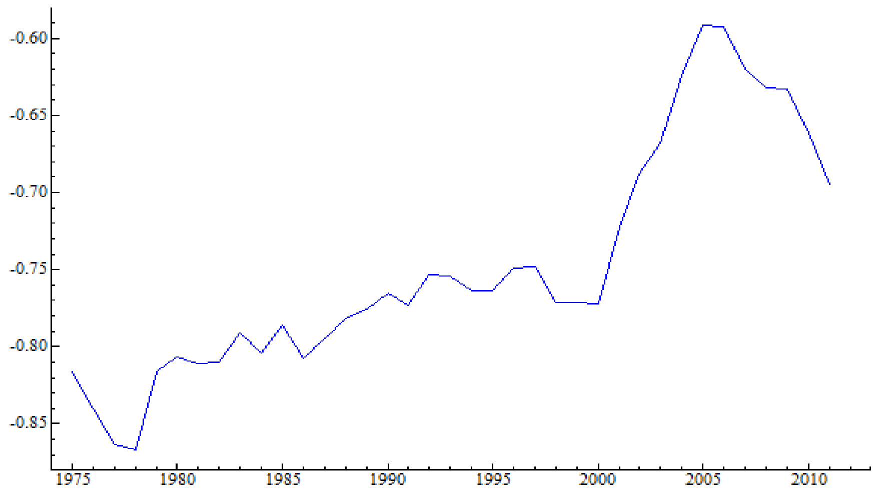


Figure 4 shows the underlying productivity trend of Ghana. This is adapted from Hunt et al (2003) who measured the underlying energy demand trend. According to Ackah et al (2014), the slope of the line determines productive behaviour or not. When the line slopes downwards, it shows a general productive behaviour. According to figure 4, Ghana has not been much productive until 2006 when the slope began to decline. This may be due to several factors. First, it can be attributed to the general reduction of the manufacturing contribution to GDP and an increased in the service contribution. Since the service sector uses relatively less input such as energy, productive can increased. In addition, the distribution of free energy saving bulbs to both industry and households in 2007 can also explain the rise in productivity.

5. Conclusion and Recommendations

The purpose of this study was to identify the energy efficiency practices of SMEs in rural Ghana and also examine the barriers to energy efficiency practices. Further, the study sought to ascertain the relationship between energy intensity and productivity at both the aggregate and micro (SMEs) level. In order to achieve these objectives, three methods were employed. First, a descriptive analysis was used to examine the barriers and energy efficiency indicators.

Second, a two stage least squares is applied to test the relationship between energy efficiency and productivity at the micro level. Finally, autometrics is used to examine the relationship between energy efficiency and productivity at the aggregate level.

The study finds that energy consumption of most SMEs in rural Ghana has reduced. However, this reduction was attributed to the power crises and high electricity prices. Energy efficiency came third on the rank of factors behind the reduction of electricity consumption. Further, the study finds that most SMEs use post-paid metres despite effort by policy makers to encourage the use of pre-paid metres since post-paid ones are inefficient and could be used as a tool to pay reduced bills. Moreover, 62% of the respondents indicated that energy efficiency leads to profitability through reduced electricity bills. The study also finds that lack of information on energy efficiency practices is the most important barrier to energy efficiency. On the practices, methods such as putting off electrical appliances when not in use or when closed, using new electrical appliances and using less appliances to achieve the same goal are some of the common ones adopted by SMEs in rural Ghana.

The study recommends that the Ghana Energy Commission should intensify its energy efficiency education and extend this to rural areas. In addition, associations and organizations such on churches and mosques can be used to train SMEs in rural areas on energy efficiency measures. Further, the 'old freezer for new freezer' should be extended to cover common appliances used by SMEs. Since price is a vital factor for reduction in energy consumption, policy makers should charge realistic prices for electricity to enhance efficiency

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