

The Role of Pre-Paid Meters in Energy Efficiency Promotion: Merits and Demerits in Accra, Ghana

Michael Tuffour^{#1}, Daniella Delali Sedegah^{#2}, Kesewa Asante^{#3} & Dominic Bonsu

^{#1}Department of Business Economics, Presbyterian University College, Ghana

^{#2} Department of Ecotourism, Recreation and Hospitality, University for Energy and Natural Resources, Ghana

Abstract

In most cases economic progress is typically associated with the appearance of new products and the disappearance of old products with the former dominating the latter with available characteristics. The study analysed consumers' views of the recently introduced electricity prepaid metres in the Accra East section of the country's capital, Accra. It mainly analysed the various prepaid metres introduced by Electricity Company of Ghana (ECG) which are still in use since their inception. The study focused on three types of prepaid metres in use in the study area, namely: Electro Cash, BOT/BXC, and Pay and Smile. Primary data was used for the study and structured questionnaires were used to collect data from 180 respondents. A multi-stage sampling approach which employed purposive, stratified and simple random sampling was used to select the respondents. Garrett's ranking technique and the probit regression were used to analyse the data collected. The study indicated that prepaid meters have fostered untold freedom to consumers but there are some challenges still associated with its implementation in the country. There are also challenges associated with the use of prepaid meters at both ends. That is, the consumers of prepaid meters have challenges and ECG also have challenges. The study concludes that irrespective of the challenges, the prepaid meter system has a high prospect and the highest possibility of ensuring efficient management and use of electricity in the country and thus suggest or recommend few issues to be addressed by ECG for effective and smooth running of the prepaid meter system in Ghana.

Keywords

Prepaid Metre, Urban Ghana.

I. INTRODUCTION

In most cases economic progress is typically associated with the appearance of new products and the disappearance of old products with the former dominating the latter with available characteristics (Flam and Helpman, 1987). Thus in 1994, Ghana followed the likes of South Africa, India, Turkey, Argentina and the United Kingdom (UK) in the adoption of prepaid meter system to measure electricity consumption in the country (Casarin and

Nicollier 2008, Tewari and Shah, 2003). According to Waddams *et al.*, (1998) prepaid metre systems attained its utmost development in Great Britain in the 1990s. The Department for Environment, Food & Rural Affairs and Department of Trade and Industry (DEFRA/DFI) (2001b) noted that, about 3.6 million homes in the UK were using prepaid metering as at 2000. This number increased to 3.7 million by 2001. The usage of prepaid meter is also widespread in India (Estache *et al.*, 2000) but South Africa has the highest dissemination of prepaid metres for electricity in the world. It is estimated that, 54% of its 7.3 million electricity consumers have prepaid meters (Australian Bureau of Statistics Energy Research, 2007).

With the prepaid system, customers determine the quantity of energy required of them and pay the required sum to electricity vendors. The household is then credited with the purchased amount of electricity. The electricity flow automatically gets disconnected after the electricity credits is fully exhausted, unless the consumer makes further repayment (Anthony and Govindarajan, 2003). The prepaid meters were introduced for two main reasons. One to help address some of the operational challenges of the Electricity Company of Ghana (ECG) such as ensuring efficacy in the use of electricity, reduce the difficulties and high cost of operations of ECG, high cost of customer billing process by ECG, tempering of post-paid metres by customers aimed at evading the payment of their electricity usage, delay in payment of the bills by customers and high indebtedness by corporate bodies and private individuals to ECG (ECG, 2010). Two, to help address issues such as frequent squabbles between landlords and tenants over payment of bills, payments of flat rates by various income earners which was seen as discriminatory on the part of the consumer (Bentil, 2011).

The use of prepaid metres is of importance to both consumers of electricity and the power provision company. This assertion is made explicit in a report published by the Ministry of Power, Energy and Mineral Resources, Bangladesh in 2011. According to the ministry the importance of prepaid metres to the

users include the following; they make it easy to add credit to the metre through smart card, ensure consumption and budget control by users and also put an end to disputed bills. The Ministry further noted that, prepaid metres ensure transparency in its operation, requires no deposit, has an automated record keeping hence no difficulties with bill payments, disconnection or reconnection costs, upfront payment of bills hence helped solved the problem of outstanding debt incurred by consumers. It also ensures improved cash flow, reduced non-technical losses, lesser overheads expense (no metre reading or billing) thereby increasing the revenue of the power provision companies. In the view of power provision company, prepaid metres creates power saving attitude to the consumers, ensures automated record keeping hence enhancing better customer services and load management (Ministry of Power, Energy and Mineral Resources, Bangladesh, 2011).

II. COVERAGE AND TYPES OF PREPAID METRES IN GHANA

The introduction of the prepaid meters can best be described as a radical move in that it was unprecedented or new to the population (Damanpour and Wischnesky, 2006, Tucker, 1987; Dirisu *et al.*, 2013). Despite its radical introduction, its importance has led to its generous acceptance and usage in Ghana. Perhaps the monopoly of ECG has also helped its generous acceptance and usage. This was made clear by the Ministry of Energy (MoE) (2010) when it asserted that as part of its “Energy Sector Strategy and Development Plan”, all postpaid metering systems in residential and commercial settings will be replaced by 2015. Recent data by ECG indicates that, about 776,294 (43.6%) of the total National Special Load Tariff (NSLT) customer population use prepaid metres (2013). Northern Electricity Development Company (NEDCO), a company providing electricity to six (6) regions in Ghana have planned to supply 200,000 prepaid meters in Ghana by 2017 (NEDCO, 2013). It is only obvious and it is no greater mistake to say that the percentage total of consumers on the prepaid measuring system will continue to increase.

There are five main types of prepaid metres in use in Ghana, namely; Smart-Cash, Pay and Smile, Electro-cash, Cash-Power and the BOT/BXC. Comparatively, the Cash and Smile or Pay and Smile prepaid metres were mainly designed for commercial purposes. They are to be installed in small factories and hotels. The Cash-Power prepaid metres are suitable for domestic and commercial purposes (ECG, 2010) while the BOT/BXC is mainly for domestic purposes (ECG, 2013). As discussed above these prepaid meters are different in function, quality and design. Product difference in terms of function, quality and design can affect the performance of the product (Dirisu *et al.*, 2013). Therefore a study to ascertain the

performance of the different but common prepaid meter in Ghana is of utmost importance. After 10 years of its introduction in Ghana empirical study in the subject area is very rare (See Bentsil, 2011; Asamaoh *et al.*, 2012).

III. OBJECTIVE OF THE STUDY

The aim of this paper is to study the merits and demerits of the prepaid meter system in Ghana as indicated by consumers.

IV. LITERATURE REVIEW

The literature on industrial organization emphasizes that differences in products remain one of the primary characteristics which affects conduct and performance (Bain, 1968; Hun Chang, 1990). This is very peculiar to the Ghanaian situation where consumers have no little to no right in choosing because of the monopoly of ECG. Differences in the product are seen as a means by which suppliers bend demand to their will (Smith, 1956). Other scholars see product differentiation as a means of meeting customer wants more accurately or a prevailing condition in which all products are not perceived as equal on each of the product characteristics including pricing (Dickson and Ginter, 1987).

On the other hand consumers being rational also take into regard a number of factors prior to making a decision on whether to accept and use a facility or a product or not. When consumers recognize that there is more merit to be obtained, all things being equal, they accept and use the product or facility (Godin, 2009). Garret ranking is one of the most preferred methods used in measuring product differences. It has therefore been employed to study anything consumer related, from consumer perceptions to consumer choices.

Below we discuss a few studies that employed the Garret ranking technique. Several studies have been conducted in the area of consumers' perception of prepaid metres.

Alam and Shahriar (2012) in their article titled “Electricity Billing Systems at Residential Level in Sylhet City, Bangladesh: Is Pre-Paid System perceived as a Better Option by the Subscribers?” The study conducted on 50 subscribers from both Pre-Paid and Post-Paid systems of Sylhet city, the study was considered as ‘Small Scale’ aimed to construct a comparative picture of the satisfaction level of the subscribers of the two systems on the benchmark issues. Hypothesis was tested through the use of three different statistical tools namely: ‘Mann-Whitney Test’, ‘Independent Samples T Test’ and ‘Two Sample Kolmogorov-Smirnov Test’ to compare between the responses patterns of the pre-paid subscribers and post-paid subscribers. The study was descriptive in

nature and included the use of both primary and secondary data. From the tests and analyses conducted in the study, Alam and Shahriar (2012) concluded that, pre-paid electricity has not been able to establish itself as a better option over post-paid electricity as the subscribers of either billing system shows no mentionable difference in level of user satisfaction.

Casarin and Nicollier (2008) in their article, "Prepaid Meters in Electricity. A case study of Carmen de Areco" examined the adoption of prepaid electricity using cost-benefit analysis techniques. This method consisted of comparing the performance of the electricity distribution system in the local district after the adoption of prepaid meters (the factual scenario) with what that performance would have been had prepayment metres not been adopted (the counterfactual scenario). The results of the cost-benefit analysis seem to suggest that adoption of prepaid meters leads to a welfare increase, not only to users adopting the system but also to those that do not. The views of consumers are thus relevant not only because they might be highly correlated with changes in their welfare and so they might give additional support to the findings of the economic model but also because they become a relevant factor behind the success of prepaid systems.

In their 2013 study of farmer's experiences with hybrid rice technology Nirmala and Suhasini employed the Garret Ranking technique to analysis farmers' perceptions and constrains in the cultivation of hybrid rice in khunti district of Jharkhand State in India. With 46 different types of hybrid rice and 50 farmers as respondent from two villages, Nirmala and Suhasini ranked 10 main farmer reasons for the cultivation and continuous cultivation of hybrid rice. The study ranked that, the main reason for the cultivation of hybrid rice among rice farmers was the hope for better yield followed by other reasons like hope for new hybrid and suitability of parboiling. And the main reason constrain was high seed cost followed by others reasons such as low grain quality and lower profitability.

Uma et al., (2013) also employed the Garret Ranking technique to analyze the causes of agricultural labour migration from North Karnataka to South Karnataka. With a 100 respondents their research ranked unemployment as the main push factor for North to South migration of agricultural labour. Other causes were environmental factors like drought and low productivity.

Vishnuvarthani and Selvaraj (2012) revealed that there are many factors that influence passengers to select train as their preferred mode of transport. They sampled 10% of 9300 passengers for their study and ranked 10 factors. These factors are economy of passengers, convenience, passenger safety, speed and

punctuality among others. Employing the Garret technique they research revealed that passengers preferred rail travel mainly because of convenience, followed by their economy.

In his study of clinical bovine mastitis control constraints among dairy farmers in Villupuram District, Christy (2014) ranked the major constraints facing dairy farmers in their attempt to control mastitis in order to minimize loss and maximize profit. He concluded that although the disease cannot be eradicated but for farmers to minimize avoidable loss efforts by be geared towards removing constraints. Chief ranked among the constraints was the high cost of treatment followed by shortage of labour and difficulty in diagnosis.

V. METHODOLOGY

A. Study Area

The area of study was Accra, Ghana's capital city. It is the smallest region among all the regions in Ghana in terms of land size but mostly densely populated (Ministry of Local Government and Rural Development (MLGRD), 2006). It has an overall land area of about 3,245 square kilometers. Accra is situated between latitudes 5.40o and 6.50o north of the equator and longitudes 0.2oW and 0.4oE. It has an overall population of about 3,910,000 which represents about 16.1% of the entire population in Ghana which makes it the second largest to the Ashanti Region (Ghana Statistical Service, 2011). It has the utmost population intensity in Ghana and it is as a result of the increased level of rural urban migration and an increased population growth rate. About 57.1% of the population in the Region is massed in the Accra Metropolitan Area comprising the majority (Ministry of Local Government and Rural Development (MLGRD), 2006).

The Region's landscape is mainly lowland with an average height of 250ft above sea level. The region predominantly has savannah grassland vegetation with some mangrove and swampy areas combined with few scattered forests of which some are in Dangme West District and Ga Municipality (Ministry of Local Government and Rural Development (MLGRD), 2006). Annual temperature in the Region varies from 20°C to 30°C. The Region's major raining season is from May to July and its minor raining season is from October to November with a yearly rainfall varying from 635mm to 1140mm. The region can boast of some lagoons due to its boundaries with the sea as well as some streams. It also has numerous small rivers with the main rivers being Densu and Volta rivers which are very vital source of water supply for industrial and domestic purposes (Ministry of Local Government and Rural Development (MLGRD), 2006). The Greater Accra region has the maximum concentration of industries,

administrative offices and commercial activities in Ghana implying it is the region with the highest demand for electricity in the country. It is the Centre where most of new technologies are piloted as it was for the introduction of prepaid meter system. It is the region with the highest amount and varieties of prepaid metres in the country.

B. Method of Data Collection

The study employed primary data with the use of well-structured questionnaires. The questionnaires were strictly closed ended since issues on which the questions were asked were obtained through literature. Monitoring and assistance were given to the respondents during data collection and the answering of the questionnaires.

In order to obtain the required data, the multi-stage sampling method was used. This comprise of purposive, stratified and simple random sampling. The first stage was the use of purposive sampling and this was used to choose areas where electricity prepaid metres were used in the study area. The second stage which was the stratified sampling method was used to put the users in various levels based on the type of electricity prepaid metre used. The last stage was the use of simple random sampling and this was used to give the users in various strata the equal probability of being chosen. In all a sample size of 180 respondents were used for the study. The sample size comprised users of the three various types of electric prepaid metres introduced by ECG which is currently used in the study area. Out of the 180 total respondents, 27 of them used Pay and Smile, 98 used Electro Cash and 55 respondents used the BOT/BXC prepaid meters.

C. Method Of Data Analysis

The study used the Garret ranking method to analyse the advantages and disadvantages of the three prepaid metres separately. Before the Garret ranking method was used, the various advantages and disadvantages of the various meters were extensively reviewed through literature and five each were chosen before they were ranked. Unlike the ranking methods like the Kendall’s and Friedman’s, the Garret ranking method does not only consider respondents who do not rank every item but those who could not rank all the items.

The Garrett’s ranking score technique finds the average score of the factors and arranges them in descending order. The order of the merit given by the respondents is changed into ranks by using the formula:

$$Percent\ Position = \frac{100(R_{ij} - 0.50)}{N_j}$$

Where

R_{ij} = rank given for the i^{th} statement by the j^{th} respondent

N_j = number of statements ranked by the j^{th} respondent

The percent position of each rank is converted into scores by referring to the tables given by Garrett and Woodworth (1969). Then for each factor, the scores of individual respondents are added together and divided by the total number of respondents. The mean scores for all the factors are ranked by arranging in descending order.

VI. RESULTS AND DISCUSSIONS

A. Socio-Economic Characteristics

As indicated in the table 1 the mean age of the respondents in the study area is 38.51 years with a standard deviation of 9.12. Out of the one hundred and eighty (180) respondents, 59.4% were males while the remaining 40.6% were females. With respect to the educational level 3.9% of the respondents had primary education, 17.8% had Junior High School of Middle School education, 36.9% had Secondary / Technical / Vocational education with 41.1% having tertiary education while 0.6% had non – formal education. Thirty seven point eight percent (37.8%) of respondents were single.

Table 1: Socioeconomic Characteristics

Demo. Variable	Freq.	Percentage	Mean	SD
Age	38.51	9.12		
Gender				
Male	107	59.4		
Female	73	40.6		
Level of Education				
Primary	7	3.9		
JHS/Middle School	32	17.8		
Sec./Tec./Voc.	66	36.7		
Tertiary	74	41.1		
Non-Formal	1	0.6		
Marital Status				
Single	68	37.8		
Married	112	62.2		
Others	0	0		
Income level	€1716.2	€1453.9		

Field Data, 2014

The respondents were single while 62.2% were married with no other respondent falling in the other marital status group. The findings on tertiary education is similar to that of Tuffour *et al.*, (2014)

who also found out majority of their respondents in the Greater Accra Region were educated and also similar to that of the findings of the 2010 population and housing census where about 66% of people in the Region had education above JHS and above (Ghana Statistical Service (GSS), 2011). On marital status, the findings is similar to that of GSS (2011) where about 45% of residence were single with the second largest married who were 39.94% where marriage.

B. Merits of the Electricity prepaid System

Out of the various advantages of the prepaid metres, “no outstanding payment to the ECG” was the 1st for Electro Cash and Pay and smile but 2nd for BOT/BXC; implying the issue of no debts to ECG came out as a big relief for many residents. The “control on the use of electricity”, it ranked 1st for BOT/BXC but 2nd for Electro Cash and Pay and Smile. “Reduction in wrong reading with post-paid” was ranked 3rd for all the three types of prepaid metres. With the advantage of “Reduction in Disconnection and Connection fee” it was the 4th for both the Electro Cash and Pay and Smile whiles it was 5th for the BOT/BXC. The idea that prepaid “Creates power saving attitude” was 4th for the BOT/BXC but 5th for Electro Cash and Pay and Smile. “Reduction in bill evasion by tenants” was the 6th for all the three types of metres

Though each individual metre has its respective rank for the various issues, the relative weight with respect to the issues concerning users of the prepaid metres is different. With the issue of no outstanding payment to the ECG, the mean was 63.65 for the Electro Cash, Pay and Smile as 66.85 with BOT/BXC as 59.48; meaning Pay and Smile users on the average have the highest appreciation with respect to this advantage, followed by Electro Cash and BOT/BXC. For the advantage of “Control on the use of electricity” the mean score for BOT/BXC was 61.18, with Electro Cash having 57.29, and Pay and smile at 57.29. This implies on the average BOT/BXC users appreciate this advantage than the other two who see the same advantage. For “Reduction in Disconnection and Connection fee”, the average for Electro Cash, Pay and smile and BOT/BXC were 51.33, 50.59 and 45.83 in that order which obviously indicates that on the average their appreciation of this as an advantage is also in the same sequential order. For “Reduction in Disconnection and Connection fee”, those who appreciate it the most are the Electro cash users followed by the Pay and Smile then BOT/BXC users since their average scores were 44.70, 44.59 and 43.89 respectively. All these are indicated in Table 2.

Table 2: Garrett ranking on the advantages of prepaid metres

Advantage	Electro Cash		BOT/ BXC		Pay and Smile	
	Garrett Mean Score	Rank	Garrett Mean Score	Rank	Garrett Mean Score	Rank
No outstanding payment to ECG	63.65	1 st	59.48	2 nd	66.85	1 st
Control of use of electricity	57.29	2 nd	61.18	1 st	55.30	2 nd
Reduction in wrong reading with postpaid metres	51.33	3 rd	45.83	3 rd	50.59	3 rd
Reduction in Disconnection and Connection fee	44.70	4 th	43.89	5 th	44.59	4 th
Creates power saving attitude	39.59	5 th	45.81	4 th	37.67	5 th
Reduction in bill evasion by tenants	30.57	6 th	29.73	6 th	23.00	6 th

Field Data, 2014

Table 3: Garrett ranking on the disadvantages of prepaid metres

Disadvantage	Electro Cash		BOT/ BXC		Pay and Smile	
	Garrett Mean Score	Rank	Garrett Mean Score	Rank	Garrett Mean Score	Rank
Technical faults with the metre	62.50	1 st	36.57	4 th	35.27	4 th
Expensive nature of the prepaid metres	59.95	2 nd	59.76	1 st	64.54	1 st
Difficulty in uploading prepaid units	53.80	3 rd	33.80	5 th	61.26	2 nd
Delays in obtaining a metre	39.18	4 th	51.35	3 rd	47.00	3 rd
Scarcity of prepaid units	31.68	5 th	51.50	2 nd	30.63	5 th
Low current	24.21	6 th	33.25	6 th	23.00	6 th

Field Data, 2014

Table 3 shows the disadvantages of the prepaid metres from the perspective of the prepaid metres users according to the Garret ranking method. “Technical faults with metres” was the 1st demerit for Electro cash users but was 4th for both BOT/BXC and Pay and Smile users whiles “Expensive nature of the prepaid metres” were first for BOT/BXC and Pay and Smile whiles it was the 2nd demerit for Electro Cash users. “Difficulty in uploading prepaid units” was the 2nd disadvantage for Pay and Smile, 3rd for Electro Cash but 5th for BOT/BXC. “Delays in obtaining a metre” was the 3rd disadvantage for both BOT/BXC and users but 4th for Electro Cash users. “Scarcity of prepaid units” was the 2nd ranked disadvantages of the prepaid metre but was 5th for both Electro Cash and Pay and Smile users. The issue that they cause “low current” was the least for all three types of prepaid metres. With respect to the weights, Table 3 clearly indicates that Electro Cash users had 62.50, whiles BOT/BXC users had 36.57 and Electro Cash 35.27 for the issue of “Technical faults with the metre”. This implies though they were ranked the same for BOT/BXC and Electro Cash users, it was more of an issue to BOT/BXC than Electro Cash users with respect to technical fault.

C. Demerits Of The Electricity Prepaid System

Challenges faced by ECG with respect to the introduction of the prepaid system includes: a blow of the fuse in any of company’s transformers causing a power outage, some customers tempering with the meters thereby causing losses to the company (ECG, 2010). Challenges faced by customers include: expensive nature of the prepaid system, accessibility for the prepaid units is also scarce, technical faults with the metre, delay in electricity supply after power outage, low current and the long time in acquiring a metre (ECG, 2010). The metres most often trips off or the prepaid metre purchased card becomes faulty and makes it challenging for users to upload units purchased unto the metre and thus causing a lot of inconveniences to customers.

In South Africa, challenges associated with the electricity prepaid metre include: sale of illegal pre-paid electricity vouchers from stolen vending machines and through illegal electrification schemes, electricity theft through fraud (metre tampering and bypassing, abstracting or branching off or diverting current) and illegal connections (Eskom, 2002).

In the United Kingdom, the main challenges prepayment customers face include: higher cost tariffs, issues associated with prepaid metre settings, inconvenience caused by the top-up process,

challenges when switching supplier, problems with payment devices and self-disconnection (Owen and ward, 2007).

VII. CONCLUSION

The aims for which the prepaid meters were introduced in Ghana about 10 years ago is best determined by measuring of the merits and demerits of the prepaid meter system. This study found that among the merits of prepaid meters no outstanding bill is one serious problem that has become history to both ECG and its customers. Customers of electricity have full control of power usage now and wrong reading of post-paid meters which gave ECG a bad reputation among consumers is also a thing of the past. Irrespective of the afore mentioned merits there are some demerits predominant among is technical fault of prepaid meters. This study also found out that, there are few challenges associated with the use of the prepaid meters at both ends. That is both ECG and consumers faces some challenges which need to be addressed for the smooth running of the prepaid measuring systems. Challenges to ECG include blow out fuse in meters, problems with transformers causing power shortage and consumers tapering with meters which causes losses to ECG. To the consumers the challenges includes expensive nature of meters, faulty prepaid meter cards make it difficult to upload units and meter trips off. It is therefore the conclusion of this study that the prepaid meter system has a high prospect and the highest possibility of ensuring efficient management and use of electricity in the country and therefore recommended the following for ECG’s consideration.

VIII. RECOMMENDATIONS

The findings of the study have therefore resulted in the following recommendations:

- Prepaid metres should be made affordable for all.
- Improvement on the efficiency of prepaid metering services by addressing Consumers’ concerns in terms of installing durable, reliable prepaid meters also acquiring prepaid meters that are user friendly, increasing prepaid meter vending points and making it less expensive to use.
- Public education for communities on the use of prepaid metres which targets women must be organized in order to get more women to appreciate the use of prepaid meters.
- Establishment and strengthening of emergency response unit that will attend to all technical emergency issues relating to prepaid metre issues promptly.

REFERENCES

- [1] Alam, J. and Shahriar, F. M. (2012). Electricity Billing Systems at Residential Level in Sylhet City: Is Pre-Paid System perceived as a Better Option by the Subscribers? Bangladesh: Industrial Engineering Letters.
- [2] Anderson, R. and Fuloria, S. (2010). On the security economics of electricity metering. England: Hoboken: Wiley Publishing.
- [3] Anthony, R. N. and Govindarajan V. (2003). Management control systems. New York: McGraw-Hill/Irwin.
- [4] Antonio Estache, Foster Vivien and Wodon Quentin. (2000). Infrastructure Reform and the Poor. Learning from Latin America's Experience. Cepal Review, New York.
- [5] Apreh, N. S. (2012). Prepaid Metering System. Accra: Blackwell Publishing.
- [6] Asamoah, D., Annan, J. and Arthur, D. Y. (2012). Time Series Analysis of Electricity Meters Supply in Ghana. International Journal of Business and Social Science. Vol. 3.
- [7] Australian Bureau of Statistics. (2007). Prepayment Metering. Canberra: Australian Bureau of Statistics.
- [8] Bentil, K. (2011). The Plights of the prepaid electricity metre to the ordinary Ghanaian. London: Think Street Solutions Limited.
- [9] Bain, J.S. (1968) Industrial Organization. John Wiley & Sons, Hoboken.
- [10] Burger, J.M. (1992). Functional Specification for a Common Vending System for Electricity Dispensing Systems. Measurement and Control Department. Eskom, Pretoria: National PTM&C Transmission Group.
- [11] Casarin, A. A and Nicollier, L. (2008). Prepaid Meters in Electricity. A Cost-Benefit Analysis. Austral University, IAE Business School, Pilar, Argentina.
- [12] Chang, M. H. (1991). The effects of product differentiation on collusive pricing. International Journal of Industrial Organization, 9(3), 453-469.
- [13] Christy, R.H. (2014). Garret Ranking Analysis of Various Clinical Bovine Mastitis Control Constraints in Villupuram District of Tamil Nadu. Journal of Agriculture and Veterinary Science, Volume, 7.
- [14] Damanpour, F., & Wischnevsky, J. D. (2006). Research on innovation in organizations: Distinguishing innovation-generating from innovation-adopting organizations. Journal of engineering and technology management, 23(4), 269-291.
- [15] Department for Environment, Food & Rural Affairs and Department of Trade and Industry DEFRA/DTI (2001b), The UK Fuel Poverty Strategy. Department for Environment, Food & Rural Affairs and Department of Trade and Industry. November.
- [16] Dickson, R. D. and Ginter, L. J. (1987). Market Segmentation, Product Differentiation, and Market Strategies. Journal of Marketing. Volume, 51.
- [17] Dirisu, J. I., Iyiola, O., & Ibiidunni, O. S. (2013). Product differentiation: A tool of competitive advantage and optimal organizational performance (A study of Unilever Nigeria PLC). European Scientific Journal, ESJ, 9(34).
- [18] Dirisu, A. R., Olumukoro, J. O., & Obayagbona, N. O. (2016). Physicochemical and bacteriological quality of water from lotic and lentic ecosystems in Agbede Wetlands, Edo State, Southern Nigeria. Ife Journal of Science, 18(3), 685-692.
- [19] Electricity Company of Ghana Limited. (2010). Prepayment metres. Accra: Electricity Company of Ghana.
- [20] Electricity Company of Ghana Limited. (2013). Ghana Electro-cash prepaid metre. Accra: Electricity Company of Ghana Limited.
- [21] Enbaya. (2003). Prepaid metres. Johannesburg: South African Companies.
- [22] Eskom. (2002). History of pre-paid electrification. Johannesburg: Eskom.
- [23] Eskom. (2002). Business requirements specification for CDU and SMS enhancements. Johannesburg: Eskom.
- [24] Godin (2009). National Innovation System: The System Approach in Historical Perspective. Journal of Science, Technology and Human values, Vol. 3.
- [25] Ghana Statistical Service. (2011). Population and Housing Census. Accra: Government of Ghana.
- [26] Garrett, H. E. and R.S. Woodworth. (1969). Statistics in Psychology and Education. Bombay: Vakils, Feffer and Simons Pvt. Ltd., P: 329.
- [27] Flam, H. and Helpman, E. (1987). Vertical Product Differentiation and North- South Trade. The American Economic Review Volume, 7.
- [28] Gómez-Lobo, A. and D. Contreras. (2004). Water Subsidy policies: A comparison of the Chilean and Colombian Schemes (Vol. 17). The World Bank Economic Review.
- [29] Heusden, P. (2009). Discipline and the New 'Logic of Delivery': Prepaid Electricity in South Africa and Beyond. Cape Town: HSR Press.
- [30] Institute of Statistical, Social and Economic Research (ISSER). (2005). Guide to Electric Power in Ghana (1st ed.). Accra: Resource Center for Energy Economics and Regulation (RCEER), ISSER.
- [31] Intermediate Energy Info Book. (2003). History of Electricity. Manassas, VA: Need Project.
- [32] Iliu, Z. (2005). The design of prepayment polyphase smart electricity metre system. International Conference on Intelligent Computing and Integrated Systems (ICISS). New York.
- [33] Measurement Canada. (2006). Policy on Prepayment Meters. Utility Metering Division Development Directorate, Canada.
- [34] Meter, M. (2012). Making more use of your multimeter. Staplehurst, Kent: Transmille Limited.
- [35] Myong-Hun, C. (1990). The Effects of Product Differentiation on Collusive Pricing. International Journal of Industrial Organization. Volume, 9.
- [36] Ministry of Energy (MoE) (2010) Energy Sector Strategy and Development Plan. Ministry of Energy. Republic of Ghana
- [37] Ministry of Local Government and Rural Development (MLGRD). (2006). About Ghana: Greater Accra Region. Accra: Government of Ghana. Retrieved March 2012, from www.ghanadistricts.com
- [38] Northern Electricity Development Company (NEDCO) (2013). NEDCO Business Plan 2013- 2017. Volta River Authority. NEDCO. Volta River Authority
- [39] Ngemah, R. (2011). The Multi-Tenants Prepaid Metres. Accra: Aabok Publications.
- [40] Nirmala, B. and Suhasini, K. (2013). Farmer's Experience with Hybrid Rice: A case Study of Khunti
- [41] District Jharkhand State in India. Africa Journal of Agricultural Research. Vol. 8(29).
- [42] Owen, G. and Ward, J. (2007). Smart Meters in Great Britain: The Next Step. Sustainability First.
- [43] Power Division. (2011). Prepaid Metering. Ministry of Power, Energy and Mineral Resources, Bangladesh.
- [44] Richard Hanks, Zoe McLeod and Holly Reilly. (2012). Smart Metering Prepayment in Great Britain. London: Accenture.
- [45] Shaw, A. (2009). Types of Electric Meters. New York: Niche Project.
- [46] Smith, W.R. (1956). Product Differentiation and Market Segmentation as Alternative Marketing Strategies. Journal of Marketing. Volume, 21.
- [47] Tewari, D.D and Shah, T. (2003). An Assessment of South African prepaid electricity, lessons learned and their policy implications for developing countries. University of Natal, Division of Economics, School of Economics and Management. Durban: Elsevier.
- [48] Tuffour, M., & Oppong, B. A. (2014). Profit Efficiency in Broiler Production: Evidence from Greater Accra Region

- of Ghana. *International Journal of Food and Agricultural Economics*, 2(1), 23.
- [49] Vishnuvarthani, S. and Selvaraj, A. (2012). Factors Influencing the Passengers to Select Train Travel: A study of Saleem Division of Southern Railway. *International Journal of Scientific and Research Publication*, Volume, 2.
- [50] UK Power Limited. (2012). *A simple guide to gas and electricity meters*. Banbury: UK Power limited.
- [51] Uma, H.R., Madhu, G. R., Mahammad, H. (2013). Analysis of the Causes of Regional Migration Using Garret's Scale. *Journal of Humanities and Social Science*. Volume 12.
- [52] Waddams, Price, Catherine, and Hancock, R. (1998). *Distributional Effects of Liberalizing UK*. Fiscal Studies, Vol. 19, London.
- [53] Size 8) S. M. Metev and V. P. Veiko, *Laser Assisted Microtechnology*, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.
- [54] J. Breckling, Ed., *The Analysis of Directional Time Series: Applications to Wind Speed and Direction*, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.
- [55] S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," *IEEE Electron Device Lett.*, vol. 20, pp. 569–571, Nov. 1999.
- [56] M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, "High resolution fiber distributed measurements with coherent OFDR," in *Proc. ECOC'00*, 2000, paper 11.3.4, p. 109.
- [57] R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, "High-speed digital-to-RF converter," U.S. Patent 5 668 842, Sept. 16, 1997.
- [58] (2002) The IEEE website. [Online]. Available: <http://www.ieee.org/>
- [59] M. Shell. (2002) IEEEtran homepage on CTAN. [Online]. Available: <http://www.ctan.org/tex-archive/macros/latex/contrib/supported/IEEEtran/>
- [60] FLEXChip Signal Processor (MC68175/D), Motorola, 1996.
- [61] "PDCA12-70 data sheet," Opto Speed SA, Mezzovico, Switzerland.
- [62] A. Karnik, "Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP," M. Eng. thesis, Indian Institute of Science, Bangalore, India, Jan. 1999.
- [63] J. Padhye, V. Firoiu, and D. Towsley, "A stochastic model of TCP Reno congestion avoidance and control," Univ. of Massachusetts, Amherst, MA, CMPSCI Tech. Rep. 99-02, 1999.
- [64] *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification*, IEEE Std. 802.11, 1997.