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Household Effective Demand for Electricity in Ghana: Analysis and Implication for Tariffs

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Abstract:

Outcomes of most developing country projects to secure inclusive growth through electricity provision appear to hinge on available information regarding households' response to electricity. To provide the needed information for policy, this study assessed the determinants of household electricity demand and estimated the mean willingness to pay for electricity by households in Ghana. The study used a Contingent Valuation modelling procedure involving over 3000 households, to derive an effective demand function for electricity in Ghana. This was done through a national household survey. A mathematical programming analytical procedure was employed, to fully account for the block pricing tariff system used in Ghana. The study found that Ghanaian households are willing to pay a monthly mean electricity

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tariff of 50.40 Ghana cedis (US$11.56), which is lower than the average monthly tariff of 73.67 Ghana cedis (US$16.90) paid by households. Thus, the average tariff paid by households monthly is 46% higher than the mean willingness to pay. The study also found that the highest impact determinants of demand for electricity in Ghana were affordability of tariffs, usage of electrical appliances, and availability of electricity, respectively. This study employs a mathematical programming procedure to determine the mean willingness to pay for electricity in Ghana. This procedure is theoretically more robust than the often-used differential calculus approach since it incorporates the block pricing of electricity in Ghana, which the calculus approach ignores. Also, it uses the largest and most inclusive known sample, specifically designed to elicit households' willingness to pay for electricity in Ghana. The study is also unique in its findings.
Keywords: Contingent Valuation, Demand for Electricity, Electricity Tariffs, Ghana, Households, Willingness to Pay.
JEL Codes: O55, Q41, Q48, Q51.

1. Introduction

The expectation that households would opt for electricity if available, appears untenable for several households in developing countries. In such countries, many issues remain unclear regarding households' effective demand for electricity. While many governments in developing countries have built some infrastructure for the supply of electricity, many households are unable to meet the requirements for effective demand and thus remain deprived of electricity. Many households in developing countries do not have effective demand for electricity (Lee et al., 2016; World Bank, 1993).

While some subsidies have assisted households, such subsidies had to be substantial, leading to the nearly free provision of utility services (Whittington et al., 1993). In the absence of tariff payments that are high enough to provide adequate resources to service providers for investments in plant and equipment, initial installations deteriorate, bringing the systems down within short periods of time. This is due to a lack of funds for the maintenance of equipment and improvement to cater to increasing consumption from growing populations. Thus, it appears the structure of tariffs does not provide information regarding the responses of different types of households to different levels of electricity tariffs in these countries.

There is very little or no information on specific households' responses to electricity tariffs in Ghana. The absence of such information hinders the improvement of planning for electricity service delivery (Greenstone, 2014). The service is provided based on very little or no knowledge about how specific households will react, except a very generalized idea that households will respond favourably, even though on numerous occasions such expectations have not worked in favour of service providers and investors (IMF, 2019; 2021). Thus, the reasons for such adverse responses to the expectations of electricity policymakers will have to be empirically ascertained to inform policy toward improving electricity planning and delivery in Ghana.

This study seeks to provide such information by eliciting from a random sample of over 3000 households in Ghana, how much electricity they would want to use if it is provided at a specific tariff over some period of time. Thus, it seeks to estimate the household's effective demand function for electricity in Ghana. This will provide a means of determining the extent to which different households will pay for electricity at different tariffs over some period of time.

The following section provides some theoretical basis for the study and the research design. The factors which determine specific household responses to electricity tariffs in Ghana are analysed in section 3. A discussion of the results of the survey with respect to how they can be employed to improve electricity delivery policy and planning is provided in section 4. The last section summarizes the findings and concludes with some policy recommendations.

2. Theoretical framework and empirical studies

Demand functions are generated when consumers' utility functions covering N goods are maximized subject to their income constraints. Let D be the quantity of the good a consumer is willing and able to pay for, I being the consumer's income and $P_1, P_2, \ldots, P_N$ being the prices of the N goods. The consumer demand function (D) can then be stated in equation 1.

$$D = M(I, P_1, P_2, \ldots, P_N) \qquad (1)$$

While the quantity demanded of many goods depends on single prices, the electricity demand however depends on a price schedule, due to the block pricing of electricity. This makes the consumer's budget constraint for electricity non-linear. Thus, the consumer's equilibrium regarding electricity demand can theoretically only be determined using mathematical programming and not differential calculus (Taylor, 1975). This study estimates the demand for electricity in Ghana through mathematical programming based on the Contingent Valuation (CV) Model.

The conceptual framework for determining the household's demand for electricity is based on the household's indirect utility relationship (*U*). This is determined by the tariff paid for electricity (*T*), his income (*I*), the prices of all other commodities consumed by the household (*P*), and the tastes (*S*) of the household as depicted by its socio-economic characteristics.

A change in the household's electricity provision from D_1 to D_2 will generate a willingness to pay (WTP) based on equality between two indirect utility functions represented by equation 2.

$$U\ (I_1 - WTP, P, D_2, S) = U\ (I_1, P, D_1, S) \quad (2)$$

This means a household's willingness to pay for electricity is related to the change from D_1 to D_2. This is given as equation 3.

$$WTP = m\ (D_1, D_2, I_1, P, S) \quad (3)$$

The study employed various formulations of demand analysis of willingness to pay (WTP) bids of households for electricity in Ghana. These are namely an Ordinary Least Squares (OLS) formulation, the Interval Regression Model, and an Ordered Logit Model approach. These formulations are theoretically depicted as equations 4, 5, and 6, respectively.

$$WTP = m\ (D_1, D_2, I_1, P, S) + e \quad (4)$$

$$WTP^{lower} < m\ (D_1, D_2, I_1, P, S) + e < WTP^{upper} \quad (5)$$

$$V^{lower} < n\ (D_1, D_2, I_1, P, S) + e < V^{upper} \quad (6)$$

WTP bids are explained by the OLS model in equation 4 where the household willingness to pay for electricity is a point estimate, with e as the error term. WTP responses are estimated as intervals in equation 5 which occur between one of the categories within the low and high starting points (WTP^{lower} and WTP^{upper}) bids. The assumption carried out by equation 5 is that households' preferences for electricity are only depicted as ordered by the responses households provide, that is, V^{lower} being the lower-ranked and V^{upper} being the higher-ranked bids. This means the elicited bids simply indicate that one is higher than the other in rank, not as a numerical quantity. The endpoints represent the WTP endpoints, which are estimated as parameters through the ordered logit model.

Beginning with Houthakker (1951) as a pioneer, several empirical studies have modelled household demand for electricity, providing some analysis of its determinants. Within the past two decades, the works of Alberini and Filippini (2011), Mohammadi (2009), and others estimated household demand for electricity using data aggregation procedures.

The use of disaggregated data made the works of some later researchers more innovative than many earlier ones. Household demand for electricity was studied by Agostini et al. (2014) employing national data from Chile, disaggregated at the household level. The results however were not too different from earlier studies.

Also, co-integration and error correction functions were employed by Fullerton et al. (2015) in a dynamic analysis study of household demand for electricity in Arkansas. They found a positive relationship between household income and demand for electricity due to the long-run effect of electricity-dependent asset acquisition.

Roy and Wolak (2021) estimated a model of household demand for electricity services and electricity demand in the Rajasthan State of India through a combination of household-level surveys and administrative data. Their model incorporated customer-level demographic characteristics, billing cycle-level weather variables, and the fact that households faced increasing block prices of electricity. Their structural demand model helped in comparing the welfare implications of current energy tariffs to those based on normative principles of efficient retail electricity pricing.

In addition, Ye et al. (2018) combined electricity tariff data with South African Income and Expenditure Survey data to explore the determinants of residential electricity demand in South Africa. They found household demand for electricity to be higher among electricity appliance-rich households, households with large family sizes as well as households living in large houses in urban areas.

Athukorala et al. (2019) studying electricity demand in Sri Lank, used survey data over 5 years to determine the effect of policy measures. They found that policy measures that used price changes would not be effective because price changes altered existing subsidies and reversed the objective of the price change. Also, Maboshe et al. (2018) found electricity tariff subsidies to be highly regressive in Zambia. They suggest a first-best response based on raising prices while targeting the vulnerable with social interventions.

3. Research design

This study adopts a quantitative research design based on a household field survey in Ghana. The questionnaire was used to elicit responses from households through face-to-face interactions. The questionnaire was a four-section document, beginning with questions on the demographic and socioeconomic characteristics of households. This was followed by questions on household electricity characteristics and how they assess it. The third section posed questions on how willing households were to pay for electricity. It began with a market description of electricity, after which willingness to pay was elicited through a bidding game procedure. The last section probed further to ascertain whether the respondent had a good concept of the value of electricity. Table 1 shows the descriptions of the variables used and their expected signs.

Questionnaire administration was carried out by 8 interviewers. This lasted for approximately two weeks within a zone. Trained teaching assistants, selected from Kwame Nkrumah University of Science and Technology's Department of Economics in Ghana served as enumerators for the survey alongside the core research team.

Table 1: Variables, their descriptions, and expected signs

Variable	Description	Sign expected
	Household characteristics	
Gender	Male respondent, 1; Female, 0	+
Age	Respondent's age in years	?
Dependents in School	Number of members of household schooling	-
Income	Total income of the head of household per month in Ghana cedis	+
Education	Highest number of years of schooling of household head	+
Water	Monthly expenditure on water	+
Savings	Monthly savings	+
	Electricity use characteristics	
Service Rating	How well the service provider was doing on a scale of 1-5; 1 being the least and 5 being the highest performance.	+
Availability	Average number of hours of electricity in a normal day	+
Usage	Number of appliances used by the household	+
Lighting Needs	Number of electricity bulbs used by the household	?
Commercial	Use of electricity for commercial purposes at home, 1; non-commercial use, 0.	+
Consumption	Monthly electricity consumption in kWh	?
Cost of Power Outage (CPO)	Amount of money spent on lighting during power Outages per day in Ghana cedis.	+
Reason for conserving Electricity (RFEC)	Cost-saving reasons for conserving electricity, 1; Non-cost saving reason, 0.	?
Affordability	Monthly tariff affordable, 1; not affordable, 0.	+
WTP (Dependent Variable)	Amount household is willing to pay for the 24-hour daily provision of reliable electricity in Ghana cedis.	

Source: Authors' construct

3.1. Method

A hypothetical market was constructed, which was described to respondents. This comprised the supply and payment characteristics of electricity services to be provided. The service was a 24-hour supply of electricity a day, through private service providers. The payment was through a pre-payment arrangement. The question to elicit the household's willingness to pay asked how much they were willing to pay for such a service daily. The iterative bidding game procedure was employed to obtain households' maximum bids due to their familiarity with that approach in purchasing goods and services within their communities.

3.2. Sampling procedure

Ghana was divided into 3 zones as an initial stage of the multi-stage sampling approach. The next stage was the selection of regions followed by the selection of districts within the selected regions from the various zones. Probability selection procedures were employed based on the official classification from the 2010 Ghana population census data. The sampling function in the R software (Becker et al., 1988) was used to select communities for the survey. Households were then selected through a systematic sampling from the communities.

Being policy-oriented, the study followed the accepted recommendation for sample size (Garrod and Willis, 2000; Mitchell and Carson, 1989; Arrow et al, 1993). Thus, based on the accuracy of WTP bids being in the range of ten per cent of the actual WTP with a 95% probability of success, the populations of the various communities as well as a reasonable allowance for incomplete responses, a sample size of 3100 households was estimated.

3.3. Reliability of contingent valuation procedure

The Arrow report (1993) guidelines for CV studies were strictly adhered to in the CV procedure. In addition, some suggested procedures in the literature, as well as practical experience from conducting CV studies, were applied as and when necessary.

3.3.1. Protest bids

The NOAA panel report considers nonresponse rates of up to 20% appropriate for a good Contingent Valuation study. The nonresponse rate for this study (including protest bids) was 8.4%. Protest bids constituted 2.3% of the responses. Carson and Hanemann (2005) observed nonresponse bids emanating from respondents protesting payment were dropped during the analysis for some time till recent evidence showed that most of such bids were similar to “no” or “low” responses or amounts from discrete choice and continuous response formats, respectively.

Excluding the protest, bids bring the sample to 3026 (The protest bids were 74, which is 2.3% of the original sample i.e., 3100). Thus, including the protest bids, the overall nonresponse rate becomes 8.4%. This percentage, based on the NOAA guidelines is very good. The NOAA report recommended a nonresponse rate of up to 20% as an acceptable benchmark (Arrow et al., 1993). Thus, the occurring nonresponse rate passed the NOAA test.

3.3.2. Validity

The traditional problem of the CV method has not been undervaluation but overvaluation of benefits yet to be obtained. If consumers want to be crafty, they would say a higher value so that they can be provided with the good (hypothetical bias) from the Independent Power Providers (IPPs). The test for hypothetical bias was done by establishing whether actual payments were consistently lower than the willingness to pay (Blumenschein et al., 2008). This test showed that the study did not have a hypothetical bias.

In Contingent Valuation studies, consistency is determined by assessing whether WTP correlates with income and other socio-economic characteristics of households (Whittington and Pagiola, 2012). In addition, Mitchell and Carson (1989) recommend a test to find out whether respondents will actually pay what they have stated in the hypothetical case for the CV study. Going by the results of the consistency tests, the respondents in this study are very consistent consumers of electricity. They were paying beyond what they were willing and/or able to pay and had their willingness to pay correlate with their incomes and socioeconomic characteristics. Thus, the study passed the CV validity test.

3.3.3. Data cleaning

Responses that were outliers as well as those showing inconsistency and those not fully answered represented about 1.8 per cent of the administered questionnaire. Such responses were discarded. After cleaning the data, the sample size came to 3100. In addition, all protest bids were excluded for the sake of estimating the mean willingness to pay as discussed under the protest bids above. This brought the final sample size to 3026.

3.3.4. Estimation procedure

Mathematical programming was used to estimate the willingness of households to pay for the daily 24-hour supply of electricity to households. This was to provide a demand function for electricity that met the theoretical plausibility criterion described in section 2 above. Here, block tariffs are reliably captured in the demand function, depicting a real and applicable demand relationship specific to electricity. To explain the determinants of the electricity demand function, a standard econometric procedure was employed using the R software framework.

4. Presentation and analysis of results

The cross-tabulation (Table 2) of independent variables against their mean willingness to pay values shows that income, electricity consumption, and educational level of household heads positively related to households' willingness to pay for a day's worth of electricity. Age of household head was also positively related to willingness to pay only up to 55 years, after which it declines. The table also shows that only about 13% of households used electricity for some commercial purpose among households. These relationships show a consistency of the respondents in their choice decisions regarding electricity demand.

Table 2. Household characteristics and willingness to pay cross-tabulation

Variables	Categories	Percentage Frequency	Mean WTP
Age (in years)	Less than 25	9.42	1.8163
	25-35	34.6	1.8518
	35-45	32.32	2.0342
	45-55	14.08	1.8475
	55-65	6.05	1.7252
	65-75	3.54	1.7150
Commercial	Non-commercial	87.05	1.8824
	Commercial	12.95	1.9740
Consumption Group	1.0-50	7.04	1.0510
(In kilowatt hours)	51-150	67.75	1.6971
	151-300	18.9	2.4962
	301-600	5.75	3.0123
	601 and above	0.56	4.5488
Education Level	No Formal Education	11.04	1.5725
	Primary Education	9.22	1.7101
	Junior High Education	28.88	1.7019
	Senior High Education	32.88	1.9753

Variables	Categories	Percentage Frequency	Mean WTP
	Tertiary	17.97	2.5961
Gender	Male	55.58	1.9865
	Female	44.42	1.7789
Income Group	Less than 100	7.04	1.4264
(In Ghana cedis)	100-500	42.99	1.6222
	500-1000	35.96	1.9880
	1000-1500	8.72	2.5700
	1500-2000	2.84	2.9873
	2000-2500	0.59	2.5911
	2500 and above.	1.85	2.7591

4.1 Regression analysis

4.1.1. Determinants of WTP for electricity

Analysis regarding the determinants of WTP for electricity sought to provide insight into the factors which influence household willingness to pay bids significantly. This was carried out through multivariate analysis, to estimate the functional relationship between the factors and WTP bids for households.

4.1.2. Diagnostic tests

To verify the genuineness of the relationships established in our models, a number of diagnostic tests were carried out. A test for multicollinearity based on the Variance Inflation Factor (VIF) showed that the study was free from multicollinearity. The results of the "imtest" and "hottest" showed the presence of heteroskedasticity, which was corrected by using robust standard methods.

The specification tests were also performed. The tests for bias in the specification of the WTP model revealed the presence of specification errors. This was corrected by the inclusion of the squares of consumption and income in the model.

4.1.3. Regression results

Tables 3, 4 and 5 show results for two different model specifications of 3 estimators. These estimators are the OLS, the interval regression, and the ordered logit models. For each estimator, the 2 different specifications are, first, an estimation comprising of the full list of explanatory variables used in the survey and secondly, the estimation comprising of a restricted list of explanatory variables. The use of this approach demonstrates the sensitivity of the model to specification variations. Thus, in all, the results show six different formulations, giving consistent results and thereby attesting to the robustness of the WTP model.

Table 3. Ordinary least squares regression results

WTP	Coefficient	Robust Std. Error	P-value	Coefficient	Robust Std. Error	P-value
Constant	0.0771748	0.1480016	0.6020	0.109701	0.1292284	0.3960
Gender	0.0873714	0.0448805	0.0520			
Age	-0.006832	0.0019599	0.0000	-0.007577	0.0018802	0.0000
Dep. in School	-0.013763	0.0129226	0.2870			
Income	0.0004223	0.0000961	0.0000	0.0004457	0.000091	0.0000
Income Square	-8.25E-08	1.98E-08	0.0000	-7.93E-08	1.98E-08	0.0000
Availability	0.1236508	0.0344266	0.0000	0.1236347	0.0330387	0.0000
Affordability	0.3941598	0.054832	0.0000	0.4036548	0.0547434	0.0000
CPO	0.0252554	0.0065544	0.0000	0.0258436	0.0064529	0.0000
Service Rating	0.0102978	0.0199838	0.6060			
Education	-0.002737	0.0054151	0.6130			
Usage	0.110607	0.0181213	0.0000	0.1136247	0.0171172	0.0000
Lighting Needs	0.0024128	0.0005096	0.0000	0.0024368	0.0005028	0.0000
Commercial	0.0072363	0.0732638	0.9210			
Consumption	0.0076241	0.0008466	0.0000	0.0074998	0.0008356	0.0000
Cons. Squared	-6.35E-06	1.69E-06	0.0000	-6.17E-06	1.68E-06	0.0000
RFEC	-0.036341	0.053446	0.4970			
Water	0.0000728	0.0002816	0.7960			
Savings	0.0002625	0.0001782	0.1410			
Observations		=	3,026		=	3,026
F (18, 3007)		=	41.39		=	72.42
P-value		=	0.0000		=	0.0000
R-squared		=	0.2545		=	0.2522
Root MSE		=	1.1832		=	1.1834

Table 4. Results for interval regression

WTP	Coefficient	Robust Std. Error	P-value	Coefficient	Robust Std. Error	P-value
Constant	-0.045193	0.1347114	0.7370	-0.011495	0.1166189	0.9210
Gender	0.0767941	0.041029	0.0610			
Age	-0.005724	0.0018092	0.0020	-0.006485	0.0017149	0.0000
Dep. in School	-0.011807	0.0114613	0.3030			
Income	0.0003854	0.0000867	0.0000	0.0004125	0.0000833	0.0000
Income Square	-7.67E-08	1.88E-08	0.0000	-7.36E-08	1.89E-08	0.0000
Availability	0.1218913	0.031395	0.0000	0.1224283	0.0302793	0.0000
Affordability	0.385214	0.0508892	0.0000	0.3938564	0.0508344	0.0000
CPO	0.0261087	0.0062836	0.0000	0.0266442	0.0061846	0.0000
Service Rating	0.0123334	0.0186975	0.5090			
Education	-0.002188	0.0049873	0.6610			
Usage	0.1093515	0.0165347	0.0000	0.1132774	0.0156488	0.0000
Lighting Needs	0.0022409	0.0004125	0.0000	0.0022673	0.0004068	0.0000
Commercial	-0.015901	0.0661765	0.8100			
Consumption	0.0075203	0.0007173	0.0000	0.0073913	0.0007105	0.0000
Cons. Squared	-6.59E-06	1.31E-06	0.0000	-6.40E-06	1.30E-06	0.0000
RFEC	-0.039322	0.0488802	0.4210			
Water	0.0000461	0.0002541	0.8560			
Savings	0.0002917	0.0001641	0.0760			
/lnsigma	0.0707794	0.0228003	0.002	0.0726228	0.0227346	0.001
sigma	1.073344	0.0244726	1.026435	1.075325	0.0244471	1.028461
Observations			3026			3026
	Wald $Chi^2(18)$		865.67			849.91
P-value			0.0000			0.0000

The results from all three estimators being consistent for all variables also show the reliability of the WTP model. Affordability of tariffs, availability of electricity, age and income of household head, cost of a power outage, the type of usage of electricity, household consumption of electricity, and the lighting needs of households were all found to be statistically significant determinants of WTP for electricity in Ghana. Each of these explanatory variables positively influenced WTP except for the age of the household head.

Table 5. Ordered logit regression results

WTP	Coefficients	Robust Std. Error	P-value	Coefficients	Robust Std. Error	P-value
Gender	0.1211456	0.0669651	0.0700			
Age	-0.0075368	0.0030302	0.0130	-0.0081176	0.0028787	0.0050
Dep. in School	-0.0129805	0.0180699	0.4730			
Income	0.0005414	0.0001386	0.0000	0.0005508	0.0001346	0.0000
Income Square	-1.26E-07	3.33E-08	0.0000	-1.28E-07	3.27E-08	0.0000
Availability	0.1894963	0.0515734	0.0000	0.1775688	0.0491913	0.0000
Affordability	0.6390285	0.0859161	0.0000	0.6478134	0.0859824	0.0000
CPO	0.0313304	0.0084591	0.0000	0.0326597	0.0083232	0.0000
Service Rating	-0.0150711	0.0312928	0.6300			
Education	-0.0012171	0.0085463	0.8870			
Usage	0.2557675	0.0292212	0.0000	0.2527533	0.0280526	0.0000
Lighting Needs	0.003262	0.0005648	0.0000	0.0033362	0.0005561	0.0000
Commercial	-0.13543	0.1075959	0.2080			
Consumption	0.0153953	0.0011538	0.0000	0.0151853	0.0011528	0.0000
Cons. Squared	-0.0000162	1.82E-06	0.0000	-0.0000161	1.85E-06	0.0000
RFEC	0.012574	0.0813491	0.8770			
Water	0.0000552	0.0004457	0.9020			
Savings	0.0006844	0.0002329	0.0030	0.0007305	0.0002315	0.0020
Observations			3026			3026
Wald $Chi^2(18)$			876.71			867.68
P-value			0.0000			0.0000
Pseudo R^2			0.0846			0.0841

In addition, the explanatory variables which were statistically not significant were the educational level and gender of the household head, the number of dependents in school, and the way a household rates the current electricity service. Also, whether a household used electricity for some commercial purpose, the reason for which the household conserves electricity, and the amount of money paid as a water bill by the household was not statistically significant in determining WTP. The WTP model is shown to be statistically significant with an F-statistic of 41.39. An R^2 of 0.2545 meets the standard of reliability based on the expected R^2 for CV studies. Whittington (1992) and Mitchell and Carson (1989) established the standard as a minimum R^2 of 0.15 for CV studies.

4.2. Highest-impact variables

The three significant independent variables with the consistently largest effects on willingness to pay for electricity in each of the models provide a very direct economic explanation relevant to policy. These variables were affordability of tariffs (0.64), usage of electrical appliances (0.25), and availability of electricity (0.19) respectively.

Households for whom the monthly tariff was affordable made higher bids than those for whom the monthly tariff was not affordable. Also, households who were better assured of getting electricity in a day made higher bids than those who were less certain whether they would get electricity in a day. In addition, households that used more electrical appliances made higher bids than those that use fewer electrical appliances.

The implication here is that if electricity is made more affordable by tariff reduction it would attract more usage if only its availability can be guaranteed. This would lead to the demand for more electrical appliances which could eventually lead to increased productive use of electricity and then the output of goods and services.

The other explanatory variables that were consistently statistically significant in all the models were the cost of a power outage, the amount of electricity consumed, the age of the household head, the lighting needs of the household, and household income, respectively. Even though these variables were statistically significant, the strength of their coefficients was too weak compared to the first three. Thus, even though significant, household income consistently had the least effect on households' willingness to pay for electricity compared to all the other explanatory variables in all the models.

4.3. Estimating WTP

Computations leading to the estimation of the mean WTP for a day's worth of electricity are provided in Table 6 as explained below. The population in the various WTP intervals (column 3) is obtained by multiplying the sample frequency (column 2) by households that have access to electricity, which is 3509901. Also, the total WTP (column 4) is obtained by multiplying the WTP midpoint for each WTP interval (column 1) by the interval's population (column 3). Thus, the total WTP per day for electricity becomes 5, 905,671.68 Ghana cedis (total of column 4) depicted by the area under the daily demand for electricity curve. This brings the mean WTP for a day's worth of electricity in Ghana to 1.68 Ghana cedis, (that is 5,905671.68

divided by 3509901). This amounts to a monthly mean willingness to pay for electricity of 50.40 Ghana cedis (US$11.56).

Table 6: Total willingness to pay for electricity in Ghana

WTP interval Midpoint	WTP Frequency Distribution (%)	Population	Total WTP for Electricity	Cumulative Population
0.25	14.04	492790	123197.53	3509901
0.75	21.78	764456	573342.33	3017111
1.25	13.38	469625	587030.94	2252654
1.75	24.75	868700	1520225.87	1783030
2.25	6.61	232004	522010.03	914329
2.75	8.2	287812	791482.68	682325
3.25	2.08	73006	237269.31	394513
3.75	2.97	104244	390915.22	321507
4.25	0.3	10530	44751.24	217263
4.75	4.36	153032	726900.50	206733
5.25	0.07	2457	12898.89	53701
5.75	0.43	15093	86782.30	51245
6.75	0.3	10530	71075.50	36152
8.5	0.73	25622	217789.36	25622
	100	3509901	5905671.68	

Source: Authors' construct

5. Discussion of findings and policy implications

5.1. Affordability of tariffs

The order in which affordability and availability of electrical work is of great importance to get the demand relationship right. If governments are bent on ensuring availability at all costs, they may enter into agreements with investors to supply electricity at a very high cost. This will work against the electricity demand, causing underutilization of the capacity created through the agreements. This is due to the strength of the affordability effect. The relative strengths of the highest impact variables are affordability of tariffs (0.64), usage of electrical appliances (0.25), and availability of electricity (0.19) respectively. It is worth noting that the affordability effect (0.64) is more than three times greater than the availability effect (0.19).

Here an increase in affordability of one unit will increase demand by 1.08 units (i.e., 0.64 + 0.25 + 0.19), where availability comes only after affordability, to complement the role of affordability and induce usage of electricity through households purchasing electrical appliances. This effect tends to exceed the unit change in affordability that caused it, making the gain higher than any reduction in tariff that would cause electricity to be affordable. Thus, a multiplier effect is produced on demand for electricity if affordability becomes the most important consideration.

If on the other hand affordability is compromised, making availability the most important consideration, then the order is broken, making the affordability effect work against the availability effect (0.19 – 0.64), reducing effective demand by 0.45 units for a unit increase in availability. This dampens the electricity demand.

In addition, affordability decisions must be guided by the mean WTP. The monthly mean WTP of 50.40 Ghana cedis is lower than the average monthly tariff of 73.67 Ghana cedis paid by households. Thus, the average tariff paid by households monthly is 46% higher than the mean WTP. This implies that to achieve optimal affordability of household electricity tariffs; household incomes must be increased to the extent that they can pay 46% higher than they are willing to pay without any loss in welfare. If incomes remain the same, then existing tariffs must be reduced by at least 46%. About 87% of the households consumed between 51 and 300 units of electricity in a month. From the PURC (2020) block tariff chart, a household consuming 300 units pays a total of 203.71 Ghana cedis per month. To make tariffs affordable, households consuming 300 units of electricity should enjoy income increases to offset the difference between what they are willing to pay and what they are actually paying. If incomes remain unchanged, then a 46% reduction in tariff, which is 93.72 Ghana cedis per household monthly will be required.

If the government decides to subsidize tariffs for these consumers, then it would need to pay 93.72 Ghana cedis per household for the households every month. Even in the case of households willing to pay the modal monthly bid tariff of 52.50 Ghana cedis, a 40.3% reduction in current tariffs is required to reach affordable levels. This set of households would require a subsidy of at least 82.1 Ghana cedis per household each month, amounting to at least 71.3 million Ghana cedis per month, making 855.6 million Ghana cedis (about US$196.24 million) per annum. This subsidy just covers about 25% of the households. It is worth noting that 49.6% of households who were willing to pay less than the modal bid value would require a higher subsidy.

It is also worth noting that whether incomes are increased or subsidies are provided, it will pay off in the long term since the additional income would induce some expenditure on electrical appliances, which would result in increased households' electricity demand. The only situation under which household welfare will be worsened is when the government does nothing about the unaffordable tariffs.

5.2. Affordability and current tariff payments

A discussion of affordability and current tariff payments is relevant for consumers whose current tariffs were higher than their average willingness to pay. Theoretically, this is possible because tariffs have been determined solely from the supply side, breaching the normal economic principle. If the tariff is to be a price, it must be determined by the interaction of demand and supply. However, this is not the case here; the cost of production and supply is rather imposed on consumers as a tariff. Thus, in economic theory, the tariff here does not qualify to be the price. Practically this has been the case because the Ghana Energy Commission recognized the very high rate of increase in tariffs, sending Ghana from a low tariff category to one of the highest in the world (Ghana Energy Commission, 2015).

End-User Tariffs in Ghana have been raised by over 593.6% between 2006 and 2015 (Ghana Energy Commission, 2016) while incomes have increased in the neighbourhood by 250%. This has increased the proportion of households' incomes that are paid for electricity, thereby reducing the welfare of consumers. It is absolutely rational for a consumer being impoverished by a commodity to decline to pay beyond a reasonable tariff, based on the proportion of his/her income being taken by the commodity, particularly if the consumer has a substitute to fall on, as the case is in Ghana.

A tariff determined solely by the cost of production is not worth being called a price! It is purely cost, and cost does not determine willingness to pay, since the cost is from the supply side. This creates a big gap between required payments (bills) and consumers' WTP. Empirical evidence from some studies on consumers of utilities whose average WTP was effectively lower than what they were currently paying as tariffs are provided in the following paragraphs.

Lee et al. (2016) in their Kenya study found the following. After a valuation experiment, households were asked whether they had made some sacrifices due to the payments they had to make for electricity. About 29% of the households had to forgo some basic consumer goods, while about 19% of them had to skip payment of outstanding school fees for their children.

If a household has to sacrifice children's school fees to pay for electricity, that household simply does not have what it takes to pay what it is currently paying. So, given the opportunity, this household expresses its true value for electricity in a WTP lower than the payment made.

A study on Rwanda published by the Center for the Study of African Economies, University of Oxford, in 2016, found the average WTP for electricity to be far below market price (bills) (i.e., 40-50% of the market price) and changed only marginally even with a credit scheme. It was evident that households might have been facing binding budget constraints that do not allow them to spend on electricity. Here the households revealed WTP were between 20%-30% of their monthly expenditures. The conclusion was that the vast majority of households were not able to pay cost-covering prices. This means there was no effective demand for electricity.

Taale and Kyeremeh (2015) found that in Cape Coast, Ghana 244 households (25.7% of their sample) were not willing to pay for improved electricity services. Over 26% of respondents in this category responded that current tariffs were already too high.

In their Anambra State Study, Whittington et al. (1990) found that WTP values were systematically related to income and socio-demographic variables, but were very low, and the perplexing result was that it was far lower than what households were already paying as tariffs to obtain the water they were consuming.

Based on this finding and another similar one, the World Bank (1993) recommended the categorization of demand for water utilities to include areas where residents were willing to pay for improved service but not able to pay and where WTP was very low relative to the cost of provision of the utility service. As a matter of fact, these are the realities on the ground. Any attempt to ignore these consumers or to revise their valuation upwards would result in a policy that will backfire.

It might appear that a large percentage of Ghanaians are paying electricity bills. However, bill non-payments for electricity in Ghana are one of the main difficulties the electricity sector faces in the country.

5.3. Future expectations and installations and gadget investments

Consumers who have already invested in the connections for electricity supply and purchased gadgets over the periods when tariffs were good may be compelled to continue paying unaffordable tariffs (McNeil and Letschert, 2005). Thus, consumers feel compelled to continue consuming some electricity and therefore have to pay something, hoping that things may get better someday when they can get higher incomes, to offset the welfare effect of current payments.

The above is based on the premise that even the government of Ghana believes tariffs are too high for most consumers; this explains why the subsidies are paid to consumers. A proposal of the Government of Ghana, to the PURC in the 2018 Budget Statement, for a 13% reduction in residential electricity tariffs vindicated the respondents. The government explained that from all its calculations, it was realized that consumers were being overcharged for electricity, hence the request for reductions. The Minister for Finance in the previous government (Mr. Seth Terkper), commended the government for the reductions in an interview on Metro TV's "Good Evening Ghana" on Wednesday, 16th November 2017 (also captured by the Daily Graphic of 20th November 2017). This shows that for quite a long time, even state authorities had been looking for some opportunity to reduce tariffs, to reduce the economic burden of consumers.

5.4. Power theft, payment defaults, and illegal connections

Customer non-payment of electricity bills has for some time been a serious problem for the Electricity Company of Ghana. This has been accompanied by so many illegalities in the household electricity sector for about a decade now. For instance, in Accra, the Accra West Region of the Electricity Company of Ghana (ECG) was reported to be losing about 3.9 million Ghana cedis per annum due to illegal connections (GNA, 2021).

In 2017, the ECG was to retrieve about GHS2.89 million being illegally used electricity from the nation's grid by 464 households through meter bypass theft of electricity in Accra. This illegality was detected through ECG monitoring of 108,896 consumers that year. It was also found that about 17% of consumers were involved in illegal electricity activities. About 85 of them had carried out unauthorized service connections, while 156 households had altered the settings of their meters, with 3 households connecting directly to the grid illegally. Too many consumers were still not paying their bills even after disconnection, and court action was being considered by the ECG (Bonney, 2017).

5.5. Availability versus affordability

The move to ensure the availability of electricity without affordability considerations has landed Ghana in a quagmire of electricity sector debt. As of 2019, Ghana had about 4,600 MW of dependable capacity to generate electricity, which was about 70% more than the peak demand load. The country had to pay about US$500 million yearly for electricity generation capacity which was not being used, due to the nature of contracts with independent private power producers (IMF, 2019; 2021).

One result of the excess capacity coupled with inefficiency has been lower economic welfare. By late 2018, Ghana had unsettled arrears of about US$2.7billion, comprising US$880million indebtedness to suppliers of fuel and private power plants. The country's own projection of the electricity sector shortfall in financing in 2019 was a minimum of US$ 1 billion, which amounted to about 1.5% of GDP. In terms of government cost accumulation which includes current arrears, the estimate is US$12.5billion by 2023 as a result of structural deficits in the sector and costly contracts with effect from 2020 (IMF, 2019; 2021).

Even in the midst of excess electricity generation capacity, the lack of reliability of supply has further worsened uptake. ECREEE (2019) and Blimpo et al. (2019) have reported that Ghana's electricity service is not always reliable. The ECG and GRIDCO have always blamed technical challenges for most of the power outages occurring (Daily Graphic, 2021). Electricity unreliability has a two-way effect on tariffs and tax revenues for the government. First, it dampens the incentive of citizens to pay tariffs and taxes. Secondly, frequent and unplanned power outages would lead to lower output than expected resulting in lower tax revenues and tariffs.

The regression results show that putting availability first will not provide an escape from acute electricity problems, since it breaks the order of flow of impact depicted by the relative strengths of the coefficients. The Ghanaian situation amply illustrates the error in giving preference to availability over and above affordability.

5.6. Uses of electricity

Increasing electricity usage by way of using more electrical appliances has a positive impact on electricity demand, as shown by the regression results. Again, this must come in the right order, where affordability is given priority followed by usage and then availability. Thus, if electricity tariffs are affordable and electricity is available, then consumers will purchase more electrical appliances and then create electricity demand. If the order is altered, however, the effect of the transmission mechanism will be curtailed. The ability of consumers to purchase electrical appliances will depend on their incomes, the prices of the appliances and the availability of credit or hire purchase schemes. The usage of electricity will tend to have a positive effect on output growth and economic growth eventually.

However, the problem with Ghana's electricity consumers with respect to output growth is that most household consumption is for nonproductive purposes. The WTP expressed was the demand for electricity based on what consumers perceive electricity to be, apart from the known household uses. Since a majority of households (70%) use electricity mainly for noncommercial purposes, it means that a large percentage of Ghanaians do not have the right information about the best uses of electricity. When electricity is perceived as a means for leisure and pleasure derived through entertainment and lighting, it will cease to influence output and economic growth significantly, even with 100% access.

6. Conclusion and recommendations for policy

This study sought to assess the factors that determine the demand for electricity in Ghana and how these factors could be harnessed to inform energy policy for inclusive growth. For many years African governments and development partners have hoped that increasing electricity availability would create effective demand for electricity, leading to increased growth. However, several efforts at providing electricity to households have not received the expected response in Ghana. This has led to excessive indebtedness of the state electricity service providers as well as the government (IMF, 2019; 2021). Evidently, there is so much that is not known about the factors which determine the demand for electricity in Ghana.

The study, therefore, used a national survey of over 3000 households to derive an effective demand function for electricity in Ghana through a Contingent Valuation approach. It also assesses the determinants of electricity demand and estimates the mean willingness to pay for electricity by households in Ghana.

The study found that Ghanaian households are willing to pay a monthly mean of 50.40 Ghana cedis (US$11.56) for electricity. This is lower than the average monthly tariff of 73.67 Ghana cedis (US$16.90) paid by households. Thus, the average tariff paid by households monthly is 46% higher than the mean WTP.

The study also found that the highest impact determinants of demand for electricity in Ghana are affordability of tariffs, usage of electrical appliances, and availability of electricity, respectively. Furthermore, the study found that most households in Ghana demand electricity primarily for non-commercial purposes. Thus, the demand for electricity in Ghana is mainly for non-income generation uses.

It is recommended that the incomes of poor households should be increased to the extent that, it will compensate for their income loss due to expenditures on electricity tariffs, created by the difference between their mean willingness to pay and their actual payments for electricity. This would go a long way in improving household welfare. The increase in incomes could also empower several households to acquire more electrical appliances and demand more electricity for increased economic output.

If incomes remain unchanged, then tariffs will have to be subsidized by at least 46% for consumers of electricity who spend more than 10% of their incomes on electricity, in order not to make them economically worse off for using electricity.

It is also recommended that electricity service providers prioritize the affordability of tariffs over and above the availability of electricity since the strength of affordability as a determinant of electricity demand generates a multiplier effect for household electricity demand in Ghana.

In addition, the government of Ghana would need to embark on an intensive educational campaign to educate households on the most productive uses of electricity. This will go a long way to help change the attitude of households toward electricity such as mostly for pleasure, leisure, and entertainment toward more productive uses. Since energy is the ability to do work, if electricity provided is not put to productive and commercial use, the needed growth in national output cannot be attained to break the vicious circle of household poverty in Ghana.

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