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WILLINGNESS TO PAY FOR IMPROVED ELECTRICITY SERVICES IN SENEGAL: HOUSEHOLDS AND BUSINESSES ESTIMATES USING CONTINGENT VALUATION SURVEYS WITH MULTIPLE BIDS

Task B: Support in Assessing the Economic Benefit and Willingness to Pay for Improved Electricity Services in Senegal

Miguel Almanzar* and John Ulimwengu**

*Miguel Almanzar is an Associate Research Fellow in the Markets, Trade and Institutions Division – MTID at IFPRI (m.almanzar@cgiar.org)
**John Ulimwengu is a Senior Research Fellow in West and Central Africa Office – WCAO at IFPRI and based in Washington, DC.

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Willingness to Pay for Improved Electricity Services in Senegal: Households and Businesses Estimates Using Contingent Valuation Surveys with Multiple Bids

Abstract

The objective of this study is to estimate the willingness to pay (WTP) for improved electricity services and the factors influencing WTP for reliable electricity in Senegal's residential and business sectors.

Stated WTP is estimated using the contingent valuation (CV) method with a multiple bid, discrete choice elicitation game. The CV game involves two differing scenarios for connected and nonconnected households. In addition, an anchored bidding game is used to estimate WTP for improvements in two attributes of electricity services: outages and low voltages. We estimate WTP using data from three surveys implemented in Senegal in 2018 for this purpose: a survey of 2,846 households, both connected and nonconnected, that are nationally representative of the 14 regions of the country; a survey of 866 informal businesses; and a survey of 206 formal businesses – both of which are nationally representative of Senegal's economic sectors.

WTP for improved electricity supply in Senegal – that is, electricity available 24 hours per day and 7 days per week without outages and stable power or voltages – is 27 USD every two months for men and 23 USD for women in nonconnected households. For the connected household sample, maximum WTP for men is 37.79 USD and 38.18 USD for women billed every two months. The differences in WTP across gender are not statistically significant. The hypothetical electricity consumption data for nonconnected households imply that on average the maximum WTP per kWh is 0.31 USD for men and 0.22 USD for women. The previous electricity consumption data for connected households imply that on average the maximum WTP per kWh is 0.24 USD for men and 0.22 USD for women. The median is estimated at 0.20 USD per kilowatt hour (kWh) for both men and women.

Men's WTP to avoid the cost of outages and decrease them to one-half of their current levels is only 81 percent of their maximum WTP and they break even when compared with their current electricity expenditures; this implies that men are not willing to pay more than their current bill for a decrease in outages. Women's WTP for this improved level of service is only 80 percent of their maximum WTP for 24/7 service, and 95 percent when compared with their current electricity bill; this implies that not only are women not willing to pay more than their current bill for this decrease in outages, they also need to be compensated with a 5 percent discount. In addition, we calculate WTP for decreasing the number of low voltages to one-half of their current levels. WTP for this improved level of service is 78 percent and 77 percent of maximum WTP for 24/7 service for men and women, respectively. When compared to their current bill, WTP is 96 percent for men and 91 percent for women, implying that decreases in the number of low voltages are less valuable than the decreases in outages and that respondents' choices reveal they are overpaying given their preferences.

Nonconnected informal businesses' maximum WTP for the initial connection fee is 33 USD. Connected informal businesses' maximum WTP is 80 USD billed every two months, below their current average bill of 145 USD. Connected formal businesses' maximum WTP is 456 USD, below their current average bill of 803 USD. The estimates imply (1) that businesses' WTP is below their current costs, and (2) a price per kWh of 0.47 USD and 0.35 USD for informal and formal businesses, respectively.

Statistical tests on the WTP measure based on economic theory show that respondents understood the CV scenarios and the bidding game.

*Miguel Almanzar is an Associate Research Fellow in the Markets, Trade and Institutions Division – MTID at IFPRI (m.almanzar@cgiar.org)
**John Ulimwengu is a Senior Research Fellow in West and Central Africa Office – WCAO at IFPRI and based in Washington, DC.

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Millennium Challenge Corporation Contact:

Francis Mulangu, Department of Policy and Evaluation, Millennium Challenge Corporation,
1099 14th Street NW suite 700, Washington DC 20005
mulangufm@mcc.gov

IFPRI Contacts:

Miguel Almanzar, International Food Policy Research Institute
1201 Eye Street NW, Washington, DC 20005
m.almanzar@cgiar.org

John Ulimwengu, International Food Policy Research Institute
1201 Eye Street NW, Washington, DC 20005
j.ulimwengu@cgiar.org

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Acronyms and Abbreviations

24/7	Twenty-four hours per day, seven days per week
ANSD	*Agence Nationale de la Statistique et de la Démographie*
CAPI	Computer assisted in-person interview
CDF	Cumulative distribution function
CFA	West African CFA franc
CV	Contingent valuation
ICDF	Inverse Cumulative distribution function
kWh	Kilowatt hour
MCC	Millennium Challenge Corporation
USD	United States dollar
WTP	Willingness to pay

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1 Introduction

Electricity is fundamental to economic and human development. In 2016, 12.6 percent of the world population, or 0.95 billion people, lacked access to electricity at home (WDI 2016). Households with no access to electricity have fewer hours of the day when they can be productive, use illumination or energy sources that can be prejudicial to their health, lack adequate refrigeration technologies, and are less able to store food safely. In addition, the lack of electricity and the relatively high costs of operating electronics and tools without a reliable source limit their productive capacity through their access to information and ability to communicate (cellphones, radios, etc.), and through limitations and constraints of traditional technologies (manual water pumps).

Access to electricity could unleash a series of changes in all these dimensions. Some recent evidence suggests that electricity may increase women's labor supply (Dinkelman 2011; Grogan and Sadanand 2013) and improve educational outcomes, consumption, and income (Khandker, Barnes, and Samad 2009; Khandker et al. 2009; Khandker et al. 2013; van de Walle et al. 2013), and improve health outcomes through indoor air pollution decreases (Barron and Torero 2017). However, other studies find no impacts beyond lighting (Bernard and Torero 2015; Bensch, Kluve, and Peters 2011).

Electricity complementarities to other infrastructure and human capital also increase the returns to investment in this sector. Better illuminated and equipped schools improved education services for youth and allow the incorporation of nontraditional students through ICT (information and communication technologies) and different working hours; healthcare centers with electronic equipment that can be reliably powered through the electricity grid promote a healthier population.

Developing economies often have an energy sector that is underutilized, lacks generating capacity, or lacks coverage outside urban centers. The Senegalese population's access to electricity has steadily increased. The World Development Indicators show that in 2016 64.5 percent of Senegal's population had access to electricity compared to 47.1 percent in 2005. Electrification in rural areas increased from 15.8 percent to 38.3 percent in the same period, the slower growth reflecting the limitations of existing infrastructure (WDI 2016). The supply of electricity has improved due to refurbishment of existing plants and an increase in independent suppliers. Rural electrification is based on concessions whereby 10 rural electrification concession areas can be awarded to private operators in a competitive auction; as of 2019, 6 of the 10 concessions have been awarded (CRSE 2017).

The high cost of energy and low access to electricity are major factors binding private investment, industry competitiveness, economic growth, and poverty reduction. The cost of electricity is high in Senegal compared to the region and this affects the budget of households throughout the country. The average electricity tariff in Senegal in 2016 was 0.24 USD per kWh compared to the global average of approximately 0.10 USD per kWh. The average electricity tariff is well above that of others in the region, such as Nigeria (0.09 USD per kWh), Ghana (0.11 USD per kWh), and Côte d'Ivoire (0.13 USD per kWh) (World Bank 2016).

To promote economic growth the Government of Senegal, through the *Unité pour la Formulation et Coordination d'un Second Compact MCA-Senegal* (hereafter UFC-MCA), decided to focus resources on the electricity sector for its second compact with the Millennium Challenge Corporation (MCC). This second compact aims to modernize the transmission and distribution network, and improve the efficiency and effectiveness of the energy sector through three projects (MCC 2018):

(1) *Modernizing and Strengthening of SENELEC Transmission Network Project*, to strengthen and increase the reliability of Senegal's high-voltage transmission network in and around Dakar, the country's capital, and improve service delivery throughout the country. The compact supports the utility, SENELEC, in reducing high production costs, facilitating private sector investment in generation, and increasing the reliability of electricity for consumers.

(2) The *Increasing Access to Electricity in Rural and Peri-Urban Areas Project*, to extend and

reinforce the electrical grid in selected rural and peri-urban areas in Senegal's south and center regions, which have high economic potential but low connection rates. The project will also help residents and businesses connect to the grid and access electrical equipment.

(3) The *Power Sector Enabling Environment and Capacity Development Project,* to strengthen laws, policies, and regulations governing the power sector as well as the institutions responsible for implementing them to support long-term economic progress.

Often, no pre-existing data are available on consumer demand for quality improvements in electricity service, so policymakers rely on stated preference surveys (also called willingness to pay [hereafter WTP] surveys) to understand and estimate consumer demand for improved services. A limitation of stated preference surveys is that demand can be overestimated because of the hypothetical nature of the survey. Such an error can trigger a spiral of activities that lead to a negative impact on public and private investments in the energy sector – that is, lower than expected demand hurts the financial viability of utilities, leading to insufficient revenues, which causes inadequate maintenance and poor service, which further lowers demand for service, and so on. Often overestimates arise because of misinterpretation of concepts and incomplete and inappropriate use of the data from such surveys (Pattanayak et al. 2006). To characterize the consumer demand for electricity service quality improvements, we use a household and business survey contracted by the MCC and implemented by SMJ Data in March 2018 for this purpose. The surveys aimed to interview: 3,000 households nationally representative of the 14 (administrative) geographic regions of Senegal; and 200 formal and 800 informal[1] businesses nationally representative of Senegal's economic sectors. The fieldwork resulted in: 2,846 households visited, of which 2,775 were successfully interviewed; 866 informal businesses visited, of which 814 were successfully interviewed; and 206 formal businesses visited, of which 194 were successfully interviewed.[2]

This paper estimates the demand for improved electricity services among households and businesses in Senegal by estimating WTP through a multiple bid game of stated preferences. The sample and game were designed to estimate the valuation or WTP of men and women in the same household across the 14 regions of Senegal, and of informal and formal businesses across the country's economic sectors. The estimates gauge the incremental value of providing electricity services 24 hours per day, 7 days per week (24/7), without outages, interruptions, or low voltages from (1) the status quo level of service for connected households and businesses, and (2) a no-electricity initial condition for households not connected to the grid or those outside the zones where electricity is available. In addition, we estimate WTP for different levels of improvements by changing the attributes of electricity services in sequential bidding games. Namely, we proposed contingent valuation (CV) scenarios with one-half of the outages or one-half of the low voltages that respondents currently experience. We then compare WTP for these different levels of service to respondents' current electricity costs and to their maximum WTP for improved 24/7 electricity services. The household sample provides intrahousehold estimates that allow us to measure differences in demand across gender. In the business sample, we measure differences across formal and informal businesses in Senegal. The estimates allow policymakers and stakeholders to compare the value and cost per unit of electricity service used in their cost-benefit analyses to evaluate projects with goals to expand electrification in Senegal. Indeed, MCC used the WTP estimates from these surveys to estimate the economic rate of return of its planned investments in Senegal.

We find that the maximum WTP for access to improved 24/7 electricity in Senegal is 27 USD every two months for men and 23 USD for women in nonconnected households. For the connected household sample, maximum WTP for men is 37.79 USD and 38.18 USD for women, billed every two months. The differences in WTP across gender are not statistically significant. Using hypothetical electricity consumption data for nonconnected households, we estimate that on average the maximum WTP per kWh is 0.31 USD for men and 0.22 USD for women. For connected households, we use their last

[1] Firms that do not use formal accounting and bookkeeping practices.

[2] The business surveys had a list of replacement businesses in case an initially selected business was no longer active. This is why more businesses than the target number were visited.

electricity consumption data (from the bill) and estimate that on average the maximum WTP per kWh is 0.24 USD for men and 0.22 USD for women. These estimates are similar to the current costs in the country and suggest that ample residual demand exists for prices above the 0.10 USD average in the region, such that improvements in the system's efficiency would find many customers willing to connect.

Men's WTP to avoid the cost of outages and decrease them to one-half of their current levels is only 81 percent of their maximum WTP, and they break even when compared with their current electricity expenditures; this implies that men are not willing to pay more than their current bill for a decrease in outages. Women's WTP for this improved level of service is only 80 percent of their maximum WTP for 24/7, and 95 percent when compared with their current electricity bill; this implies that not only are women not willing to pay more than their current bill for this decrease in outages, they also need to be compensated with a 5 percent discount. WTP for an improvement in service by decreasing the number of low voltages to one-half of their current levels is only 78 percent and 77 percent of maximum WTP for 24/7 service for men and women, respectively. When compared to their current bill, WTP is 96 percent for men and 91 percent for women, implying that decreases in the number of low voltages are less valuable than the decreases in outages; and their choices reveal they are overpaying given their preferences.

For nonconnected informal businesses, the maximum WTP for the initial connection fee is 33 USD, billed every two months. For connected informal businesses, the maximum WTP is 80 USD, billed every two months, below their current average bill of 145 USD. Connected formal businesses' maximum WTP is 456 USD, below their current average bill of 803 USD. The estimates imply that businesses' WTP is below their current costs.

The rest of the paper is organized as follows. Section 2 discusses the data sources and presents the details of the survey design. Section 3 describes the CV elicitation methods and the bidding games implemented. Section 4 presents a descriptive analysis of the characteristics of households and businesses in the sample, followed by analysis of the WTP data for improved electricity services, and for improvements in the frequency of outages and low voltages. Section 5 presents some conclusions.

2 Data Sources

To assess the economic benefit of and WTP for improved electricity services, three comprehensive surveys were undertaken: one for households in rural and urban areas, a second one for informal businesses, and a third one for formal businesses in these areas. The data collected from these households and businesses illustrate preferences for reliable and improved electricity services, respondents' views about their current services, and the constraints current services pose.

2.1 Survey Design and Implementation

The survey questionnaire was developed through a series of focus groups, several discussions with households and government officials, and previously implemented questionnaires in the West Africa region. The final survey comprised various modules, including a sample design of the CV component to gauge differences in household demand for a male and a female respondent in the same household.

These conversations led to the description of the service as providing: (1) 24-hour service with good no outage or low voltage situations, 7 days per week, (2) prompt repairs and efficient customer service (that would satisfy in general), and (3) accurate measuring meters. Households currently not connected to the network were asked to consider a bimonthly consumption charge for a service that would provide electricity with the features described above for a list of items (for example, lightbulbs and appliances) that they would own or purchase (elicited before their WTP).

Enumerators were selected from a pool of experienced surveyors and trained using a combination of lectures, role playing, and a pilot. Two field directors, two quality control specialists, and seven field coordinators supervised the implementation of the survey by forty enumerators, divided into seven teams (two six-member teams and five seven-member teams) with male and female interviewers. The main training was implemented in January 2018: classroom sessions from January 15 to 20, a pilot on January 28 and 29, and an additional session on January 30, focused on the bidding game for the WTP measures. The fieldwork started on March 19, 2018, due to delays in obtaining the selected sample lists from the National Statistical Institute (hereafter ANSD, for *Agence Nationale de la Statistique et de la Démographie*). During the elapsed month between the main training and the beginning of fieldwork, the computer assisted in-person interview (CAPI) application, manuals, and working routes were revised. A refresher session was organized on March 15 and 16 before deploying the fieldwork operation to ensure that the survey team was ready to start interviewing. The data collection was finalized in two months, with the last survey submitted on May 18, 2018.

Household Survey

A three-stage stratified random sampling approach was used to select the household sample. SMJ Data (the data collection firm) and MCC, with the help of ANSD, determined the strata to be each region of Senegal to ensure sufficient geographical coverage and spatial representation; the number of households to survey in each region was then calculated based on its population. Stage 1 of the sampling consisted of selecting a random sample of communes within each region; stage 2 randomly selected the census enumeration areas (EA) from the communes selected in the first stage with selection probability proportional to size; and stage 3 randomly selected 15–20 households from an updated listing of households in every EA. The random selection of these households ensured that the sample was representative at the national level. The resulting sample of 2,846 households was spread across 151 EAs in 14 regions of Senegal. Once in the household, heads of household or adult persons (18 to 99 years of age) who participate in decisionmaking regarding electricity issues in the household were the survey respondents.

Each survey was conducted as a CAPI that lasted approximately 50 minutes. Data were recorded on the electronic questionnaires programmed in SurveyCTO by SMJ Data. At the end of each field day, field coordinators checked the uploaded questionnaires for completeness and accuracy according to a quality checklist. During the fieldwork, field directors periodically monitored interviews for quality purposes, ensured targeting of the appropriate population, discussed complications regarding the survey instrument with enumerators, recorded enumerator opinions regarding the quality of the interviews, maintained a list of sample household addresses for follow-up surveys, and maintained a log of sample returned surveys.

Formal and Informal Businesses Surveys

A stratified random sampling approach was used to select the business sample. First, SMJ Data and MCC, with the help of ANSD, determined the strata to be each economic activity according to the General Business Census of 2016 (*Recensement Général des Entreprises* 2016), which was used as the sample frame. To ensure that the sample was nationally representative of all businesses in Senegal, a simple random draw was carried out in each economic sector in the sample frame with the sample allocated to each sector proportional to its size. For this survey, only establishments in the formal and informal market sectors with a registered office or professional premises where they operate were considered. Nonprofit institutions and professional and employers ' organizations were not included. The resulting sample of 1,008 business comprised 807 informal and 201 formal businesses.

Once the business was identified, the owner or manager who oversaw the decisionmaking regarding electricity issues in the business was the survey respondent. Each survey was conducted as a CAPI that lasted approximately 50 minutes. Data were recorded on the electronic questionnaires programmed in SurveyCTO. The survey process was parallel to the household survey over the course of two months.

2.2 Survey Response Rates

Table 1 shows the distribution of planned surveys and Table 2 the surveys that were completed successfully for each region and status of electricity access. The response rates across surveys were high, thanks to the recent sample frames used and the updating of the listing that was implemented before the sample selection. Over 97 percent of the household sample consented to the interview, as did above 94 percent of selected business (both formal and informal).

Most of the households (83 percent) are connected to the electricity network; those in Dakar and St. Louis regions have the highest electricity access rates, at 90.6 and 88.6 percent, respectively (Table 2). Almost all formal businesses are connected to the network, while informal business have a 66 percent connection rate. Overall, the sample should provide a good sense of the preferences and WTP of nonconnected households and informal businesses, and less so of nonconnected formal businesses.

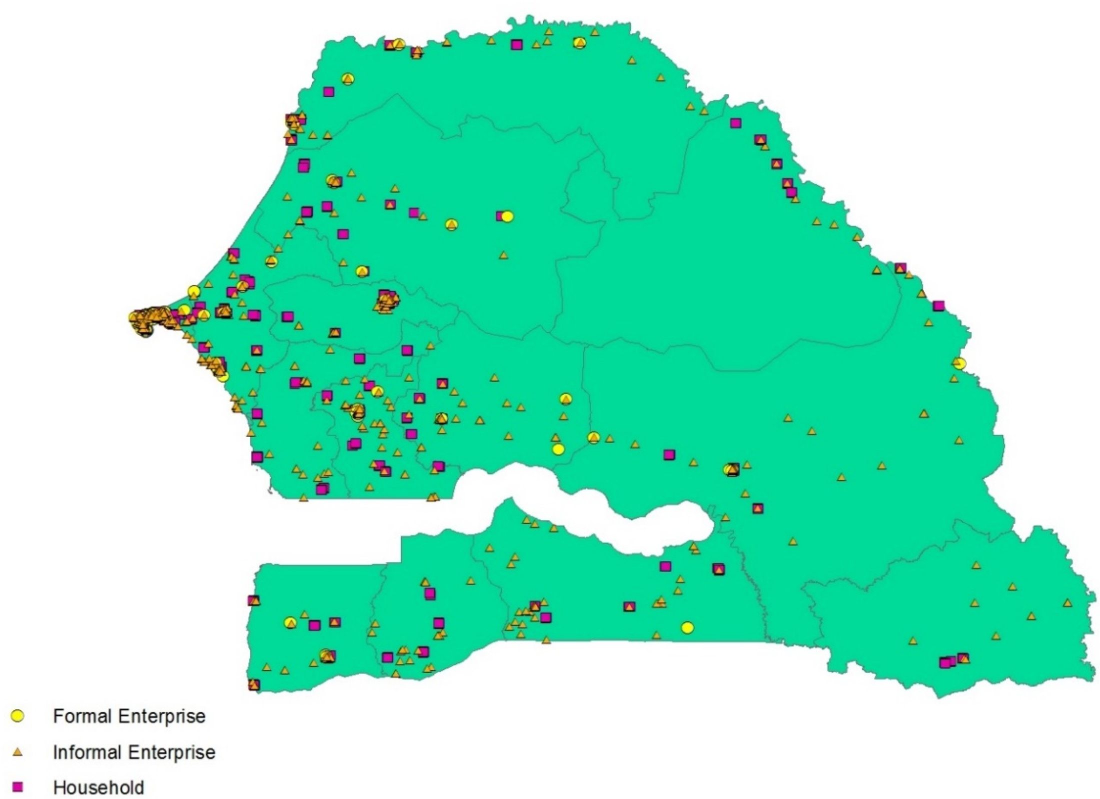
TABLE 1 SAMPLE SIZE BY REGION AND URBAN/RURAL BY SURVEY

	Household			Informal Business			Formal Business		
Region	**Urban**	**Rural**	**Total**	**Urban**	**Rural**	**Total**	**Urban**	**Rural**	**Total**
Dakar	876	56	932	317	4	321	157	1	158
Diourbel	39	201	240	12	74	86		4	4
Fatick	31	94	125	5	15	20			
Kaffrine	21	84	105	17	20	37	1	2	3
Kaolack	89	104	193	29	30	59	7		7
Kedougou	18	24	42	6	9	15			
Kolda	48	68	116	11	28	39		1	1
Louga	51	111	162	11	12	23	5		5
Matam	15	80	95	1	15	16			
Saint-Louis	61	105	166	27	16	43	3	2	5
Sedhiou	20	57	77	6	17	23			
Tambacounda	42	74	116	17	26	43	5	1	6
Thies	181	166	347	70	37	107	13	1	14
Ziguinchor	47	83	130	17	17	34	2	1	3
Total	1,539	1,307	2,846	546	320	866	193	13	206

TABLE 2 SAMPLE SIZE BY ACCESS TO ELECTRICITY AND URBAN/RURAL BY SURVEY IF CONSENTED

	Household			Informal Business			Formal Business		
Region	**Not connected**	**Connected**	**Total**	**Not connected**	**Connected**	**Total**	**Not connected**	**Connected**	**Total**
DAKAR	83	806	889	79	231	310	2	146	148
DIOURBEL	41	194	235	28	54	82		4	4
FATICK	39	81	120	9	7	16			
KAFFRINE	28	72	100	19	15	34	2	1	3
KAOLACK	53	138	191	22	23	45		7	7
KEDOUGOU	11	29	40	8	4	12			
KOLDA	35	81	116	27	12	39		1	1
LOUGA	23	135	158	7	16	23	1	3	4
MATAM	22	73	95	3	13	16			
SAINT-LOUIS	19	147	166	12	28	40		5	5
SEDHIOU	20	57	77	11	11	22			
TAMBACOUNDA	25	91	116	14	24	38		6	6
THIES	54	288	342	24	79	103	1	12	13
ZIGUINCHOR	21	109	130	13	21	34		3	3
Total	474	2,301	2,775	276	538	814	6	188	194

FIGURE 1 GEOGRAPHIC DISTRIBUTION OF THE SAMPLE BY SURVEY



3 Choice Experiments and Contingent Valuation Elicitation Methods

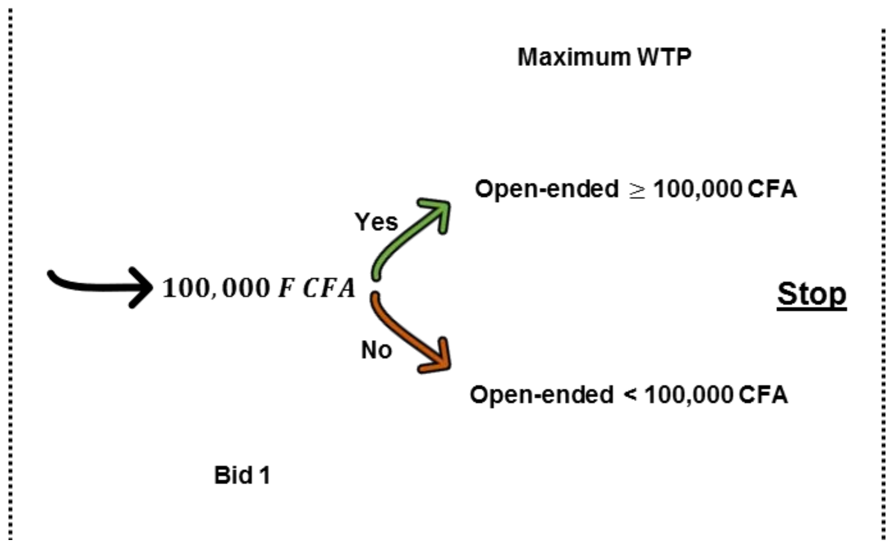
Crafting good CV scenarios is difficult. It amounts to writing a short story about the problem or situation that is the focus of the survey, and then posing an interesting choice (or decision) for the respondent (Whittington et al. 1990; Whittington 1998, 2002). Since households are either currently receiving electricity service or not, and since connected households can have access to different levels of service (both in quantity and quality), it did not make sense to ask all households in the sample precisely the same questions about whether they would like to have improvements in their electricity services and if so how much they would be willing to pay. We thus designed different versions of the CV questionnaire for each group of households and businesses: those with and without connections to the existing grid.

Each group received a different version of the survey instrument and CV scenario.

3.1 Nonconnected Households and Businesses

We use a referendum with an open-ended follow-up for the maximum WTP for an initial connection fee. Respondents are asked to consider a one-time connection cost of 100,000 CFA (180 USD[3]) and to provide their maximum WTP in a follow-up open-ended question. Figure 2 shows the structure of the elicitation procedure.

FIGURE 2 INITIAL CONNECTION ELICITATION PROCEDURE FOR NONCONNECTED HOUSEHOLDS AND BUSINESSES



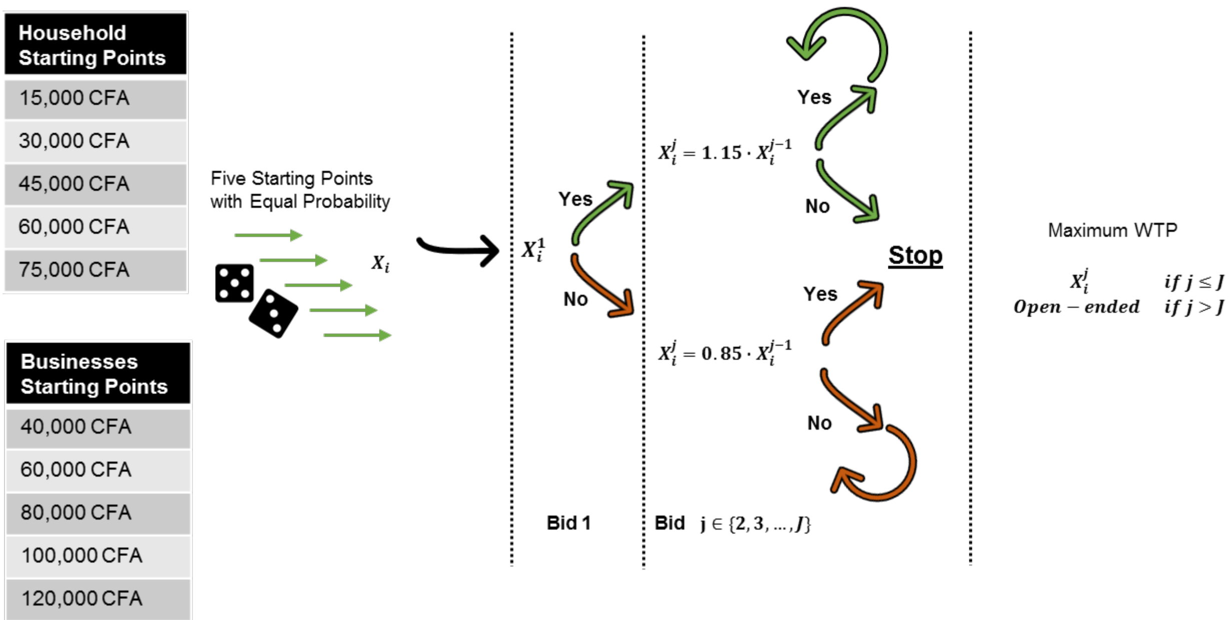
This is followed by a bidding game to elicit respondents' WTP for improved electricity services for nonconnected households (Figure 3). The bidding game is close-ended, Yes/No, discrete choice, with a final open-ended option after the twelfth proposed bid is accepted or denied. In this case the CV scenario describes the hypothetical service, and respondents are then asked whether they would buy it at a specified bimonthly cost.

The elicitation procedure needs a specific quantity of the service. For those nonconnected this is difficult, since they do not have the "counterfactual" of appliances; that is, we do not know what appliances they would have if they were connected to the network. In this case we use a list of hypothetical appliances the

[3] We use an exchange rate of 1 USD = 555 CFA or 1 CFA = 0.0018 USD throughout the report. We discuss the bidding game in local currency so the reader can see the amounts the respondent was presented.

respondent would buy to gauge the quantity of electricity this household would consume. From this we can obtain the price that is implicit in the bill. One-fifth of respondents in the sample received a bidding game with a sequence of Yes/No questions. The bids for households were the bimonthly consumption charges for 24/7 electricity service, distributed randomly with five starting points from 15,000 CFA to 75,000 CFA (in 15,000 CFA increments).[4] The initial bids for businesses were distributed randomly with five starting points from 40,000 CFA to 120,000 CFA (in 20,000 CFA increments). After the initial bid, the bids increased or decreased by 15 percent if the respondent accepted the bid or declined it, respectively.

FIGURE 3 BIDDING GAME WITH FIVE STARTING POINTS– NONCONNECTED RESPONDENTS (1 USD = 555 CFA)



The scenario presented to nonconnected households was as follows:

> ***Opening Statement:*** Taking into account your **current expenses** and that your household **is not connected to the electricity grid** and that the electricity bill would be in addition to your current monthly household expenditures.
>
> If you were to receive “satisfactory electricity services” that give you electricity 24/7 without outages or low voltages and **have the equipment mentioned before** in the home.
>
> The electricity will be metered, and you will be **billed every 2 months**. You would probably use more electricity for the equipment that are turned on at night (like lights) and those that might be always on (like fridges). Note that if you are paying money to purchase electricity from a source other than SENELEC, that amount would be deducted from your current monthly household expenditures.
>
> Would you be willing/ready to pay every 2 months [**Random- Bimonthly bill]** CFA to have **the equipment mentioned before with electricity 24H/7J**?

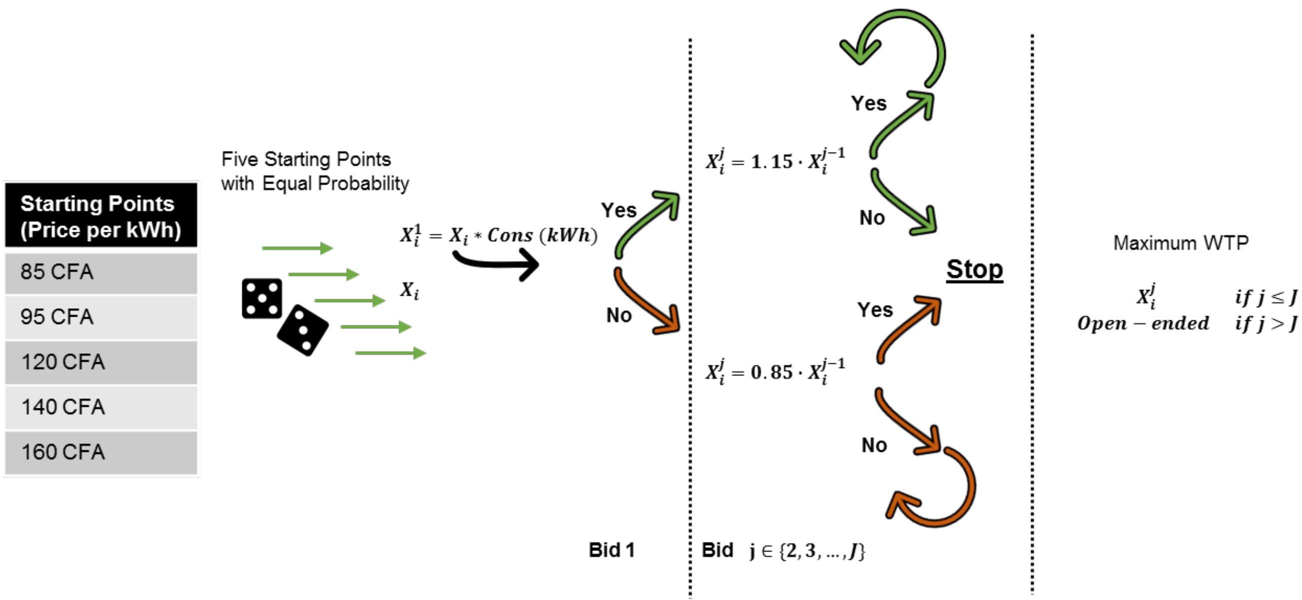
[4] The amounts above are based on our calculation for a low-consumption and high-consumption household based on the current prices per kWh posted by SENELEC. Low consumption is defined as having: three bulbs, one TV, one radio, and two fans with a consumption of 180 kWh every two months with an average price per kWh 85 CFA/kWh and 160 CFA/kWh. High consumption is defined as having: three bulbs, one TV, one radio, two fans, one fridge, and one miscellaneous (100-watt) item with a consumption of 450 kWh every two months with an average price per kWh 85 CFA/kWh and 160 CFA/kWh. The prices per kWh in the calculation were selected to span the range of prices in the tariff schedule of the SENELEC that are applicable from the 1st of May 2017 (http://www.senelec.sn/tarification/).

3.2 Connected Households and Businesses

For connected households we use three different bidding games to elicit respondents' WTP for improved electricity services with 24/7 service, decreases in outages by one-half, and decreased low voltages by one-half. The changes in the attributes (outages, low voltages) allow estimation of the sensitivity of demand to these changes. The bidding games are close-ended, Yes/No, discrete choice questions, with a final open-ended option after the twelfth proposed bid is accepted or denied.

The resulting CV scenario describes the hypothetical service, but the respondents have experience with a given level of electricity services. The respondents are asked whether or not they would buy improved (24/7) service at a specified price. Since the elicitation procedure needs a specific quantity of the service offered, for those connected, we use the electricity consumption (in kWh) from their last bill, and we inform them that they could end up using more electricity with the 24/7 level of service. The bids were presented as bimonthly consumption charges for 24/7 electricity service using their past level of consumption and as the price per kWh that was being used/bid in that iteration of the game. One-fifth of respondents in the sample received a bidding game with a sequence of Yes/No questions starting at one of five prices per kWh (85, 95, 120, 140, or 160 CFA/kWh) based on the existing tariff/price schedule of SENELEC. After the initial bid, the bids increased or decreased by 15 percent if the respondent accepted the bid or declined it, respectively. Figure 4 shows the bidding game for connected respondents to elicit their maximum WTP for improved electricity services 24/7.

FIGURE 4 BIDDING GAME WITH FIVE STARTING POINTS – CONNECTED RESPONDENTS– 24/7 ELECTRICITY SERVICES (1 USD = 555 CFA)



The scenario presented to connected respondents was as follows:

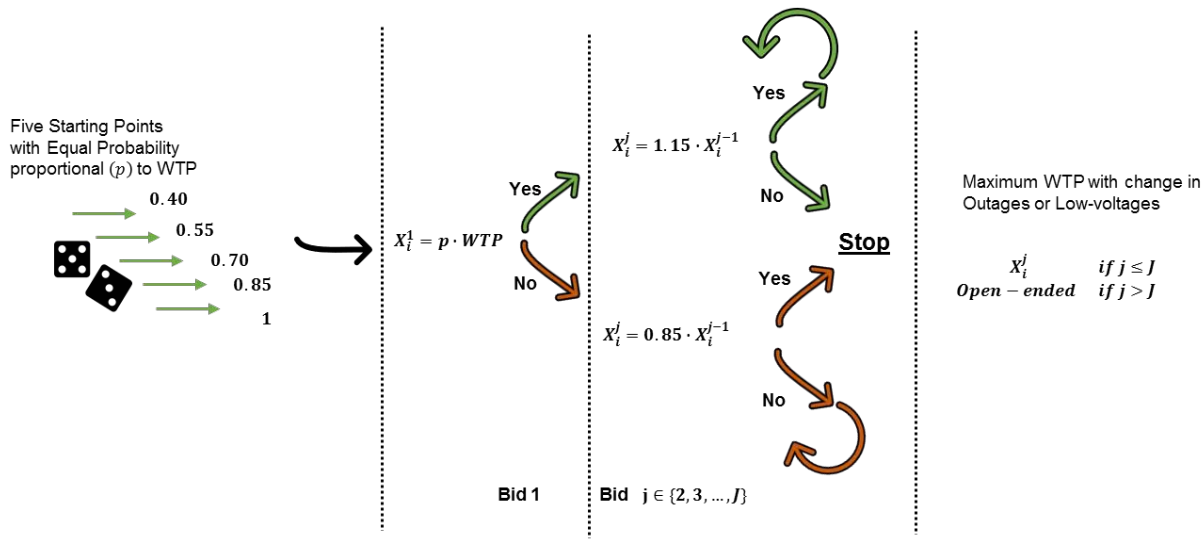
> ***Opening Statement***: Taking into account your current expenses and that your household currently pays **[amount previous bill]** FCFA for **[consumption in the previous bill]** Kwh. The average price is **[average price paid in previous bill]** CFA/Kwh and you experience **[number of outages per week]** outages per week.
>
> If you were to receive "satisfactory electricity services" that give you electricity 24H/7J without outages or low voltages, would you be willing/ready to pay: **[random initial price]** CFA/Kwh or a bimonthly bill of **[consumption in the previous bill]x[random initial price]** for your current consumption?

The electricity will be metered, and you will be billed every 2 months and you would probably use more electricity than you use at the moment.

Note that if you are paying money to purchase electricity from a source other than the SENELEC or Concessionaires, that amount would be deducted from your current monthly household expenditures.

For WTP for improvements in outages and low voltages, we use a similar bidding game with an open-ended question following the fifth accepted or denied bid. These two games are anchored in the maximum WTP elicited in the previous game. The bids were presented as bimonthly consumption charges for 24/7 electricity service using their maximum WTP obtained in the previous games. One-fifth of respondents in the sample received a bidding game with a sequence of Yes/No questions starting at one of five fractions of their maximum WTP: 0.40, 0.55, 0.70,0.85, or 1.0. Figure 5 shows the bidding game for connected respondents to elicit their maximum WTP for electricity services they currently have but with one-half of the outages or low voltages.

FIGURE 5 BIDDING GAME WITH FIVE STARTING POINTS – CONNECTED RESPONDENTS– IMPROVEMENT IN OUTAGES AND LOW VOLTAGES (1 USD = 555 CFA)



The scenario presented was as follows:

Taking in to account the outages and low voltages you experiment per week and that you would be willing to pay **[Maximum WTP or Last accepted bid]** every two months for 24h/7j service without outages or low voltages.

Would you be willing/ready to pay **[Random proportion]x[Max WTP]** CFA every 2 months to **reduce [outages/low voltages]** to **half** of the number per week you experience?

4 Results

The survey allows us to estimate electricity demand relationships suggested by consumer demand theory and to reliably estimate individuals' WTP for improved electricity services[5]. Economic theory suggests that an individual's demand for a good is a function of its price, prices of substitute and complementary goods, income, and the individual's tastes or a business's production and cost function. To get at these important relationships, we first describe the general characteristics of households and businesses and their access to different sources of energy. We follow that discussion with the main analysis of WTP for improved electricity services, defining the relationships between price and quantities and how they relate to electricity expenses and other characteristics that can proxy for aspects of individuals' taste, the production process, and businesses' cost parameter.

4.1 Household Characteristics

Table 3 shows the characteristics of the households in the sample. For the survey, a household is defined as the group of people who live together in the same compound, eat together, and are under the authority of one head of household. Households are at the center of many demographic, social, and economic processes, since decisions about living arrangements, education, healthcare, etc., are made at the household level. Most households (over 73 percent) in the sample are large, with more than five persons per household. The average household has more than two school-aged children, with more male children aged 6 to 14. The typical household spends 299 USD per month. Seventy-six percent of households own or co-own the house where they live, and 22 percent have access to formal savings. Access to electricity is high – 83 percent of households in the sample are connected to the network. Electricity is the main source of energy for lighting and 73 percent also use other energy sources such as batteries, lamps, wood, and/or candles. Since households can have access to multiple energy sources, we ranked the sources available and created an indicator for "best energy source available" by selecting the better-quality source. For example, if a household has access to and uses both battery-powered flashlights and candles, that household's "best source" would be "batteries." This categorization considered connection to the electricity network to be the best source, followed by direct connection from concession, generators, batteries/lamps/solar, and wood/candles/biomass. Table 4 shows the results for this indicator. Over 82 percent of households have access to electricity services through SENELEC or a concessionaire; only 149 households (5.4 percent) do not have access to electricity and have access only to wood or candles for illumination in the house.

Table 5 presents the energy situation of the sample households. Coping costs are expenditures that households make to collect, store, or access an energy source. More reliable and better-quality electricity is generally expected to reduce these costs. These costs include expenditures on buying and maintaining alternative sources, storage in the form of batteries, cash expenditures to access electricity through other households, and payments to vendors. The average household spends 12.86 USD per month (5 percent of total expenditures) to access energy sources other than the network electricity; 7.00 USD per month on average is spent on candles and wood.

Connected households report having electricity for 13.9 hours per day. We calculated the consumption capacity of each household in kWh from the number of appliances, the average time they use the appliance in one day, and the consumption capacity of the appliance. For example, a household with 10 incandescent lightbulbs of 60 watts that are turned on for four hours at night would have a daily consumption capacity for incandescent lights of 10*60W*4h = 2400Wh or 2.4 kWh. The table shows these consumption capacities for different light sources, and small and large appliances. The light bulbs most reported are energy-saving with a low consumption capacity, and most households report owning small appliances, such as radios and TVs, with a 2.67 kWh average consumption capacity. To connect to the

[5] The estimates presented throughout the report are unweighted to highlight the behavior of the households and individuals in the sample (as opposed to the population). The population weighted estimates are numerically similar.

network, households paid on average 37.87 USD to the service provider but spent 78.54 USD on average on other connection costs such as hiring an electrician, installing wiring inside the house, and paying incentives to utility workers.

Over one-half of the connected households were able to produce their last electricity bill. Billing is usually bimonthly, and the data reflect this, covering 59 days on average. Total electricity consumption for a two-month period is 199 kWh. The average electricity bill is 35 USD (11.7 percent of household expenditures), with the price per kWh averaging 0.24 USD.

Figure 6 shows the pattern of electricity consumption throughout the year as perceived by respondents. The figure shows the proportion of households that respond they have low, average, or high consumption for each month in the year. Sixty percent of households report higher consumption during July and August, and average consumption in March, April, October, and November. Given that the survey was conducted in the March to May period, the electricity consumption reflected in the bills of the sampled households reflects average consumption levels as perceived by respondents.

TABLE 3 HOUSEHOLD CHARACTERISTICS AND DEMOGRAPHICS

	Mean/ Percent	Std. Dev.	Median	P75	Max	Obs
Household Composition and Resources						
1 to 5	26.16					
6 to 10	39.46					
11 to 15	19.75					
16 to 20	8.11					
21 or more	6.52					
No. male school-aged (6-14) children	1.37	1.91	1.0	2.0	40.0	2,775
No. female school-aged (6-14) children	1.20	1.57	1.0	2.0	30.0	2,775
Monthly expenditure in USD-Win(H-.01)	298.55	212.67	246.6	369.3	1368.0	2,775
Owns or co-owns house	0.76	0.43	1.0	1.0	1.0	2,775
Household head access to formal savings	0.22	0.42	0.0	0.0	1.0	2,775
Access to Energy Sources						
Connected to electricity network	0.83	0.38	1.0	1.0	1.0	2,775
Use of alternative energy sources	0.73	0.44	1.0	1.0	1.0	2,301

TABLE 4 BEST ENERGY SOURCE AVAILABLE

	Observations	%
Direct connection to network	2,286	82.4
Direct connection from concession	15	0.5
Batteries/lamps/solar	324	11.7
Wood/candles/biomass	149	5.4
Other/gas/generators	1	0.0
Total	2,775	100.0

TABLE 5 HOUSEHOLDS' COPING AND ENERGY COSTS

	Mean/Percent	Std. Dev.	Median	P75	Max	Obs.
Coping Costs						
Expenditure coping (USD/month): Batteries/lamps/solar	0.87	3.40	0.0	0.5	94.3	2,775
Expenditure coping (USD/month): Wood/candles/bio	7.03	10.92	2.0	10.8	135.4	2,775
Expenditure coping (USD/month): Other/gas/generators	4.96	9.30	0.0	9.7	172.8	2,775
Expenditure total coping (USD/month)	12.86	15.57	10.1	19.8	203.4	2,775
Electricity Capacity Available						
Hours of electricity use per day	13.9	8.23	13.0	24.0	24.0	2,626
Capacity kWh: Incandescent lights	1.87	2.34	1.1	2.2	19.5	795
Capacity kWh: Fluorescent lights	0.78	1.12	0.4	0.8	9.1	304
Capacity kWh: Energy-saving lights	0.59	0.64	0.4	0.7	7.0	1,219
Capacity kWh: Small appliances	2.67	12.04	1.2	2.6	441.4	2,095
Capacity kWh: Large appliances	4.78	9.69	3.0	7.2	230.4	875
Electricity Costs						
Connection cost billed by the provider	37.87	52.72	32.4	36.0	1080.0	1,142
Billed + additional connection costs (electrician, wires, incentives, etc.)	78.54	113.17	45.0	89.1	1836.0	1,125
Electric bill during interview	0.57	0.50	1.0	1.0	1.0	2,111
Days covered in the bill	58.79	11.18	60.0	62.0	182.0	1,199
Electricity consumption in last 2 months (kWh)	199.29	938.62	121.0	228.5	31875.0	1,188
Expenditure on electricity bill (USD/ 2 months)	35.12	41.62	23.5	44.2	720.0	1,198
Avg. price per kWh (USD)	0.24	0.34	0.2	0.2	9.0	1,187

FIGURE 6 PATTERN OF ELECTRICITY CONSUMPTION – PROPORTION OF HOUSEHOLDS WITH LOW/AVG./HIGH CONSUMPTION THROUGHOUT THE YEAR

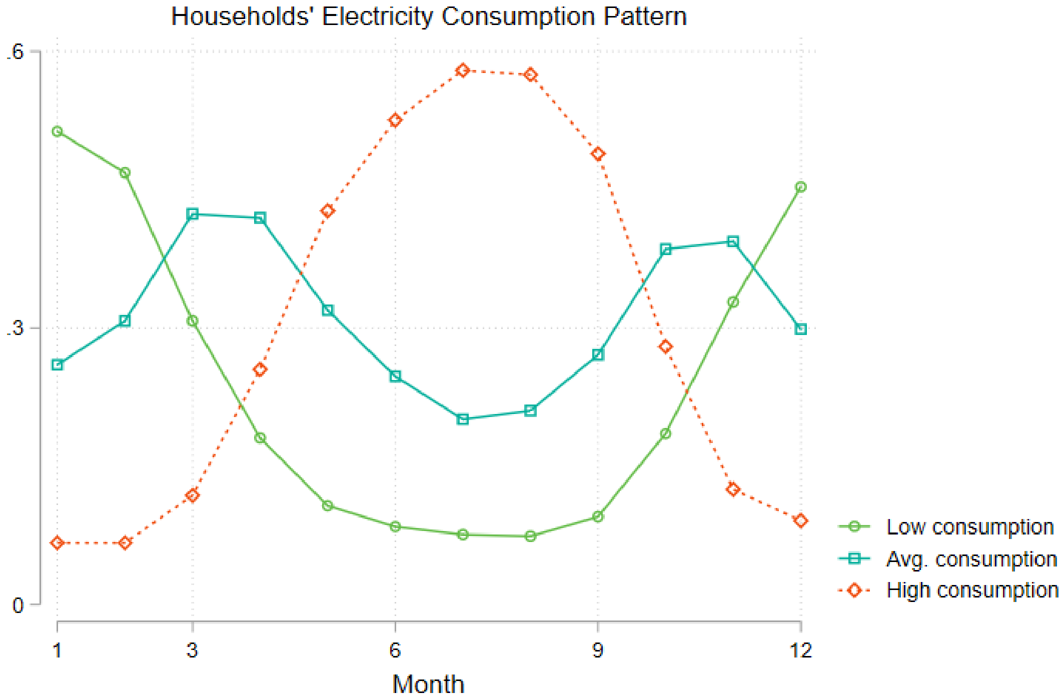


Table 6 shows the number of outages per day that households experience, while Figure 7 shows the months when households report having more outages. Only 21.8 percent of households do not experience outages and 60 percent experience one or two outages per week. August is the month with most outages, corresponding to the time of the year with the highest electricity consumption (Figure 7). Figure 8 shows the survey results for respondents' satisfaction with electricity services, which include availability of electricity, billing services, outages, connection delay, problem resolution, and overall quality. The aspects with the highest dissatisfaction are outages, connection delay, and problem resolution. The highest satisfaction is reported for availability of services, consistent with the high access rate found in the survey. Overall satisfaction is high: over 80 percent of households report being satisfied or very satisfied.

TABLE 6 WEEKLY INCIDENCE OF OUTAGES – HOUSEHOLDS

Outages per week	Observations	%
0	502	21.8
1	867	37.7
2	536	23.3
3	216	9.4
4	77	3.4
5	43	1.9
6	18	0.8
7	25	1.1
More than once per day	17	0.7
Total	2,301	100.0

Figure 7 Annual Incidence of Outages – Households

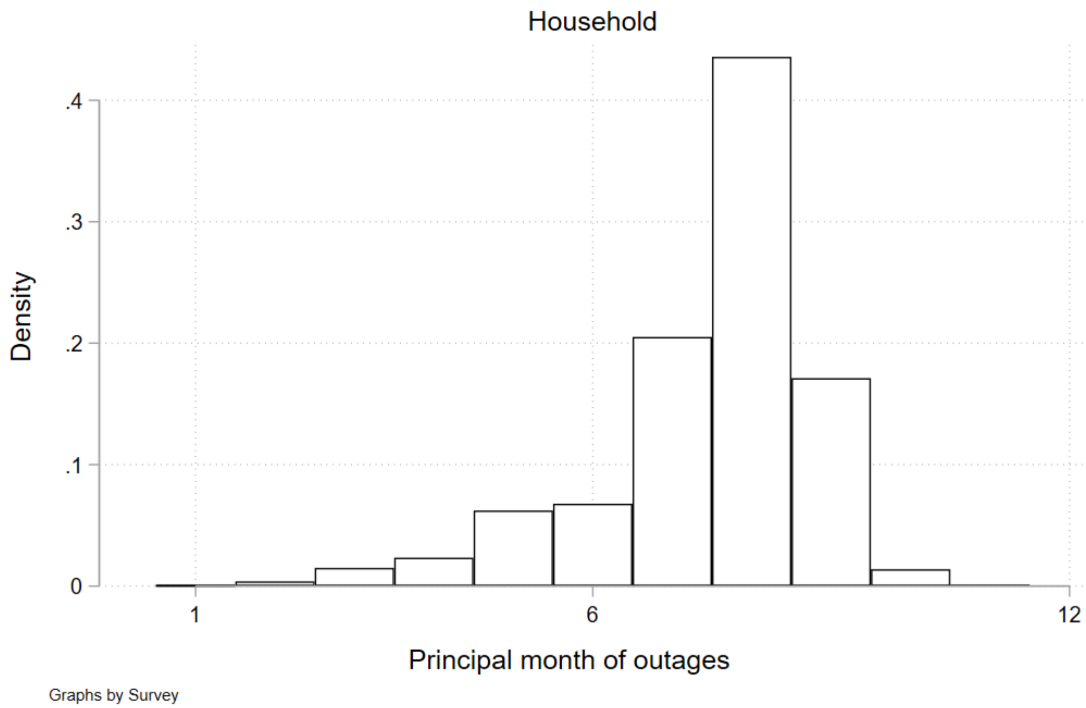
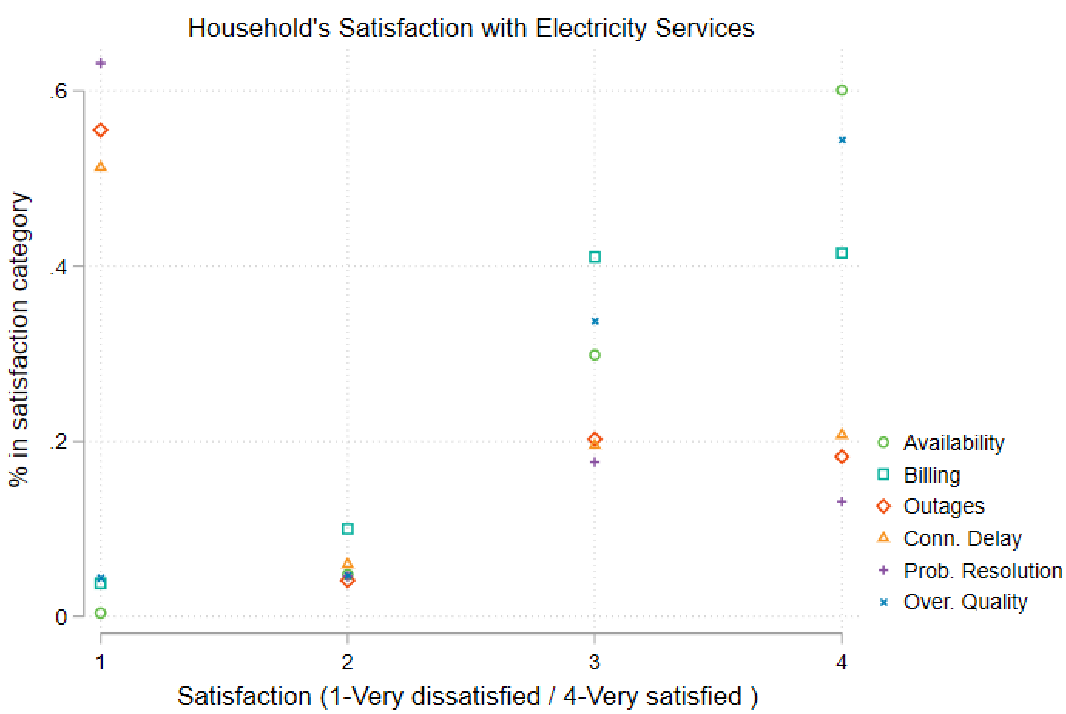


Figure 8 Satisfaction with Current Electricity Services – Households



4.2 Informal and Formal Business Characteristics

Table 7 presents the characteristics of the informal and formal businesses in the sample. Informal businesses have more female managers or owners than formal ones; indeed, 20 percent of informal businesses are managed by women versus 12 percent of formal businesses. The median age of business managers or owners is 41 years for informal businesses and 48 years for formal businesses. Formal businesses are larger, with 7.0 male workers on average and 3.5 female workers; informal businesses have on average 1.7 male workers and 0.6 female workers.

Informal businesses operate in owned and rented establishments in similar proportion (45 percent), while 60 percent of formal businesses are in rented locales. The principal economic sector for informal and formal businesses is general commerce followed by services (Table 8).

Figure 9 shows the pattern of businesses' activity throughout the year as perceived by respondents. The figure shows the proportion of businesses that respond they are closed (no business) or have low business activity, average business activity, or high business activity for each month in the year. The pattern of economic activity is similar throughout the year for both types of businesses. The lowest business season is July through September, when over 30 percent of businesses report a low level of business activity. The high season follows from September to the end of the year; the proportion of businesses that indicate they have high business activity increases from around 30 percent in September to over 50 percent in December. Most businesses categorize the first six months of the year as average business activity.

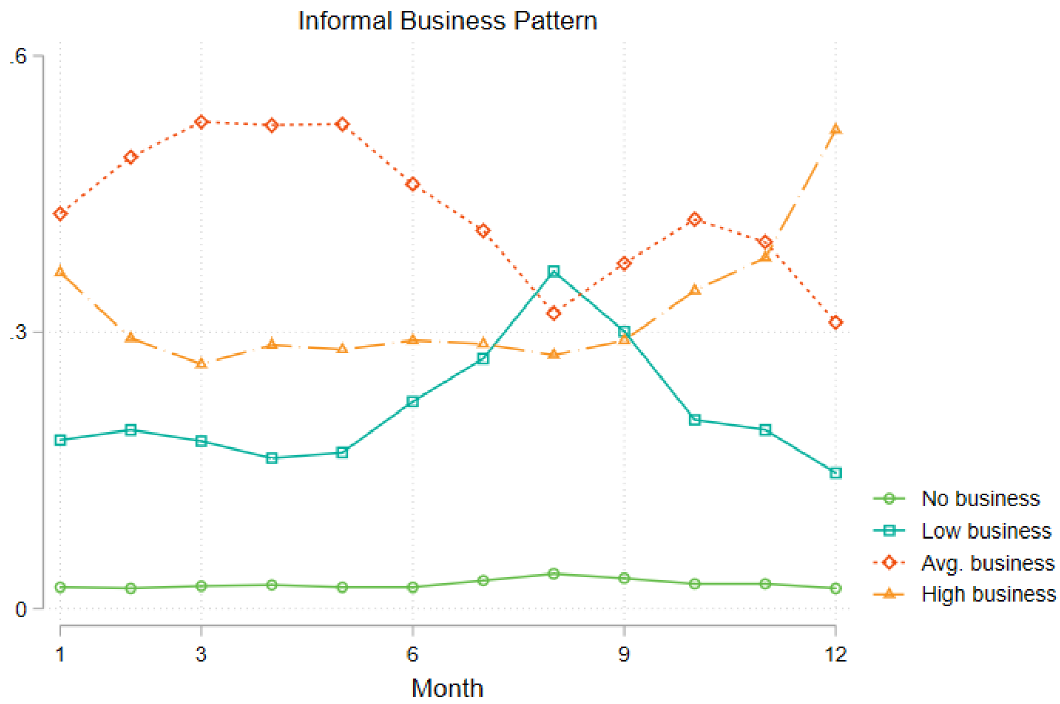
TABLE 7 BUSINESS CHARACTERISTICS

	Mean/Percent	Std. Dev.	Median	P75	Obs.
Informal Enterprise					
Female manager or owner	0.20	0.00	0.0	0.0	814
Age of manager or owner	42.93	19.00	41.0	50.0	814
Business has access to formal savings	0.39	0.00	0.0	1.0	814
No. male permanent workers	1.7	0.00	1.0	2.0	814
No. female permanent workers	0.6	0.00	0.0	0.0	814
Formal Enterprise					
Female manager or owner	0.12	0.00	0.0	0.0	194
Age of manager or owner	48.4	25.00	48.0	57.0	194
Business has access to formal savings	0.88	0.00	1.0	1.0	194
No. male permanent workers	7.0	0.00	3.0	7.0	194
No. female permanent workers	3.5	0.00	1.0	3.0	194

TABLE 8 OWNERSHIP OF BUSINESS ESTABLISHMENT AND BUSINESS ACTIVITY

	Informal	Formal
Ownership of Establishment		
Owned	44.7	34.0
Rented	45.2	60.3
Other	10.1	5.7
Economic Activity		
Agriculture	3.4	2.1
Industry	18.9	20.1
Commerce	44.0	36.6
Services	27.5	25.3
Public/government/education/professional	6.1	16.0

FIGURE 9 PATTERN OF BUSINESS ACTIVITY – PROPORTION OF INFORMAL AND FORMAL BUSINESSES WITH NO/LOW/AVG./HIGH BUSINESS ACTIVITY THROUGHOUT THE YEAR



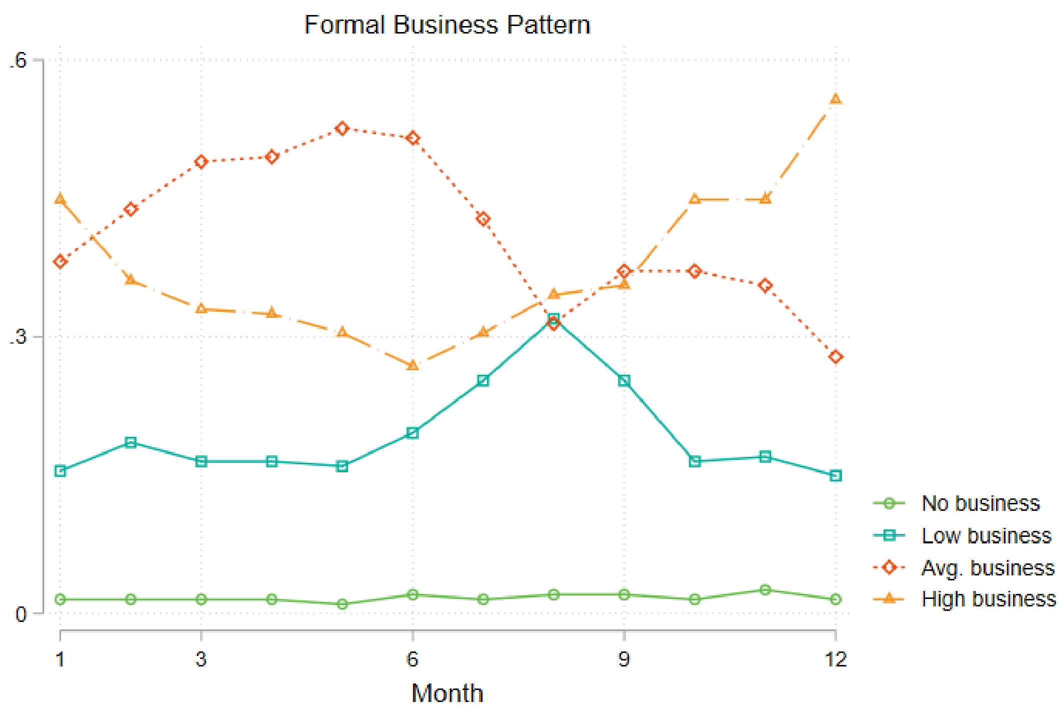


Table 9 presents the energy situation of the sampled businesses. Sixty-six percent of informal businesses are connected to the electricity network and few rely on alternative sources. Informal businesses spend 40.56 USD per month on electricity and 3.13 USD per month on generators. Total expenses on energy sources in 2017 were 567 USD on average and 143 USD for the median informal business. Almost all formal businesses (97 percent) are connected to the network, and they spend 324.70 USD per month on electricity. Total expenses on energy sources in 2017 were 4,010.90 USD on average and 1,078.80 USD for the median informal business.

TABLE 9 BUSINESSES' ACCESS TO ENERGY SOURCES AND COPING COSTS

	Mean	Std. Dev.	Median	P75	Obs.
Informal Enterprise					
Connected to electricity network	0.66	0.47	1.0	1.0	814
Access to alternative energy sources	0.01	0.09	0.0	0.0	538
Expenditure (USD/month): Network	40.56	397.60	9.0	31.5	814
Expenditure coping (USD/month): Batteries/lamps/solar	0.86	7.31	0.0	0.0	814
Expenditure coping (USD/month): Wood/candles/bio	0.63	5.08	0.0	0.0	814
Expenditure coping (USD/month): Other/gas/generators	3.13	24.24	0.0	0.0	814
Expenditure total coping (USD/month)	4.63	25.86	0.0	0.0	814
Total expenses on energy sources	567.10	4,844.82	143.0	403.2	814
Formal Enterprise					
Connected to electricity network	0.97	0.17	1.0	1.0	194
Access to alternative energy sources	0.01	0.10	0.0	0.0	188
Expenditure (USD/month): Network	324.70	701.41	90.0	249.0	194
Expenditure coping (USD/month): Batteries/lamps/solar	0.05	0.65	0.0	0.0	194
Expenditure coping (USD/month): Wood/candles/bio	0.01	0.08	0.0	0.0	194
Expenditure coping (USD/month): Other/gas/generators	62.03	486.83	0.0	0.0	194
Expenditure total coping (USD/month)	62.09	486.83	0.0	0.0	194
Total expenses on energy sources	4,010.90	9,178.83	1,078.8	2,486.7	194

TABLE 10 BUSINESSES' ELECTRICITY CAPACITY

	Mean	Std. Dev.	Median	P75	Obs.
Informal Enterprise					
Capacity kWh: Incandescent lights	0.53	0.75	0.3	0.5	128
Capacity kWh: Fluorescent lights	0.41	0.59	0.2	0.5	60
Capacity kWh: Energy-saver lights	0.29	0.49	0.1	0.3	318
Capacity kWh: Small appliances	1.45	3.40	0.6	1.4	376
Capacity kWh: Large appliances	6.38	21.36	2.9	5.8	133
Formal Enterprise					
Capacity kWh: Incandescent lights	2.93	4.24	1.0	3.7	46
Capacity kWh: Fluorescent lights	3.19	6.80	0.7	1.5	22
Capacity kWh: Energy-saver lights	1.59	4.51	0.4	1.0	117
Capacity kWh: Small appliances	6.03	11.69	2.0	6.3	155
Capacity kWh: Large appliances	29.61	130.54	7.2	15.0	87

The consumption capacity of each business is calculated for from the inventory of its machinery and appliances, the capacity of each, and the time these are used on average per day, analogous to the treatment of the household data. The composition of consumption capacity for businesses is higher for formal businesses than informal ones. The light bulbs most reported are energy-saving, and formal businesses have larger consumption capacity due to their use of large and small appliances. Table 11 shows the characteristics of electricity services and the costs associated with them. Professional contracts (as opposed to domestic consumption contract class) are used by formal businesses: 82 percent have them and 20 percent have a heavy-duty or higher power service.

To connect to the network, informal businesses paid on average 58.50 USD to the service provider and 38.13 USD on other connection costs such as hiring an electrician, installing wiring inside the house, and paying incentives.

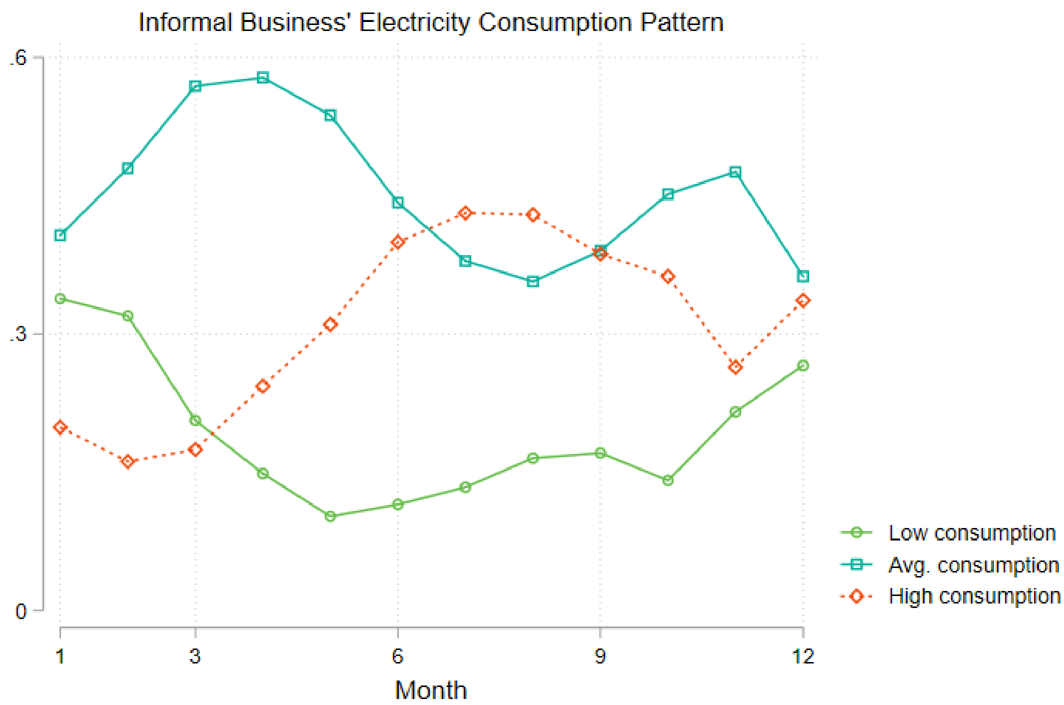
Most business were able to produce their last electricity bill – 67 percent of informal and 84 percent of formal businesses. The average bill covers over 50 days. Total electricity consumption was 341 kWh for informal businesses and costs ascend to 69.33 USD every two months. The price per kWh for informal businesses is estimated at 029 USD. Formal businesses' average total electricity consumption was 1,869.10 kWh and costs ascend to 448.41 USD every two months. The price per kWh for formal businesses is estimated at 0.42 USD.

Figure 10 shows the pattern of electricity consumption throughout the year for informal (top panel) and formal (bottom panel) businesses. Most businesses report higher consumption during the summer months, and average consumption in March, April, October, and November. Thus the electricity consumption reflected in the sample corresponds to the average consumption level, given the timing of the fieldwork.

TABLE 11 BUSINESSES' ELECTRICITY COSTS

	Mean	Std. Dev.	Median	P75	Obs.
Informal Enterprise					
Type of contract - Professional	0.58	0.49	1.0	1.0	527
Type of contract - Professional and heavy power	0.02	0.16	0.0	0.0	527
Connection cost billed by the provider	58.50	101.48	36.0	45.0	175
Billed + additional connection costs (electrician, wires, incentives, etc.)	94.29	157.23	45.0	90.0	178
Connection cost gap (effective-billed)	38.13	84.36	3.6	45.0	171
Electric bill during interview	0.67	0.47	1.0	1.0	538
Days covered in the bill	53.30	20.62	60.0	61.0	528
Electricity consumption in last month (kWh)	341.40	2427.21	100.0	204.0	499
Expenditure on electricity bill (USD/ 2 months)	69.33	495.85	23.4	51.6	531
Avg. monthly expenditure on electricity bill (USD)	49.21	476.96	14.4	28.9	526
Avg. price per kWh (USD)	0.29	0.23	0.2	0.3	499
Formal Enterprise					
Type of contract - Professional	0.82	0.4	1.0	1.0	186
Type of contract - Professional and heavy power	0.20	0.4	0.0	0.0	186
Connection cost billed by the provider	214.38	861.9	36.0	108.0	53
Billed + additional connection costs (electrician, wires, incentives, etc.)	374.18	958.6	108.0	270.0	50
Connection cost gap (effective-billed)	151.19	418.1	2.7	98.1	50
Electric bill during interview	0.84	0.4	1.0	1.0	188
Days covered in the bill	54.68	12.5	60.0	62.0	187
Electricity consumption in last month (kWh)	1869.10	6771.6	481.5	1209.5	180
Expenditure on electricity bill (USD/ 2 months)	448.41	1078.2	117.3	369.3	187
Avg. monthly expenditure on electricity bill (USD)	296.26	860.0	60.2	201.8	187
Avg. price per kWh (USD)	0.42	0.9	0.3	0.3	180

Figure 10 Pattern of Electricity Consumption – Informal and Formal Businesses



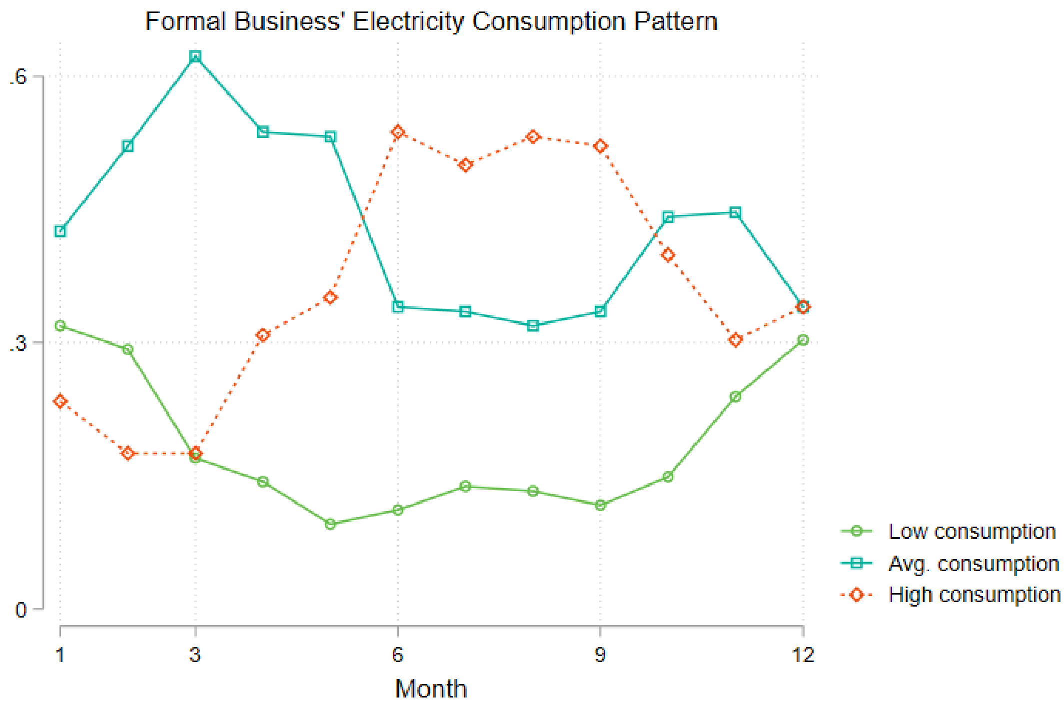


Figure 11 Annual Incidence of Outages – Informal and Formal Businesses

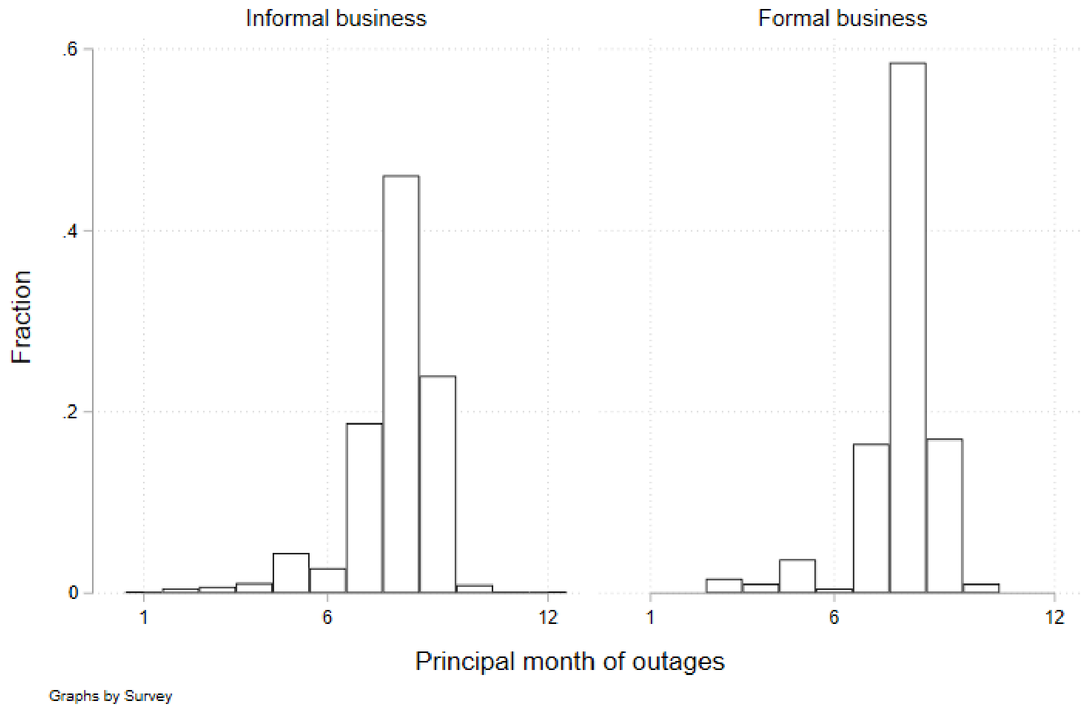
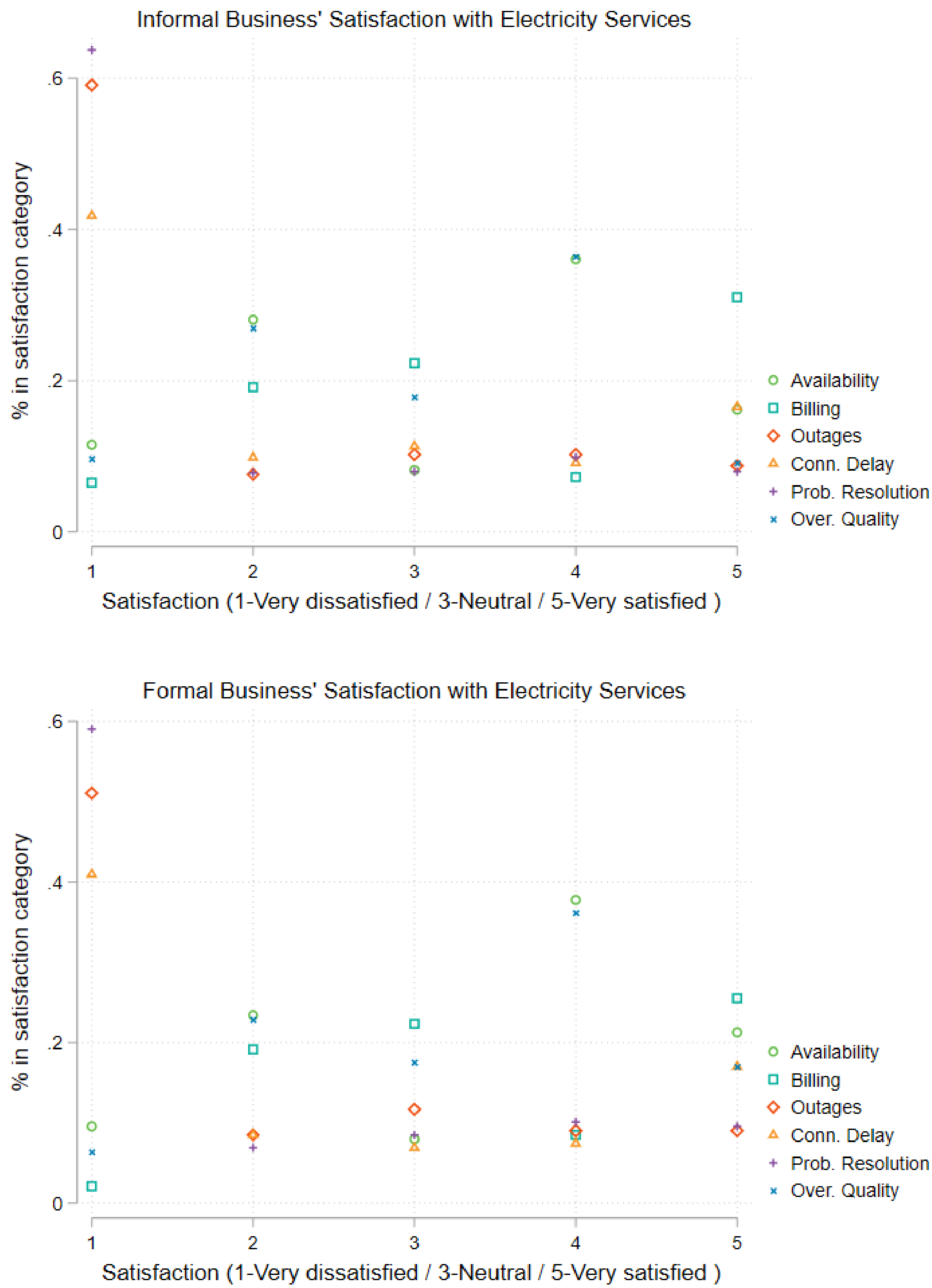


Figure 11 shows the months when businesses report having more outages. August is the month with the most outages, corresponding to the time of the year with the highest electricity consumption. Figure 12 shows the results for the satisfaction with electricity services in the survey (that is, availability of electricity, billing services, outages, connection delay, problem resolution, and overall quality). The aspects with the highest dissatisfaction are problem resolution, outages, and connection delay. The highest satisfaction is reported for billing and availability of services. Overall satisfaction is above average – over 40 percent of businesses report being satisfied or very satisfied.

Figure 12 Satisfaction with Current Electricity Services – Informal and Formal Businesses



4.3 Analysis of Willingness to Pay for Improved Electricity Services

Whether or not a household or business demands electricity from a public or private utility depends on the price charged for access to the system. For example, if the charge is higher than a given household's maximum WTP, the household will elect not to use the service. Maximum WTP will vary from household to household, and business to business, and should be a function of all variables in the demand function. Households' WTP bids should thus be positively related to income, the cost of obtaining energy from other sources, and the education of household members, and negatively correlated with individuals' perception of the quality of services.

CV surveys can be used to estimate demand relationships suggested by consumer demand theory, including individuals' WTP for improved electricity services. Typically, researchers make parametric assumptions regarding both the functional form of WTP and the distribution of the error term to estimate a model via maximum likelihood techniques. Theory, however, provides little guidance regarding the appropriate parametric specifications to use and the resulting WTP estimates can be quite sensitive to these assumptions.

The following analysis presents a distribution-free or nonparametric estimate of maximum WTP for improved electricity services. CV analysis is used to characterize the distribution of WTP in the population. The estimates presented are based on the fact that the dichotomous choice CV response for each bid proposed provides a single observation on the outcome of a Bernoulli trial, where the probability of success ("yes") for a bid value is equal to the proportion of yes respondents that were presented with a bid, bid_k. Estimating this proportion throughout the range of observed bids in the bidding game traces out the distribution of the maximum WTP in the population (Crooker and Herriges 2004).

We disaggregate the analysis by gender in the household analysis and by informal and formal business in the business analysis. It is hypothesized that WTP bids are higher for individuals or types of businesses that bear the most costs of coping with lack of electricity and that experience the most problems with shortages.

The analysis is guided by a general understanding of the demand for goods. First, we describe the quantities that enter in the bidding game and the implications for discussing WTP of connected and nonconnected households and businesses. Next is a discussion of the prices or bids used to characterize the demand for improved electricity services. This analysis concludes with some validation tests of the WTP measure derived, namely starting point bias and how WTP is related to income and other household and business characteristics.

The next part of the analysis focuses on the demand for improvement in the current services for connected households and businesses, in the form of changes in the number of outages and low voltages. We build on the WTP analysis and present this part relative to the maximum WTP derived before and to households' current expenses on electricity.

Players of the Willingness to Pay Bidding Games

The household survey applied the CV scenario to the male or female respondent in the household who is part of the decisionmaking with respect to electricity or energy use. The idea is to analyze differences in WTP across gender.

From our observations in the field, respondents generally took the CV questions and the interview seriously.[6] Sixty-nine percent of men designated to answer the WTP module were successfully interviewed, yielding 327 observations from nonconnected male respondents. The comparable figure for women was 59 percent, or 280 women living in households without electricity. In connected households, 65.2 percent of male respondents and 65.8 of female respondents identified for the WTP module were successfully interviewed. For the connected household sample, we have information on WTP for 1,500 men and 1,513 women (Table 12).

Table 12 Sample Distribution for WTP Module in Household Survey

	Men				**Women**			
	Nonconnected		**Connected**		**Nonconnected**		**Connected**	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Completed	327	69.1	1,500	65.2	280	59.1	1,513	65.8
Temp. absence	32	6.8	191	8.3	36	7.6	142	6.2
Long absence	28	5.9	205	8.9	16	3.4	63	2.7
Not located or refused	86	18.2	495	21.5	142	30.0	583	25.3
Total	473	100	2,301	100	474	100	2,301	100

Table 13 and Table 14 present the characteristics of male and female respondents for the WTP questionnaire, respectively. The male decisionmakers are of similar age across connected and nonconnected households. Male respondents in nonconnected households are more likely to be monogamous and are less educated than male respondents in connected households. Men in nonconnected households are less likely to speak French: 24 percent speak French in nonconnected households versus 54 percent in connected households. The data for female respondents suggest that they are on average younger and less educated than the male respondents and the rank comparisons across connection status remain. Women in connected households are more likely to be in polygamous households and have higher education levels, while women who live in nonconnected households are less likely to speak French.

[6] Note that the sample for this module is smaller due to nonresponse and attrition in the overall survey. The household sample comprised 2,846 households visited, of which 2,775 were included in the analysis with complete interviews. However, households could refuse any part of the questionnaire, or if the appropriate respondent was not present during the visits and revisits, the WTP module could be incomplete.

TABLE 13 MALE RESPONDENTS' CHARACTERISTICS

	Mean	Std. Dev.	Median	P75	Obs.
Nonconnected					
Age	47.20	14.80	45.50	58.00	326
Head of household	0.85	0.36	1.00	1.00	327
Monogamous	0.63	0.48	1.00	1.00	327
Polygamous	0.22	0.42	-	-	327
None/below primary	0.74	0.44	1.00	1.00	327
Primary	0.21	0.41	-	-	327
Speaks French	0.24	0.43	-	-	327
Connected					
Age	47.30	14.77	46.00	59.00	1,500
Head of household	0.76	0.43	1.00	1.00	1,500
Monogamous	0.61	0.49	1.00	1.00	1,500
Polygamous	0.23	0.42	-	-	1,500
None/below primary	0.44	0.50	-	1.00	1,500
Primary	0.31	0.46	-	1.00	1,500
Speaks French	0.54	0.50	1.00	1.00	1,500

TABLE 14 FEMALE RESPONDENTS' CHARACTERISTICS

	Mean	Std. Dev.	Median	P75	Obs.
Nonconnected					
Age	38.63	12.49	37.0	46.0	280
Head of household	0.31	0.46	-	1.0	280
Monogamous	0.56	0.50	1.0	1.0	280
Polygamous	0.25	0.43	-	-	280
None/below primary	0.85	0.36	1.0	1.0	280
Primary	0.14	0.35	-	-	280
Speaks French	0.13	0.34	-	-	280
Connected					
Age	42.01	13.24	40.0	51.0	1,513
Head of household	0.35	0.48	-	1.0	1,513
Monogamous	0.54	0.50	1.0	1.0	1,513
Polygamous	0.26	0.44	-	1.0	1,513
None/below primary	0.58	0.49	1.0	1.0	1,513
Primary	0.31	0.46	-	1.0	1,513
Speaks French	0.35	0.48	-	1.0	1,513

Table 15 presents the response rates for the WTP module in the business survey. The response rate is high, although the number of formal businesses without electricity is small and limits the scope of the proposed analysis.

TABLE 15 SAMPLE DISTRIBUTION FOR WTP MODULE IN HOUSEHOLD SURVEY

	Informal				Formal			
	Nonconnected		Connected		Nonconnected		Connected	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Completed	274	99.3	537	99.8	6	33.3	188	100
Not located	2	0.7	1	0.2	12	66.7	0	0
Total	276	100	538	100	18	100	188	100

The Quantities: Consumption Patterns of Connected Households and Businesses and Hypothetical Capacity

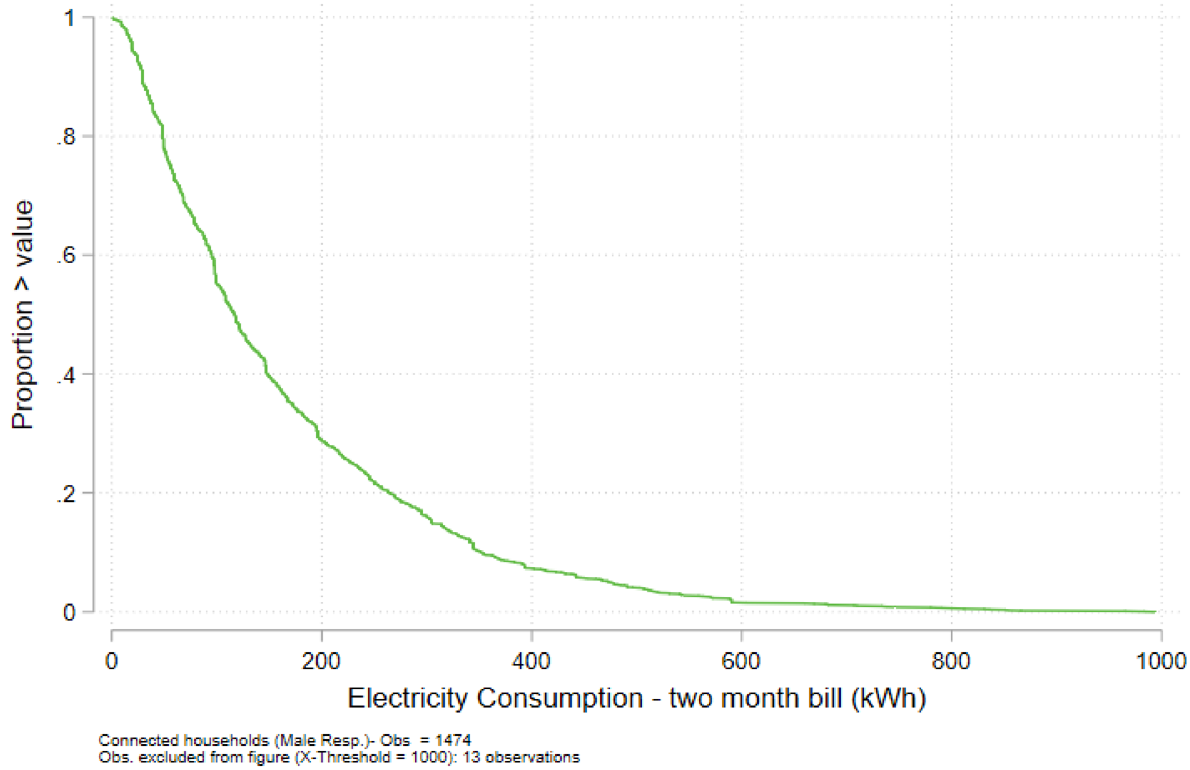
As explained before, to estimate demand with the CV method we need a quantity measure. For the case of electricity, this quantity is the amount of energy consumed, which depends on the capacity or appliances households have and the amount of time they use each. For households and businesses that do not have access to electricity, this quantity measure is not observed. For those nonconnected, we use a list of hypothetical appliances the respondent would buy and construct a hypothetical consumption measure. For these, the bids proposed in the game do not depend on this hypothetical capacity, since they are presented with a bimonthly bill amount. However, the maximum WTP should depend on the appliances' capacity since we explicitly indicate in the scenario's opening statement that respondents should imagine that these are the appliances they would have. Our discussion of the quantity thus focuses on connected households and businesses.

Figure 13 presents the inverse cumulative distribution function (ICDF) of consumption in kWh and the costs associated with those levels of consumption for households[7]. The ICDF shows the proportion of observations that are above a given value. The data have peaks across the distribution, an indication of heaping on some values, suggesting that households might have provided a "round" estimate when the bill was not available.

Most informal businesses are below 1000 kWh and 800 USD every two months (Figure 14). Figure 15 presents similar estimates for formal businesses. The distribution is more spread out for formal businesses and decreases more smoothly. Note that the figures exclude a few observations to the right of the threshold depicted in the figure, so the spread is even more. These figures give a sense of the range of WTP expected for households and businesses by type.

[7] We include the reports of male respondents only since the information comes from the same bill for the female respondent and we have slightly more observations for men.

FIGURE 13 CONSUMPTION AND EXPENDITURES IN ELECTRICITY SERVICES – CONNECTED HOUSEHOLDS



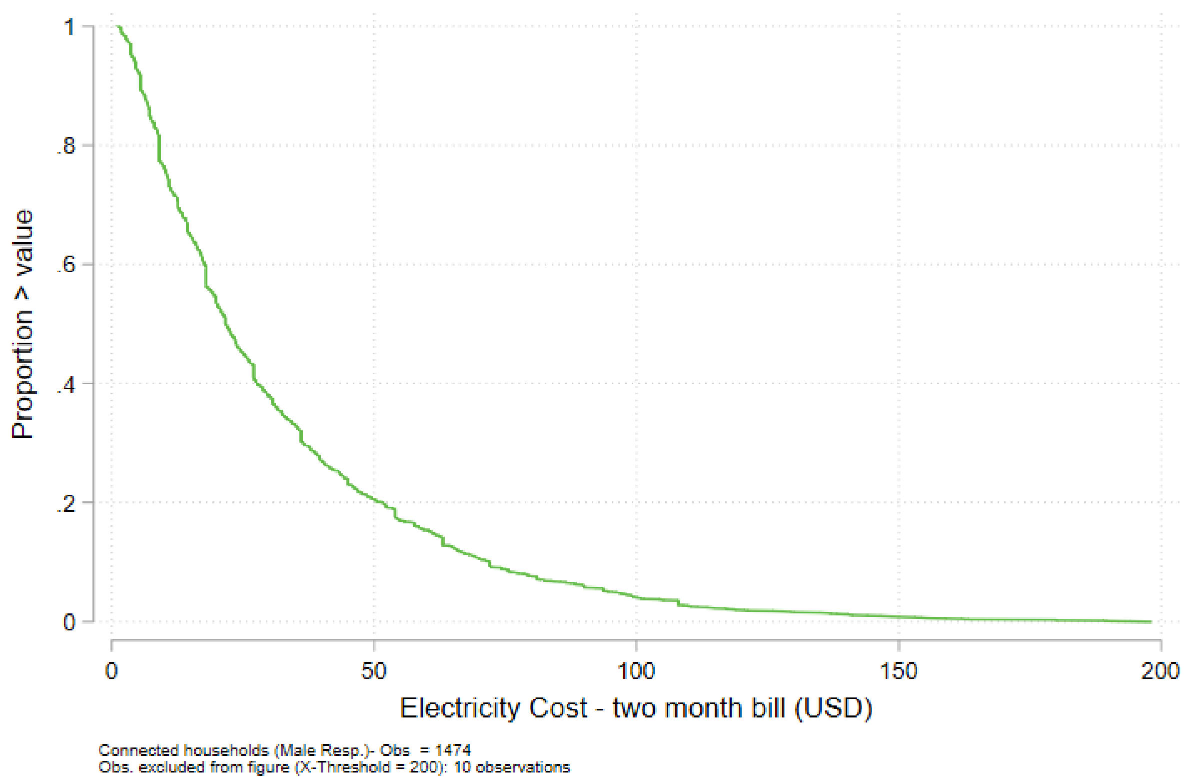
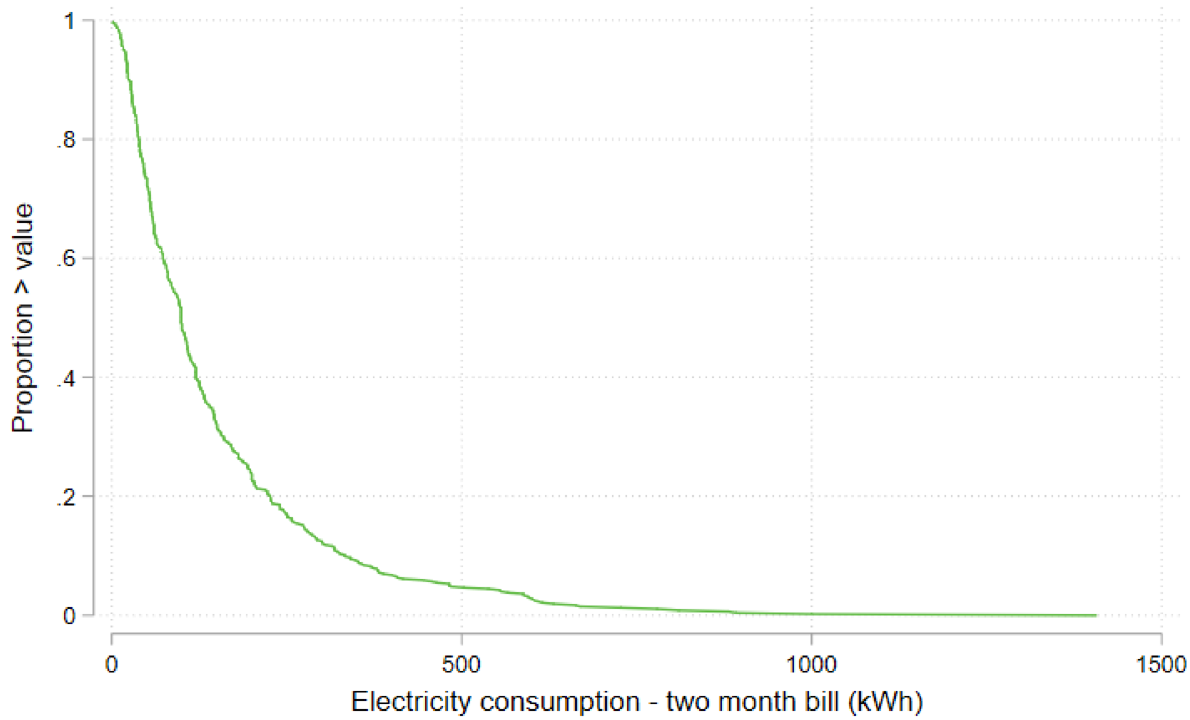
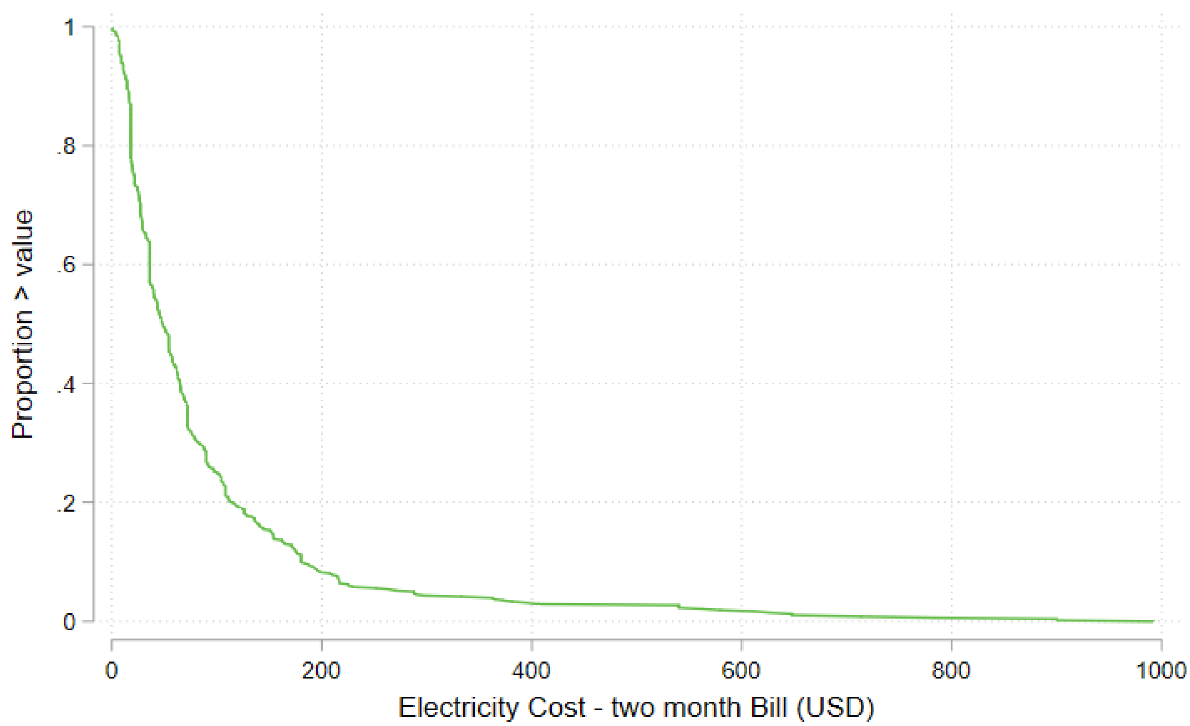


FIGURE 14 CONSUMPTION AND EXPENDITURES IN ELECTRICITY SERVICES – CONNECTED BUSINESSES - INFORMAL

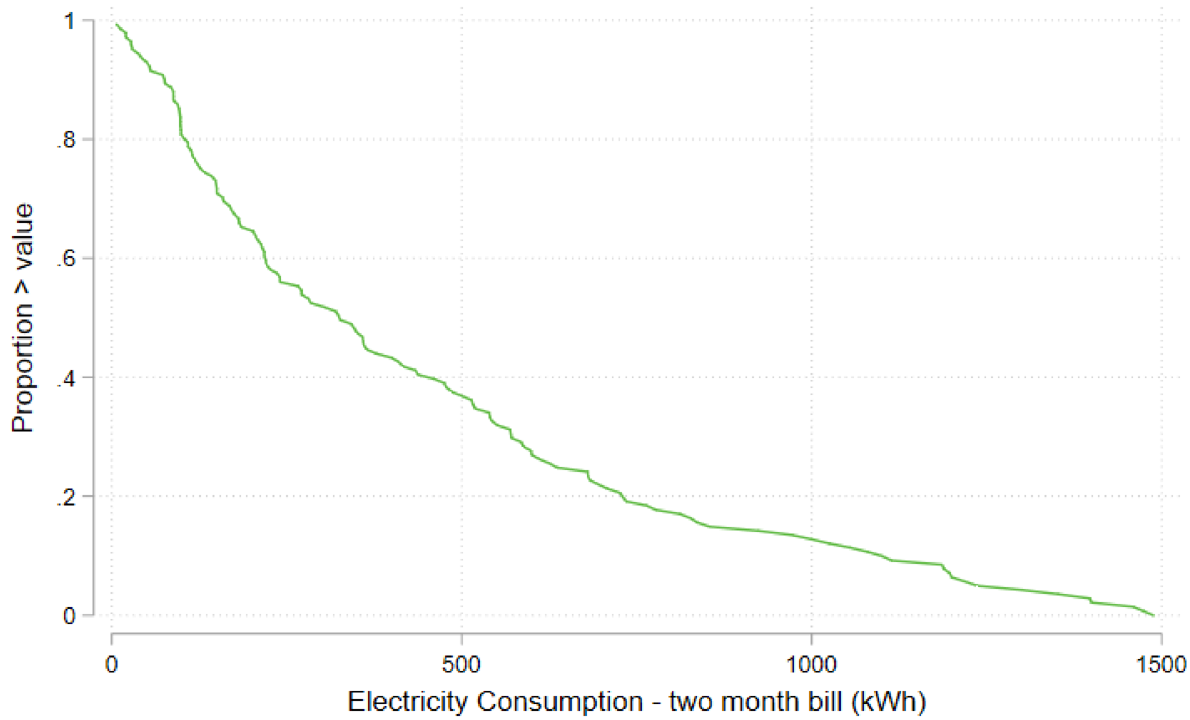


Connected informal businesses - Obs = 487
Obs. excluded from figure (X-Threshold = 1500): 13 observations

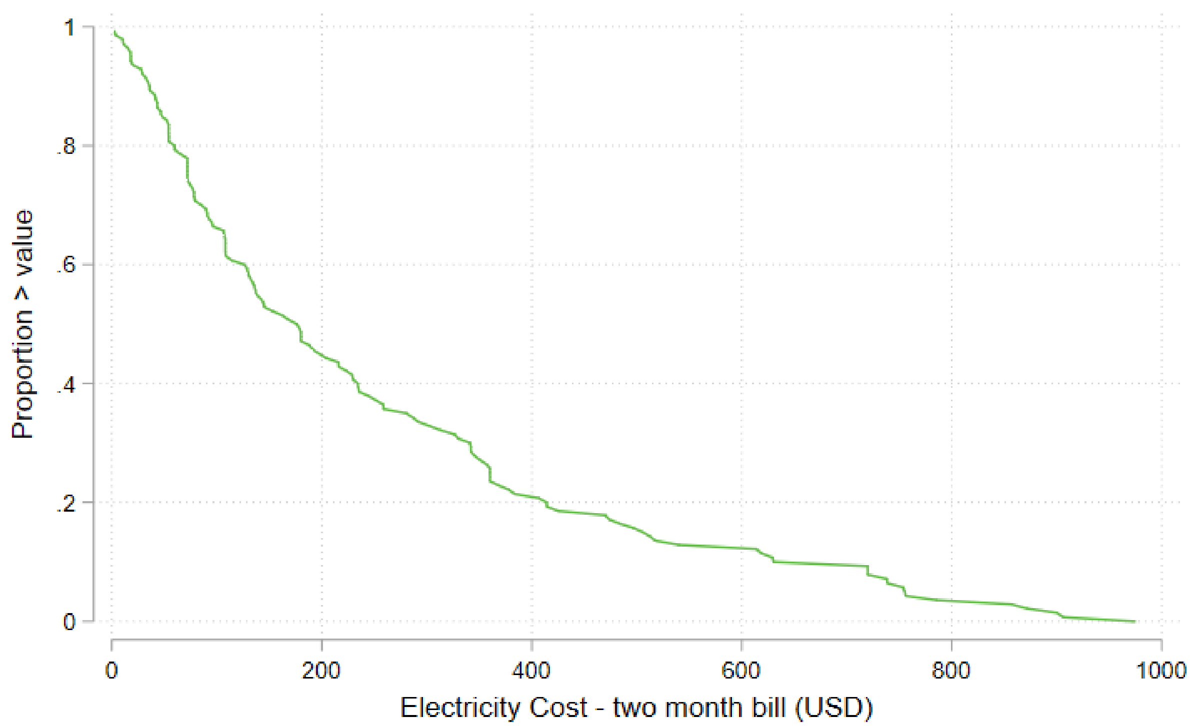


Connected informal businesses - Obs = 487
Obs. excluded from figure (X-Threshold = 1000): 4 observations

FIGURE 15 CONSUMPTION AND EXPENDITURES IN ELECTRICITY SERVICES – CONNECTED BUSINESSES - FORMAL



Connected formal businesses - Obs = 173
Obs. excluded from figure (X-Threshold = 1500): 32 observations

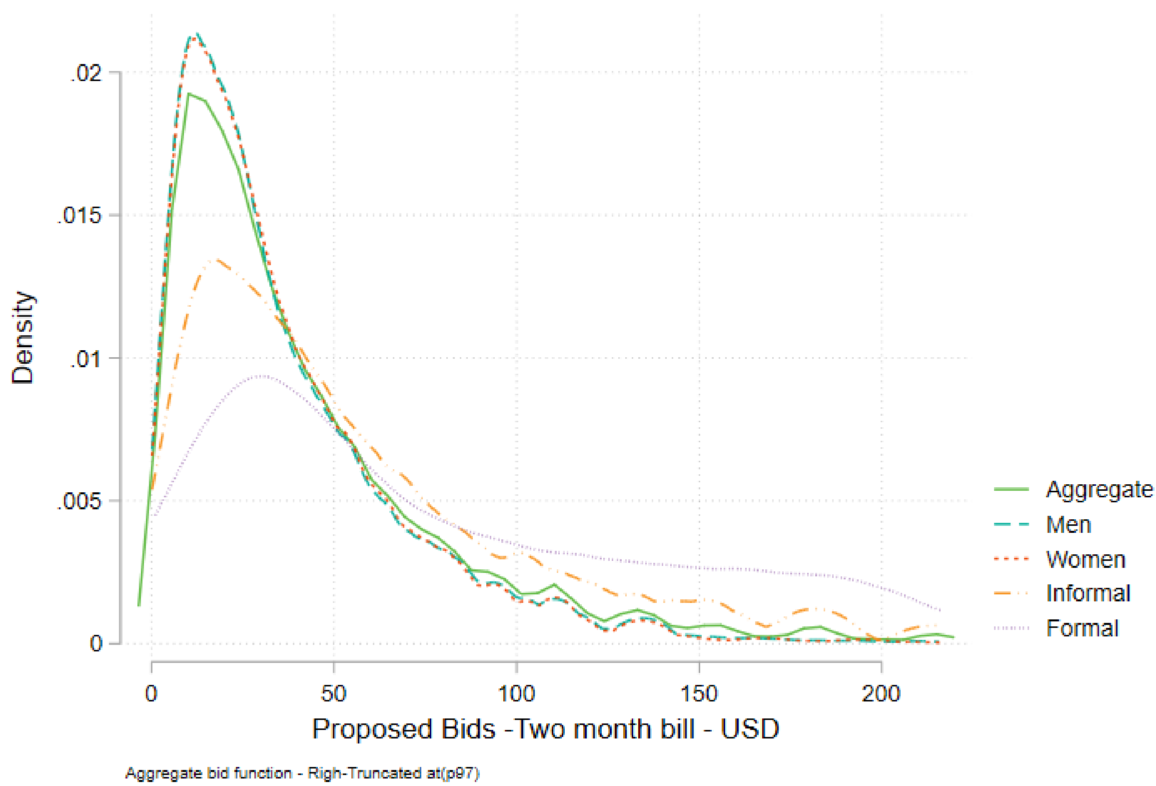


Connected formal businesses- Obs = 173
Obs. excluded from figure (X-Threshold = 1000): 33 observations

The Prices: Bids, Demand for Improved Electricity Services, and Maximum Willingness to Pay

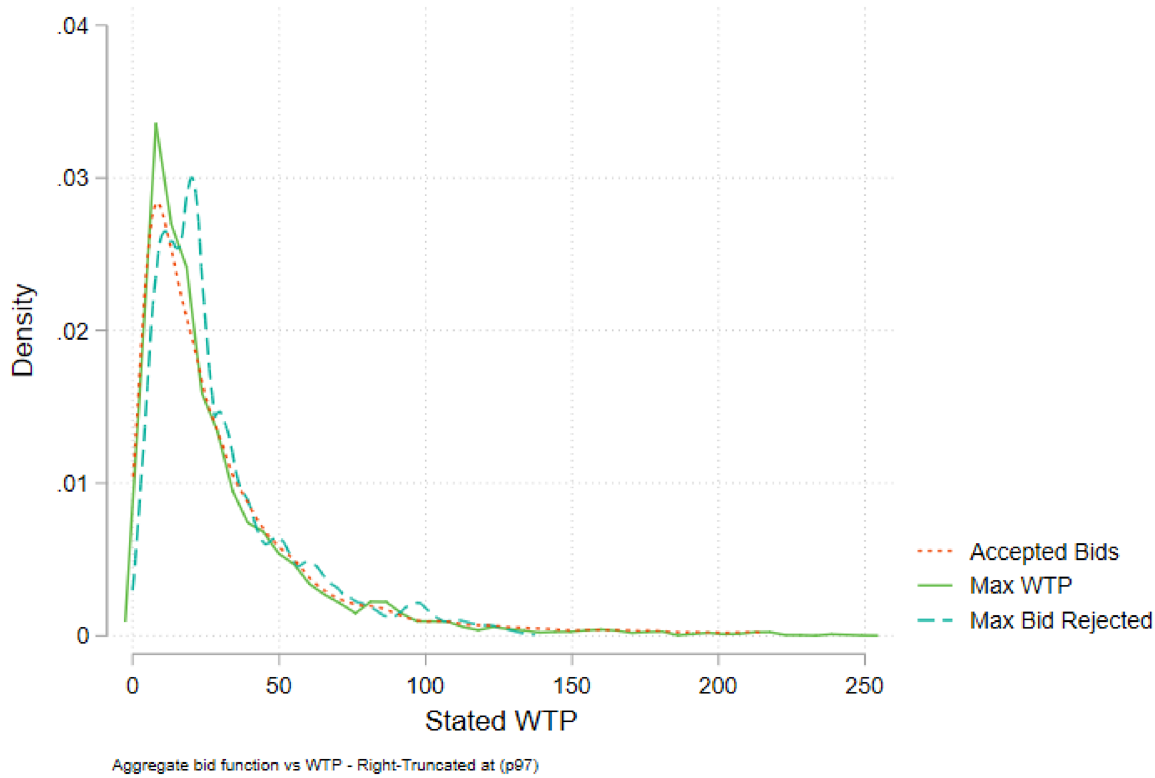
An important part of the CV method is the bids used in the game. To be able to trace out WTP in the population, the elicitation method must propose bids across a range of plausible costs. We calibrated the proposed bids based on the tariff structure currently used by the utility company. Figure 16 shows the density of the bids that respondents were exposed to or asked about for WTP. The aggregate distribution pools the observations for households and businesses. The bidding game used a wide range of bids; female and male respondents had very similar densities and the businesses had games with higher bids, as designed. The figure shows that most of the proposed bids are concentrated below 50 USD.

FIGURE 16 DENSITY ESTIMATES OF PROPOSED BIDS FOR BIDDING GAME



All respondents went through the series of questions and were asked if they were willing or not to pay those costs for improved electricity services. The bidding game consists of a string of "yes" answers and increasing bids until the respondent says "no"; or a string of "no" answers and decreasing bids until the respondent says "yes." The distribution of the maximum bid accepted (that is, respondents' maximum WTP), their highest rejected bid, and their accepted bid are reported in Figure 17. Accepted bids should be lower than the maximum WTP and the maximum rejected bid should be above the maximum WTP. This is verified in the figure. Note that the maximum WTP line is between the accepted and maximum rejected bid up to the point where they intersect; at that point the rejected bid distribution is above the maximum WTP line. Our findings suggest that small changes in the cost will not exclude large parts of the population, pointing to a somewhat inelastic demand.

FIGURE 17 DENSITY ESTIMATE OF MAXIMUM WTP VS. BIDDING FUNCTIONS



We derive the ICDF of the maximum WTP for all households and businesses by connection status (Figure 18). The figure depicts "demand" for 24/7 electricity service, with regular and fair billing based on metered use, and prompt and efficient repairs and customer service. That is the proportion of households and businesses that at a given cost are willing to connect or pay for the service. As predicted by economic theory, demand for the improved service is inversely related to its price – as the monthly consumption charge increases, the percentage of households willing and able to purchase the service declines. In addition, the ICDF of connected households and businesses dominates that of the nonconnected; for any given cost the proportion of connected households and businesses that are willing to connect is greater than that of the nonconnected.

FIGURE 18 ICDF OF MAXIMUM WTP FOR IMPROVED ELECTRICITY – AGGREGATE BY CONNECTION STATUS

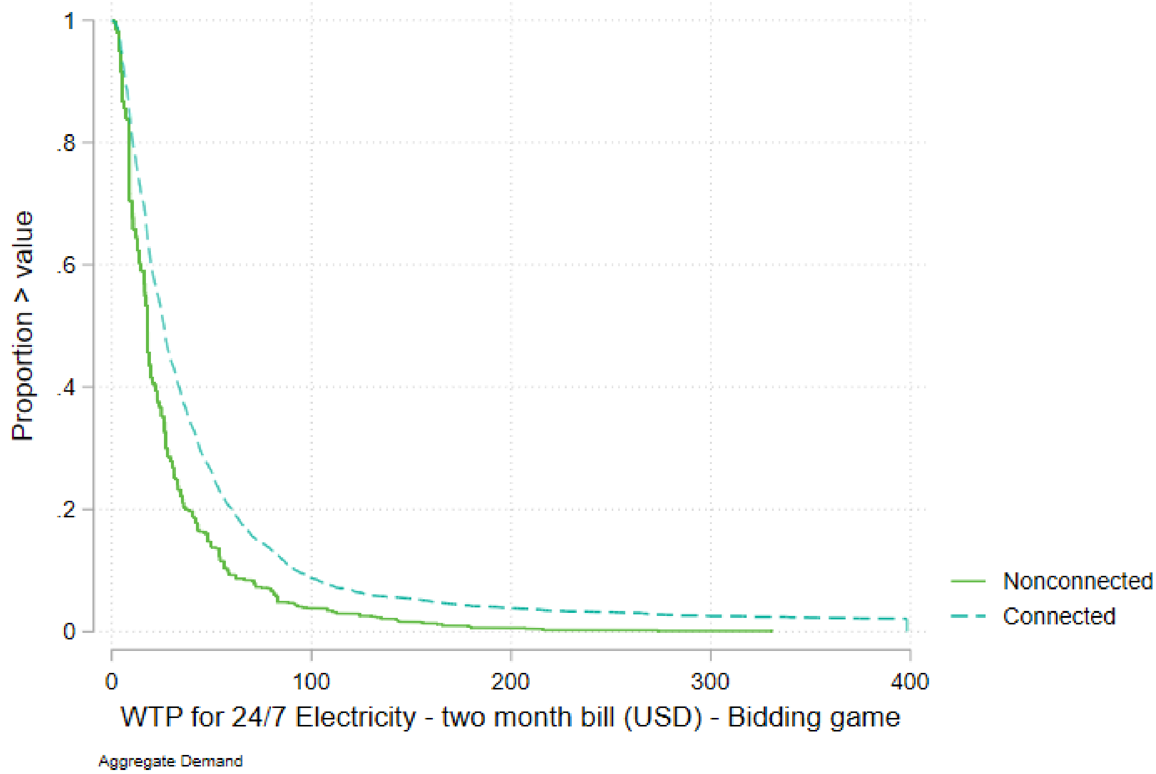


Table 16 reports the estimated WTP for nonconnected households for male and female respondents and other results from the WTP module. Over 90 percent of respondents live in areas where the electricity network is present and over 80 percent say they are willing to connect. The maximum WTP for the initial connection fee is 32.78 USD for men and 25.50 USD for women. When we compare the WTP obtained from an open-ended question versus the bidding game, both men and women have a much lower WTP. The maximum WTP from the open-ended question is on average 11.69 USD for the bimonthly electricity bill for men and 10.93 USD for women. In contrast, the bidding game obtains higher WTP estimates. Male respondents' maximum WTP is estimated at 27.09 USD for the bimonthly bill and at 23.42 USD for women in nonconnected households. Men have a higher maximum WTP for improved electricity services than women. The median WTP is estimated at 18 USD for both men and women in nonconnected households compared to 35 USD for the average connected household and 23.50 USD for the median connected household.

On average, the maximum WTP per kWh is estimated at 0.31 USD for men and 0.22 USD for women living in nonconnected households; the median is estimated at 0.10 USD per kWh for both men and women, compared to the estimated median cost of 0.20 USD experienced by connected households. For comparison, the price per kWh posted by SENELEC is 112 CFA or 0.20 USD for the highest block for domestic power users.

Table 17 presents the estimated WTP for connected households for male and female respondents and other results from the WTP module.Male respondents in connected areas spend on average 34.52 USD for 178 kWh every two months and women report spending 35.12 USD for 204.95 kWh every two months on average. Under the bidding game, male respondents' maximum WTP is 27.79 USD for the bimonthly bill and 35.12 USD for women in connected households. Women have a higher maximum WTP for improved electricity services than men, but the difference is small and not statistically significant. The median WTP is estimated at around 22 USD for both men and women in connected households. The average man is willing to pay a 9.5 percent premium to improve electricity services to 24/7 and no outages or low voltages; women's premium is estimated at 8.7 percent.

On average the maximum WTP per kWh is estimated at 0.24 USD for men and 0.22 USD for women living in connected households; the median is estimated at 0.20 USD per kWh for both men and women. This is equal to the median cost experienced by connected households in the sample.

The geographical distribution of maximum WTP estimates is mapped for connected and nonconnected households (Figure 19 and Figure 20, respectively). As expected, Dakar and suburbs have the highest WTP in the country.

TABLE 16 MAXIMUM WTP FOR NONCONNECTED HOUSEHOLDS, BY GENDER

	Men					Women				
	Mean	Std. Dev.	Median	P75	Obs.	Mean	Std. Dev.	Median	P75	Obs.
Electrified zone	0.91	0.28	1.0	1.0	315	0.92	0.28	1.0	1.0	272
Willing to connect	0.82	0.39	1.0	1.0	315	0.81	0.40	1.0	1.0	272
WTP for initial connection fee	32.78	48.03	18.0	36.0	315	25.50	33.62	18.0	29.7	272
WTP for 2-month bill 24/7 (open ended)	11.69	12.13	9.0	18.0	315	10.93	11.84	9.0	16.2	272
Max accepted bid - WTP for electricity 24/7 (USD bimonthly)	27.09	31.54	18.0	31.1	315	23.42	20.09	18.1	28.8	272
WTP for electricity 24/7 (USD per kWh)	0.31	1.71	0.1	0.2	315	0.22	0.52	0.1	0.2	272

TABLE 17 MAXIMUM WTP FOR CONNECTED HOUSEHOLDS, BY GENDER

	Men					Women				
	Mean	Std. Dev.	Median	P75	Obs.	Mean	Std. Dev.	Median	P75	Obs.
Cost of electricity	34.52	45.25	22.0	44.0	1,474	35.12	59.01	22.4	45.0	1,483
Consumption (kWh) for bidding game	178.51	224.28	118.0	234.0	1,474	204.95	881.23	119.5	242.0	1,484
Max accepted bid - WTP for electricity 24/7 (USD bimonthly)	37.79	54.97	25.0	45.9	1,474	38.18	83.51	24.1	45.9	1,484
WTP for electricity 24/7 (USD per kWh)	0.24	0.15	0.2	0.3	1,474	0.22	0.15	0.2	0.3	1,484
First bid to reduce outages to one-half (bimonthly)	24.06	34.27	15.1	29.2	1,474	23.24	34.64	14.7	28.6	1,483
WTP for one-half the outages currently (USD bimonthly)	29.60	46.85	18.0	36.0	1,474	29.27	66.84	18.0	35.2	1,484

FIGURE 19 GEOGRAPHIC DISTRIBUTION OF MAXIMUM WTP – CONNECTED HOUSEHOLDS

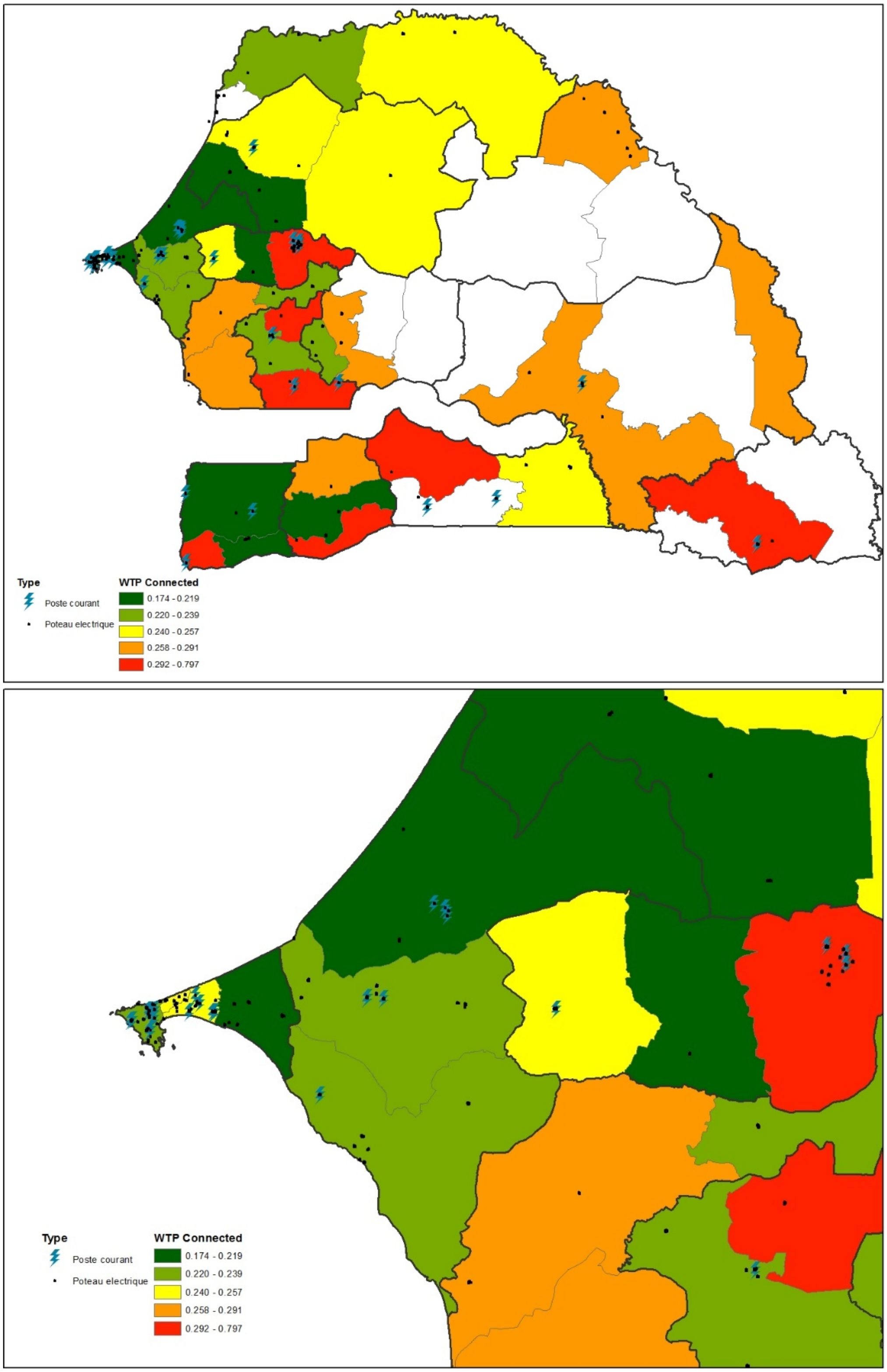
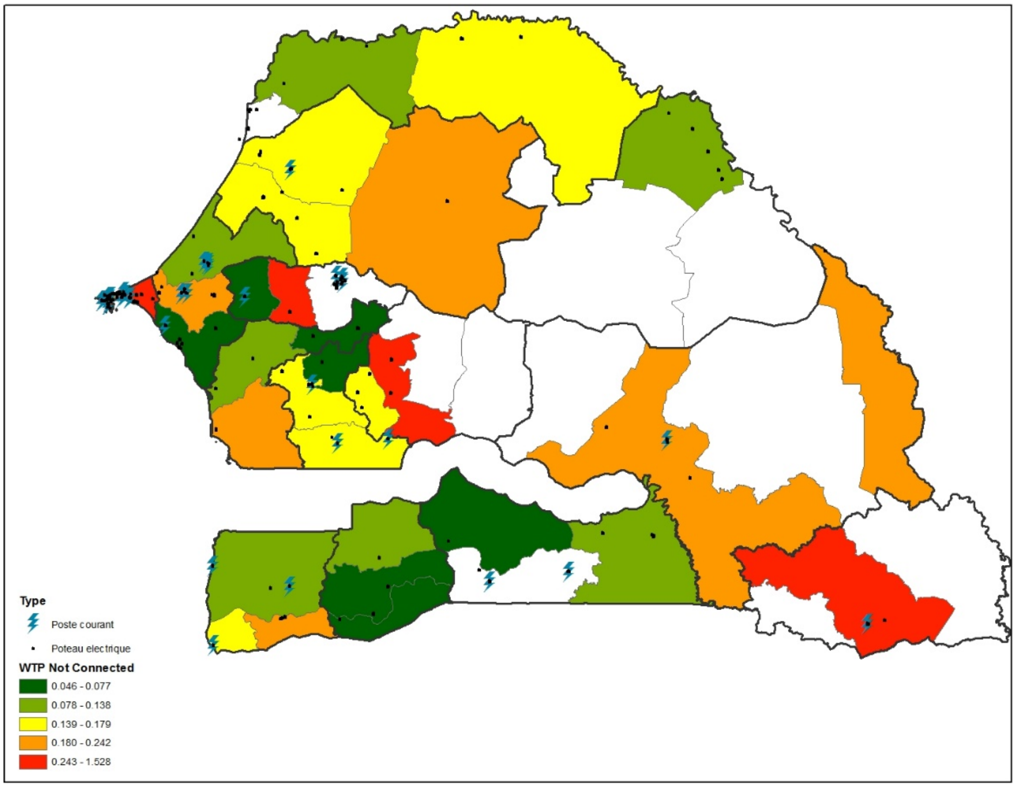


FIGURE 20 GEOGRAPHIC DISTRIBUTION OF MAXIMUM WTP – NONCONNECTED HOUSEHOLDS



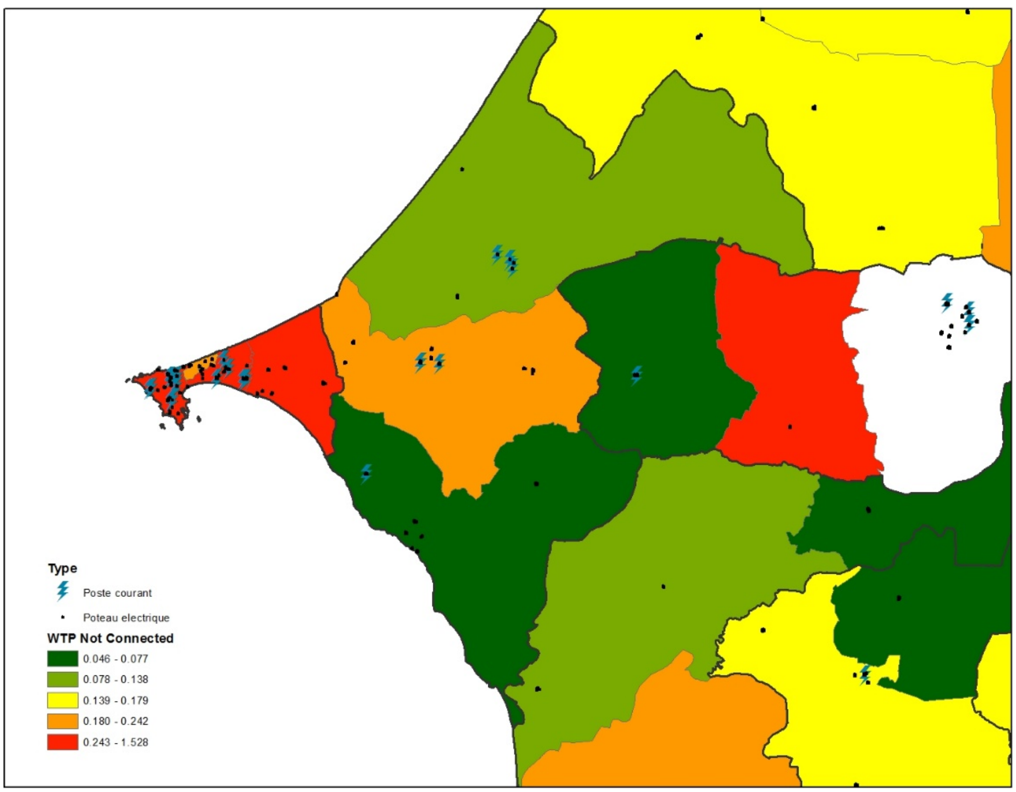


Figure 21 separates the CDF by respondents' gender for the household survey to gauge differences across the distribution for both connected and nonconnected households. The distributions are similar. The distribution for women has a more compact range and a wider gap between connected and nonconnected women. The demand for electricity is very steep for nonconnected households; a 15 percent increase in the electricity bill from 35 to 40 USD every two months pulls the proportion of men and women willing to pay below 20 percent.

FIGURE 21 CDF OF MAXIMUM WTP FOR IMPROVED ELECTRICITY BY RESPONDENTS' GENDER

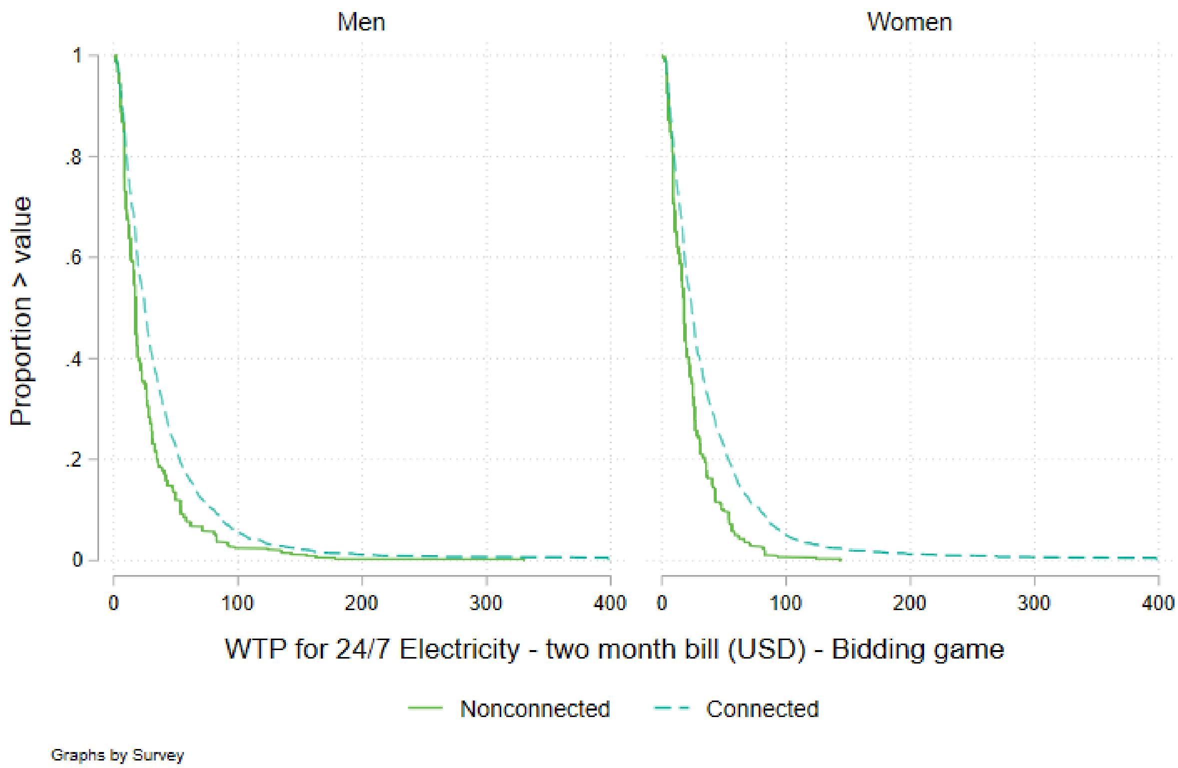


Table 18 shows the results for nonconnected informal businesses. Eighty-one percent of these businesses are in areas where there is access to electricity and 58 percent express interest in connecting to the network. The maximum WTP for the initial connection fee is estimated at 32.84 USD for the average informal business that is not connected to the network. The maximum WTP is estimated at 9.75 USD for the average informal business from the open-ended question and at 36.68 USD from the CV scenario and bidding game. The median price per kWh is estimated at 0.10 USD.[8] For comparison, the price per kWh posted by SENELEC is 149 CFA or 0.27 USD for the highest block for business power users.

[8] The sample of nonconnected formal businesses does not have enough observations to meaningfully analyze WTP, thus they are excluded from the discussion.

TABLE 18 MAXIMUM WTP FOR NONCONNECTED BUSINESSES – INFORMAL

	Mean	Std. Dev.	Median	P75	Obs.
Electrified zone (informal)	0.81	0.39	1.0	1.0	276
Interest in electricity connection	0.58	0.49	1.0	1.0	276
WTP for initial connection fee	32.84	51.99	13.1	36.0	248
WTP for 2-month bill 24/7 (open ended)	9.75	16.57	3.6	13.1	248
Max accepted bid - WTP for electricity 24/7 (USD bimonthly)	36.68	46.59	18.0	46.2	207
WTP for electricity 24/7 for nonconnected households (USD per kWh)	0.28	0.50	0.1	0.3	162

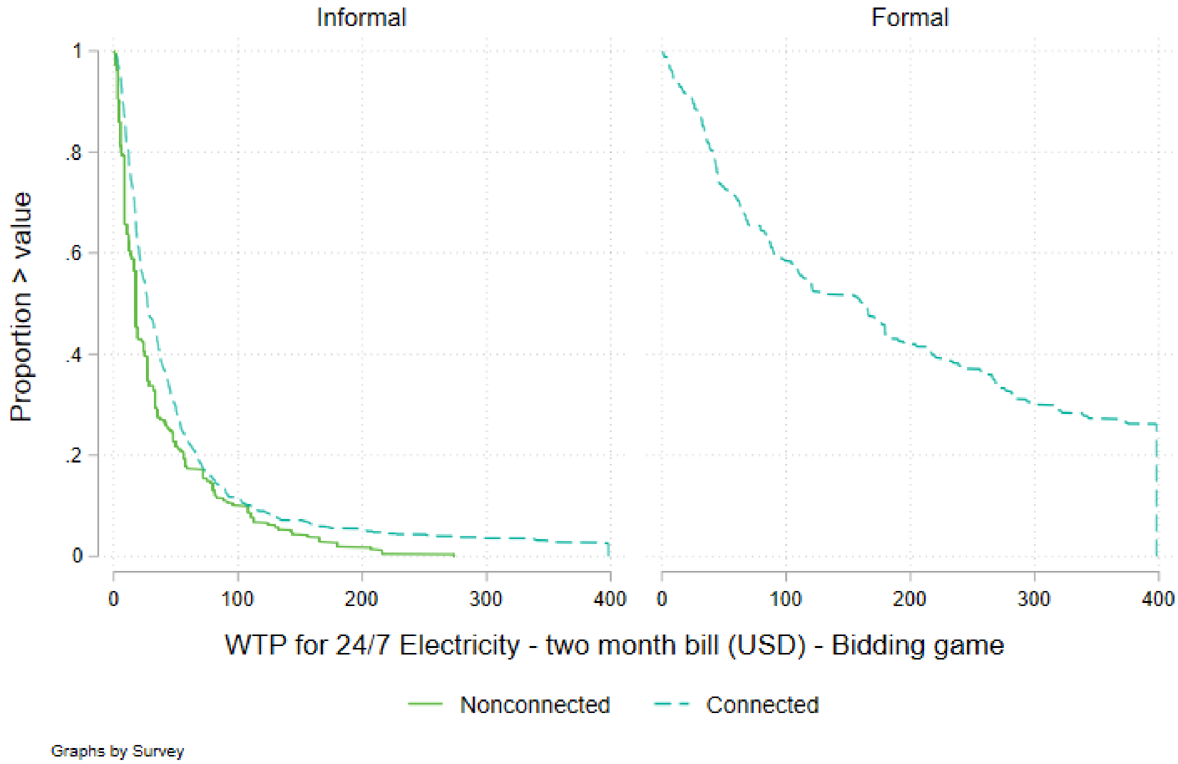
The average cost for informal businesses in connected areas is 145.38 USD for 304.40 kWh every two months and 803.25 USD and 1,200.39 kWh for formal businesses every two months (Table 19). The bidding game estimates that informal businesses have a maximum WTP of 80.06 USD for the bimonthly bill, versus 455.59 USD for formal businesses in connected areas. The estimates imply that businesses' WTP is below their current costs.

TABLE 19 MAXIMUM WTP FOR CONNECTED BUSINESSES – INFORMAL AND FORMAL

	Informal Business					Formal Business				
	Mean	Std. Dev.	Median	P75	Obs.	Mean	Std. Dev.	Median	P75	Obs.
Cost of electricity	145.38	1035.02	49.56	103.50	487	803.25	1778.69	244.80	738.36	173
Consumption (kWh) for bidding game	304.40	2376.89	100.00	200.00	487	1208.39	2212.38	478.00	1189.00	173
Max accepted bid - WTP for electricity 24/7 (USD bimonthly)	80.06	582.93	26.96	54.00	487	455.59	1060.29	159.68	398.11	173
WTP for electricity 24/7 (USD per kWh)	0.47	2.36	0.29	0.38	487	0.35	0.19	0.31	0.43	173

Figure 22 presents the CDF for businesses by connection status. Businesses' demand is less steep than that of households. For informal businesses at 100 USD every two months, over 10 percent are still willing to pay that cost. For formal connected businesses, almost 60 percent are willing to pay that amount, probably because of the expected increase in revenue and the fact that these businesses have more resources.

FIGURE 22 CDF OF MAXIMUM WTP FOR IMPROVED ELECTRICITY BY BUSINESS TYPE



Implicit Electricity Prices for kWh

To further understand the demand for improved electricity, we create a price measure that we argue is comparable across households and businesses whether they are connected or not (see Figure 23, Figure 24, Figure 25). The mass of the distributions across types and surveys is well below 0.50 USD per kWh; the household data have more outliers for nonconnected households (likely because the consumption measure is hypothetical and calculated based on a few assumptions, limiting the variation in the consumption distribution of nonconnected households). The implicit prices estimated are consistent with those observed among connected households and businesses; they are concentrated around 0.20 USD (the gap between the median price per kWh and the 75th percentile is 0.18–0.21 USD for households, 0.24–0.31 USD for informal businesses, and 0.30–0.32 USD for formal businesses). For comparison, the average tariff in Senegal is 0.24 USD and the government plans to improve the efficiency of the system to bring this to 0.10 (comparable to other countries in the region). The estimate suggests that residual demand exists for a tariff of 0.10–0.24 USD.

Figure 23 Distribution of Price per kWh from Maximum WTP – Nonconnected Households by Respondents' Gender

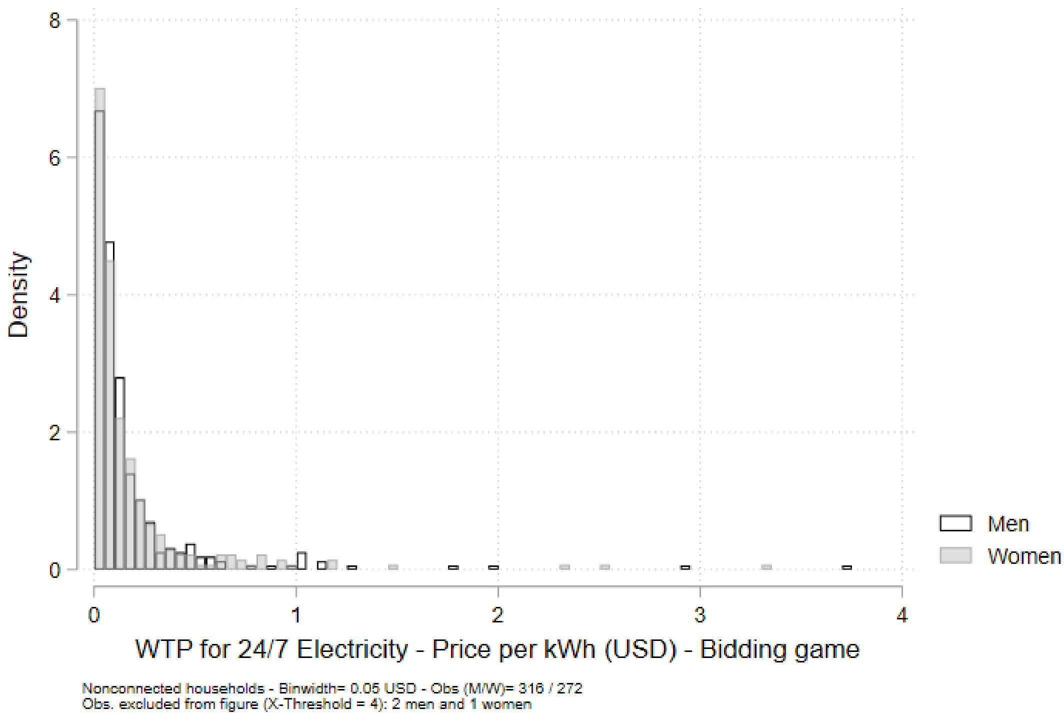


Figure 24 Distribution of Price per kWh from Maximum WTP –Connected Households by Respondents' Gender

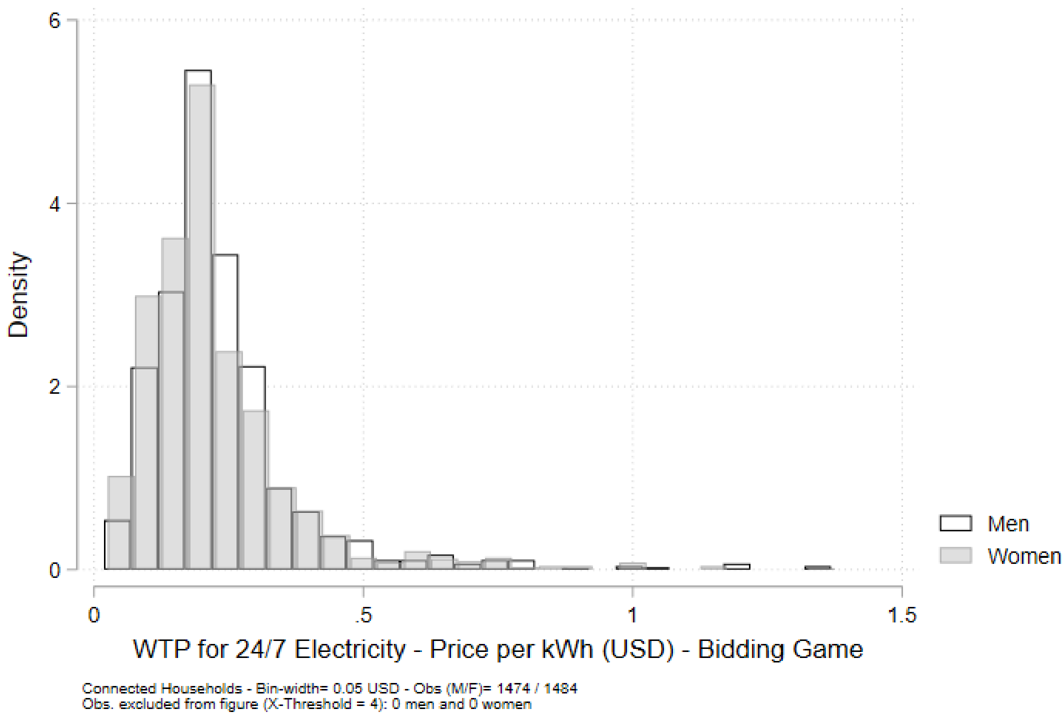
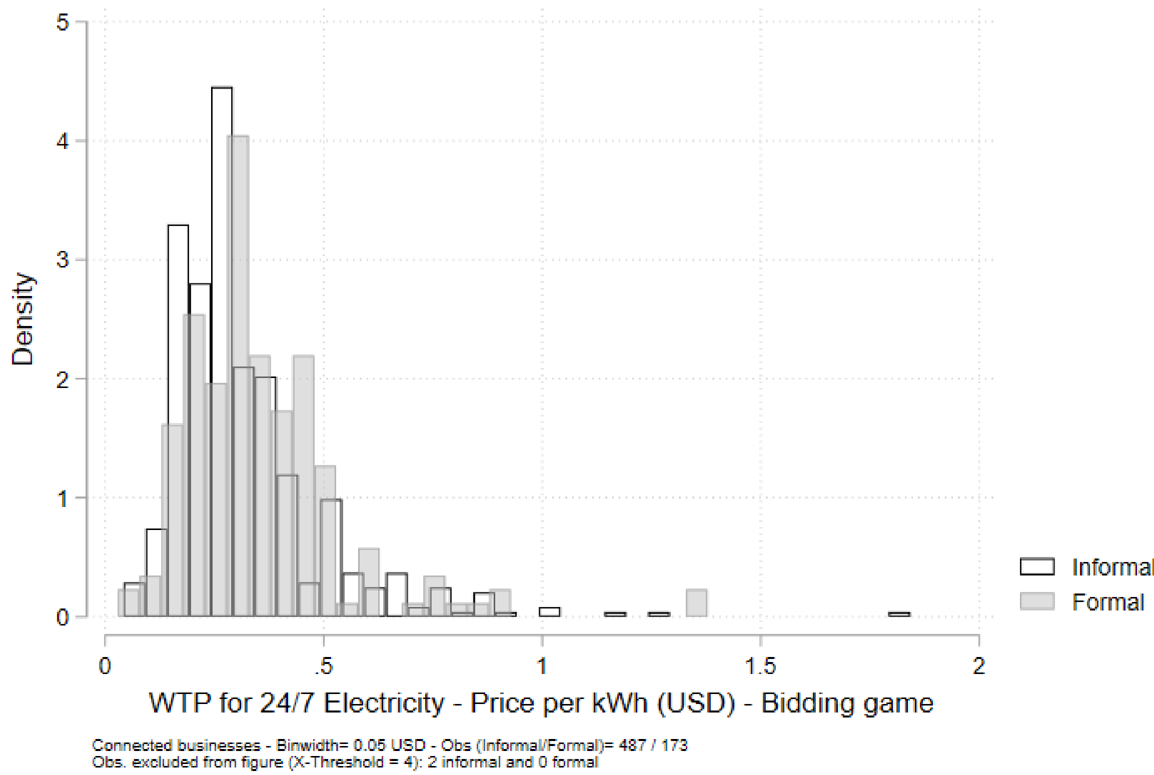


FIGURE 25 DISTRIBUTION OF PRICE PER KWH FROM MAXIMUM WTP –CONNECTED BUSINESSES BY TYPE



Validation Tests: Starting Point Bias and Elasticities of Prices and Income

In the bidding game, the interviewer starts the questioning at an initial price. A respondent who is unsure of an appropriate answer and wants to please the interviewer may interpret this initial price as a clue as to the "correct" bid. Starting point bias exists if this initial price affects the individual's final WTP. To test for starting point bias, the sample is distributed across five different initial bids. This allows us to test whether respondents' WTP is influenced by the magnitude of the first price they receive (Herriges and Shogren, 1996).

A way to think about the effect of different starting points is that respondents hold a precise WTP amount in their mind and they try to accurately communicate it to the interviewer. Respondents would have to answer very different numbers of questions depending on which starting point game they received. Figure 26 shows the cumulative distribution function (CDF) of bids respondents had to answer in the bidding game. Respondents who want to “tell the truth” about their WTP are sent through a maze of questions depending on which starting point they are randomly assigned. Finding their way through such a maze during the course of a long interview is very taxing. Our finding suggests that when bids are high or low (in the extremes), the number of questions is larger, pointing to respondents having a WTP in mind and taking the bidding game seriously (Vossler, Doyon, and Rondeau 2012).

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Figure 26 CDF of Number of Bids Received by Starting Point

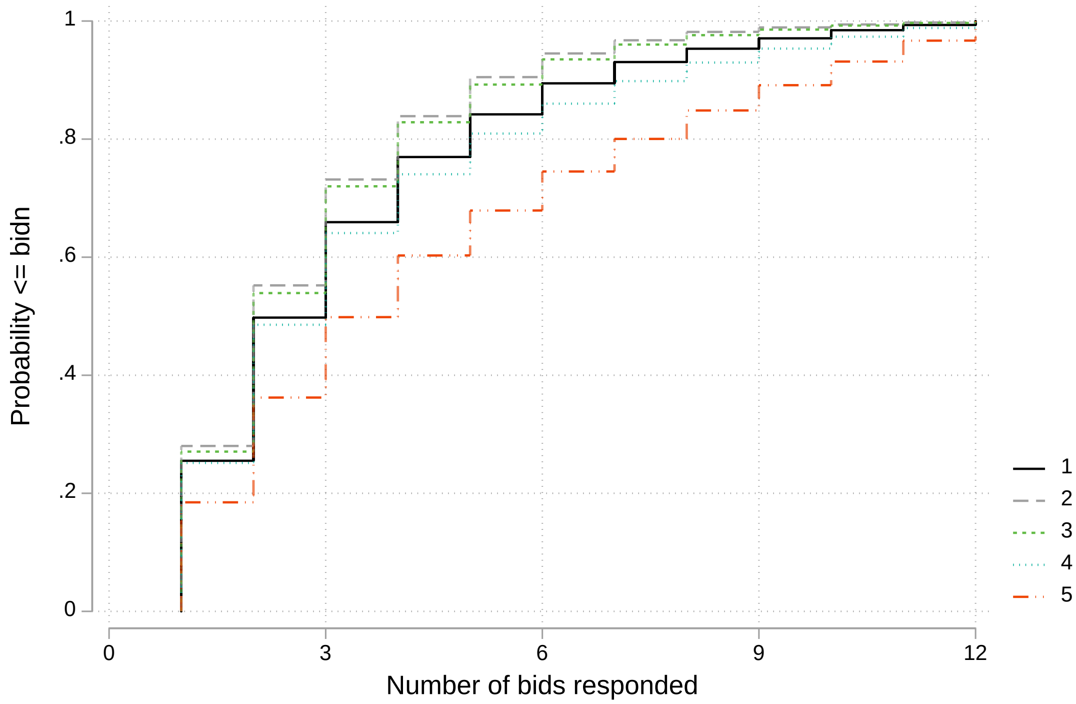


Figure 27 presents the ICDFs of maximum WTP responses for the five starting points in the bidding games for nonconnected households by gender. The results for the bidding games look similar across gender. However, a "starting point" effect arises for both women and men, with the distribution heaped at the first bid values. For example, the 54 USD starting point distribution has a "kink," suggesting that more respondents appear to have answered "yes" to the starting price in this bidding game (that is, more respondents said that they were willing to pay this price than the other bidding games would suggest). This could be interpreted as lending support to the hypothesis that the initial starting price conveys information about the perceived cost of electricity among nonconnected households.

If different starting points convey information about the cost of the good or service provided, then they should induce different answers from respondents. In other words, if the different starting points elicit different answers, one would conclude that respondents in fact took the CV scenario seriously. Across genders, the starting point effect is more pronounced among men. That is, higher starting points move the distribution of maximum WTP more for men than for women. Men are more susceptible to the information conveyed by the starting point. Estimation of the mean maximum WTP for men (first column) and women (second column) and the F test for joint significance of the starting bid indicators support findings from the figures (Table 20). For men the results suggest that the mean WTP increases with the amount of the first bid but that the final WTP is not significantly different across men who had different starting bids. Men end up at the same WTP regardless of the starting point but are affected by the starting point. For women, regardless of the starting point they end up at the same place; that is, they are not very affected by the starting point. They are less susceptible to the initial nudge.

Based on these results, there is no overwhelming reason to adjust the WTP bids for starting point bias. The mean of WTP bids for nonconnected households was 23 USD per household every two months for men and 27 USD for women. With an average monthly expenditure of 299 USD in the sample, the mean bid for nonconnected households is 3.8–4.5 percent of household expenditures. Respondents who received different starting points provided essentially the same WTP answers, suggesting we should have confidence that they were revealing their “true” WTP.

FIGURE 27 STARTING POINT BIAS OF MEN (TOP) AND WOMEN (BOTTOM) IN NONCONNECTED HOUSEHOLDS

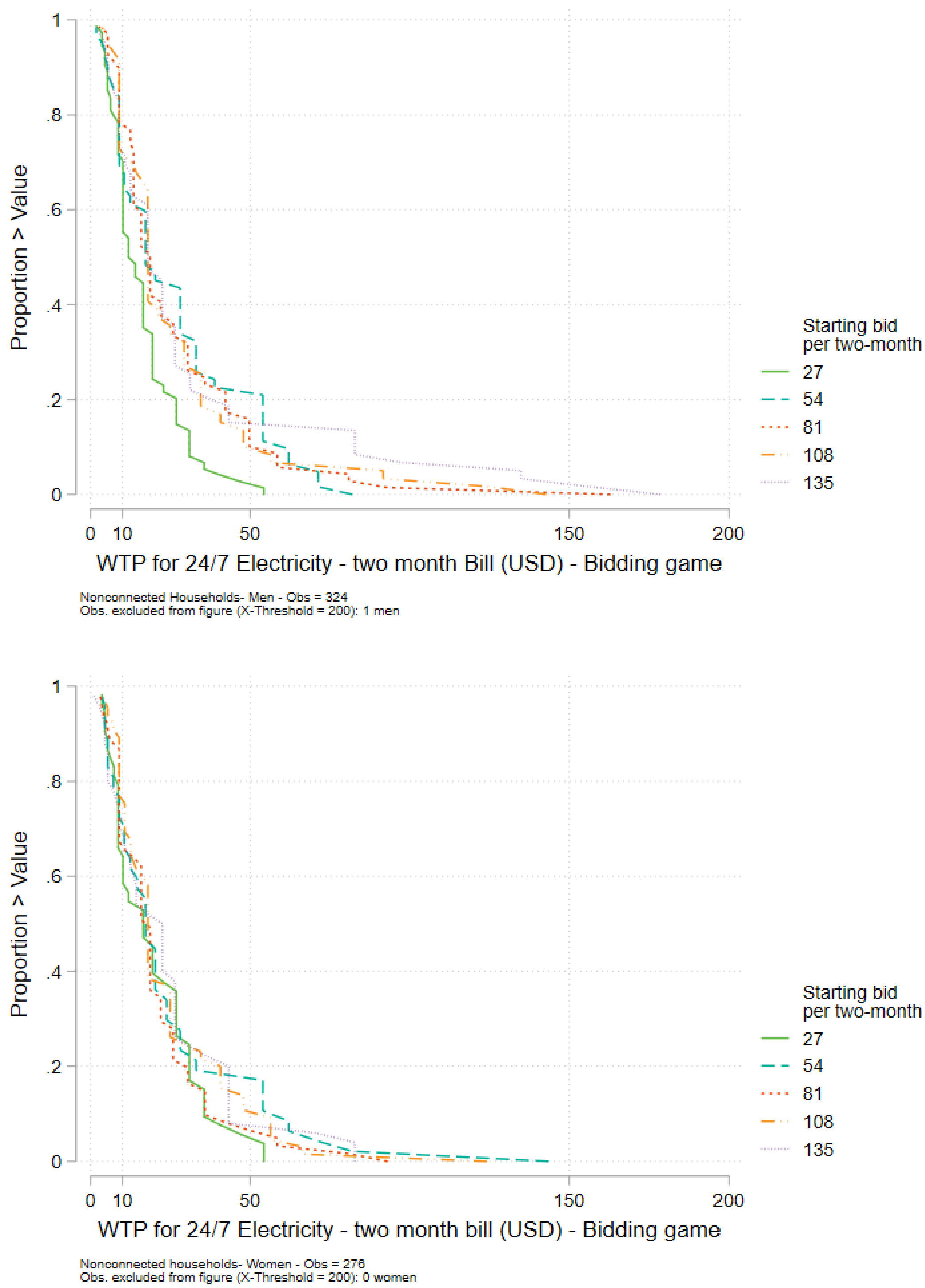


TABLE 20 REGRESSION TEST FOR STARTING POINT BIAS FOR NONCONNECTED HOUSEHOLDS, BY GENDER

	Max accepted bid - WTP for electricity 24/7 (USD bimonthly)	
	Men	**Women**
First bid for bidding game=54 USD	10.5	5.26
	[2.80]***	[4.27]
First bid for bidding game=81 USD	10.7	1.19
	[3.18]***	[2.90]
First bid for bidding game=108 USD	16	4.51
	[5.62]***	[3.10]
First bid for bidding game=135 USD	16.1	4.05
	[5.48]***	[3.81]
Lowest bid (27 USD)	16.4	20.1
	[1.42]***	[2.23]***
Mean WTP	26.8	23.2
Std. Dev. WTP	31.3	20
Join F Test	1.16	4.21
Prob>F	0.33	0.0036
Number of clusters	115	106
Observations	324	276
R-Squared	0.039	0.01

Standard errors in brackets.
Std. errors are clustered at the PSU level and adjusted for the sampling design. Differences in sample sizes are due to missing information in variables.

* p<0.10, ** p<0.05, *** p<0.01

The discussion of WTP for nonconnected households concludes with Table 21, which shows the validity tests performed on WTP based on economic theory. The tests consist of linear regressions of the maximum WTP with correlates and proxies of tastes and variables assumed to be in the demand function for electricity and for which economic theory would suggest a particular effect on demand. We perform the following tests:

- positive and significant coefficient for income, or positive income elasticity in column (1);
- negative and significant coefficient for the bid and connection charges, or negative price elasticity in columns (2) and (3) [9];
- positive and significant coefficient for the monthly per capita consumption of electricity or capacity in the nonconnected case in column (4);
- positive and significant coefficients for coping costs in column (5), and education level in column (6).

These tests have the expected results with statistical significance for both male and female respondents. This shows that respondents understood the CV scenarios, and we can thus be confident of the information derived from the WTP data.

[9] Column (3) is a probit equation where the dependent variable is an indicator for a yes response for a given bid to show the negative price elasticity in the bidding game with a discrete choice model. This complements the results in column (2).

TABLE 21 REGRESSION TESTS FOR VALIDITY OF WTP FOR NONCONNECTED HOUSEHOLDS, BY GENDER

	(1)	(2)	(3)^	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
	Max accepted bid - WTP for Electricity 24/7 (USD bimonthly) (m)						Max accepted bid - WTP for Electricity 24/7 (USD bimonthly) (f)					
	Men						**Women**					
Monthly expenditure in USD	0.066						0.03					
	[0.016]***						[0.013]**					
Bid 1		-2.55						-2.33				
		[0.26]***						[0.19]***				
Bid 2		3.17						2.88				
		[0.31]***						[0.23]***				
Total capacity kWh (hypothetical)		0.77	0.027	1.17				0.45	0.053	0.82		
		[0.24]***	[0.0091]***	[0.39]***				[0.18]**	[0.015]***	[0.31]***		
Bid 1			-0.00002						-0.00005			
			[0.000006]***						[0.0000086]***			
Household size				5.88						0.9		
				[2.07]***						[1.33]		
Electrified zone					-2.04						-8.69	
					[9.60]						[4.97]*	
Distance to nearest electricity pole (meters)					0.026						0.012	
					[0.0081]***						[0.0036]***	
Expenditure total coping (USD/month)					0.33						0.019	
					[0.17]*						[0.076]	
Age						0.12						0.095
						[0.17]						[0.12]
Head of household						-5.26						-6.9
						[5.41]						[2.87]**
Marital status						0.54						0.07
						[2.15]						[1.54]
Primary						26.9						-1.28
						[10.2]***						[4.36]
Secondary or more						31.7						-8.59
						[11.1]***						[11.6]
Speaks French						-15.3						7.8
						[9.27]						[4.70]
Constant	13.8	3.42	-0.71	6.87	21	21.4	17.5	6.47	0.19	16.4	29.5	20.7
	[2.76]***	[2.53]	[0.21]***	[4.27]	[9.25]**	[10.7]**	[2.50]***	[1.90]***	[0.26]	[2.63]***	[4.92]***	[4.93]***
Mean WTP	26.8	27.2	0.13	27.2	26.8	26.8	23.2	23.4	0.12	23.4	23.2	23.2
Std. Dev. WTP	31.3	31.5	0.34	31.5	31.3	31.3	20	20.1	0.32	20.1	20	20
Number of clusters	115	114	114	114	115	115	106	106	106	106	106	106
Observations	324	317	319	317	324	323	276	273	274	273	276	276
R-Squared	0.14	0.67		0.21	0.075	0.068	0.035	0.48		0.13	0.039	0.032

Std. errors in brackets are clustered at the PSU level and adjusted for the sampling design. Differences in sample sizes are due to missing information in variables. Column (3)^ is a probit where the dependent variable is an indicator for a yes response for a given bid. Other columns are OLS regression where the dependent variable is the maximum WTP for each respondent from the elicitation game.
* p<0.10, ** p<0.05, *** p<0.01

For connected households (Figure 28), respondents who received different starting points provided essentially the same WTP answers, and differences across starting points are not significant. Here too, the results suggest we should have confidence that they revealed their “true” WTP, and that for those who have experience with electricity services, starting point differences do not matter much. They have a maximum WTP in mind and the bidding game reveals it.

Overall, there is no reason to adjust the WTP bids for starting point bias. The mean of WTP bids for connected households was around 38 USD per household every two months. With an average monthly expenditure of 299 USD, the mean bid for connected households is 6.4 percent of household expenditures.

The results reported in Table 22 are the converse of those found for nonconnected households, indicating that the mean maximum WTP for men (first column) and women (second column) and the final WTP are not significantly different across different starting bids. Men end up at the same WTP regardless of the starting point and are not affected by the starting point (as opposed to nonconnected men, who had a positive correlation with the starting bid). The results indicate that the starting point affects women’s maximum WTP and that they are affected by the higher two starting points. Women are susceptible to the initial nudge if it is large enough, and the effect is smaller for them than for men in nonconnected households.

Figure 28 Starting Point Bias of Men (top) and Women (bottom) in Connected Households

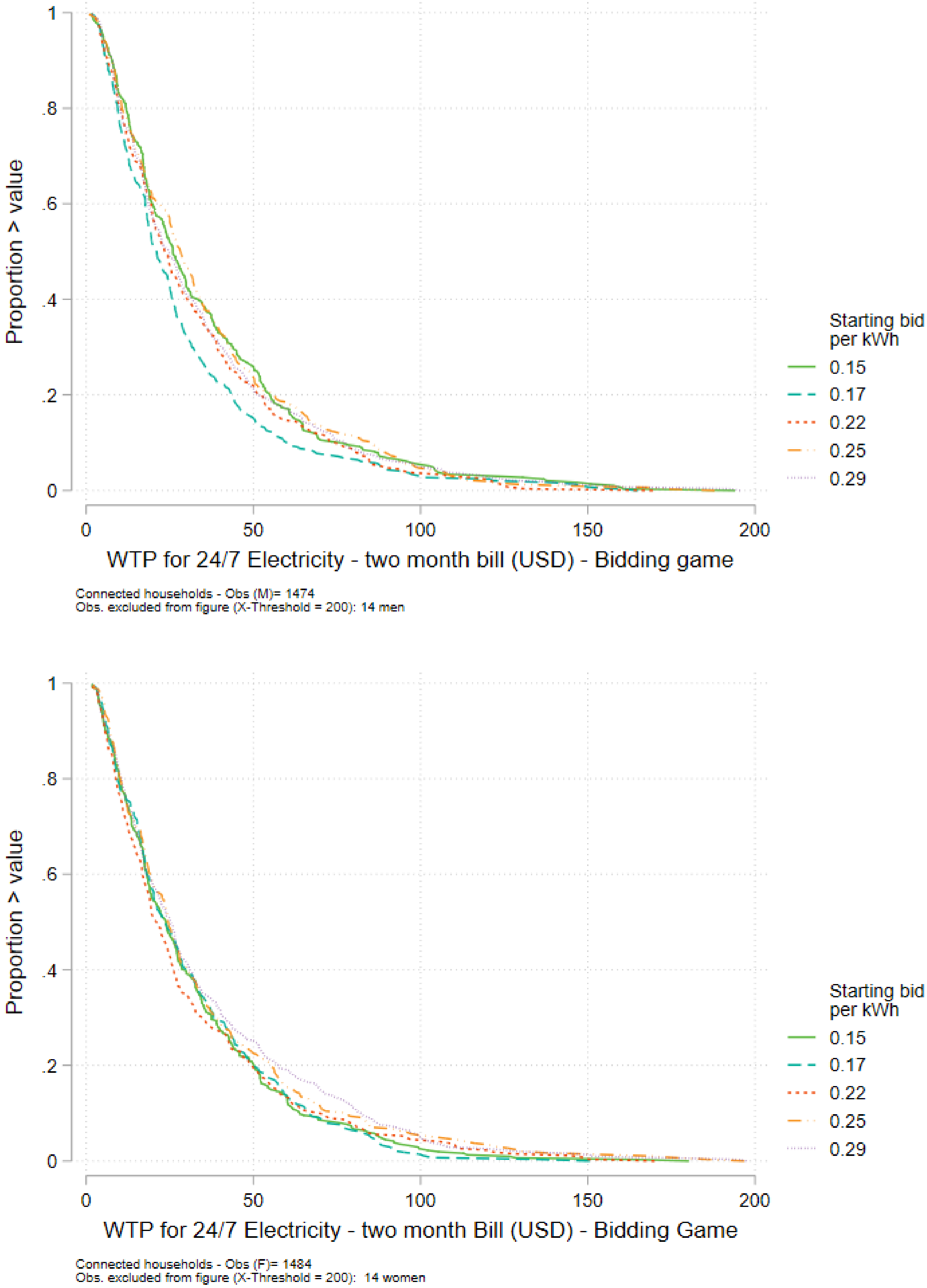


TABLE 22 REGRESSION TEST FOR STARTING BID BIAS FOR CONNECTED HOUSEHOLDS, BY GENDER

	Max accepted bid - WTP for electricity 24/7 (USD bimonthly)	
	Men	**Women**
Starting price per kWh =0.171 USD	-20	2.31
	[16.0]	[2.76]
Starting price per kWh =0.216 USD	12.2	11.4
	[27.4]	[7.84]
Starting price per kWh =0.252 USD	-16.8	21.2
	[15.2]	[9.20]**
Starting price per kWh =0.288 USD	-2.77	23
	[18.0]	[11.1]**
Constant	54.2	31.6
	[15.5]***	[1.82]***
Mean WTP	47.9	43.7
Std. Dev. WTP	217.9	144
Join F Test	2.42	13.8
Prob>F	0.051	1.90E-09
Number of clusters	150	150
Observations	1497	1498
R-Squared	0.0029	0.0049

Standard errors in brackets.
Std. errors are clustered at the PSU level and adjusted for the sampling design. Differences in sample sizes are due to missing information in variables.
* p<0.10, ** p<0.05, *** p<0.01

The discussion of WTP for connected households concludes with Table 23, which shows the validity tests performed on WTP based on economic theory. Column (1) shows a positive but insignificant coefficient for income, or nonnegative income elasticity; columns (2) and (3) estimate a negative and significant coefficient for the bid, or negative price elasticity; column (4) estimates a positive and significant coefficient for the monthly per capita consumption of electricity; column (5) does not find significant (or positive) effects of coping costs for men, but coping costs are positive and significant for women; column (6) finds that education level is positive and significant only for women.

These tests have the expected results in most cases, with statistical significance for male and female respondents. This shows that respondents understood the CV scenarios, and we can thus be confident of the information derived from the WTP data. For both connected and nonconnected men and women, the results indicate that the WTP bids are not random guessess but are systematically related to the variables suggested by economic theory.

TABLE 23 REGRESSION TESTS FOR VALIDITY OF WTP FOR CONNECTED HOUSEHOLDS, BY GENDER

	(1)	(2)	(3)^	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
	Max accepted bid - WTP for Electricity 24/7 (USD Bimonthly)						Max accepted bid - WTP for Electricity 24/7 (USD Bimonthly)					
	Men						Women					
Monthly expenditure in USD	0.0067						0.0034					
	[0.0082]						[0.0043]					
Bid 1		-3.05						-2.41				
		[0.25]***						[0.20]***				
Bid 2		4.07						2.78				
		[0.30]***						[0.094]***				
Consumption (kWh) for bidding game		-0.083	0.0035	0.016				0.059	0.0026	0.064		
		[0.032]***	[0.0012]***	[0.016]				[0.043]	[0.00088]***	[0.025]**		
Bid 1			-0.000036						-0.000022			
			[0.000013]***						[0.0000075]***			
Household size				5.98						5.72		
				[2.04]***						[2.88]**		
Hours of electricity use per day					0.77						1.43	
					[0.61]						[0.27]***	
Outages per day					0.019						2.78	
					[2.57]						[3.90]	
Avg. duration of outages (minutes)					0.066						-0.071	
					[0.066]						[0.042]*	
Prior notice of outages					71.4						12.4	
					[49.4]						[16.4]	
Experiences low voltages					-12.6						-1.16	
					[17.4]						[8.14]	
Expenditure total coping (USD/month)					0.016						0.66	
					[0.27]						[0.35]*	
Age						-0.54						0.31
						[0.53]						[0.34]
Head of household						0.55						-8.97
						[14.3]						[6.01]
Marital status						-11.2						0.88
						[6.64]*						[4.58]
Primary						-2.81						11.2
						[11.2]						[5.79]*
Secondary or more						-2.43						48.5
						[12.1]						[18.8]**
Speaks French						3.89						7.48
						[9.44]						[8.01]
Constant	46	12.9	0.49	20.7	33.1	90.4	42.2	14.1	0.19	12.4	8.98	20.8
	[6.43]***	[1.53]***	[0.080]***	[5.04]***	[26.5]	[39.8]**	[3.46]***	[1.13]***	[0.067]***	[8.22]	[15.7]	[16.2]
Mean WTP	47.9	37.8	0.63	37.8	48.3	47.9	43.7	38.3	0.57	38.3	43.8	43.7
Std. Dev. WTP	217.9	54.9	0.48	54.9	230.2	217.9	144	83.5	0.5	83.5	147.5	144
Number of clusters	150	150	150	150	148	150	150	150	150	150	149	150
Observations	1497	1480	1480	1480	1160	1497	1498	1492	1493	1492	1198	1498
R-Squared	0.0012	0.75		0.069	0.012	0.0022	0.00076	0.86		0.44	0.016	0.016

Standard errors in brackets.
Std. errors are clustered at the PSU level and adjusted for the sampling design. Differences in sample sizes are due to missing information in variables. ^Column (3) is a probit where the dependent variable is an indicator for a yes response for a given bid. Other columns are OLS regression where the dependent variable is the maximum WTP for each respondent from the elicitation game.
* p<0.10, ** p<0.05, *** p<0.01

4.4 Analysis of WTP for Improvement in Outages and Low Voltages

The maximum WTP obtained in the previous section is for the best service level that could be hypothesized. The level of service might be less than perfect and the benefits of access to electricity would remain: increased access to refrigeration, increased hours of lighting, etc. Taking this into account, we designed two additional bidding games to gauge the differential maximum WTP for electricity services that are not perfect but still represent an improvement over the current level of services. In the analysis that follows, we estimate the maximum WTP for electricity services where outages or low voltages are reduced to one-half of their current level. We compare this amount to the maximum WTP obtained before and to respondents' current electricity cost (last bimonthly bill).

These ratios convey the discount necessary to make respondents indifferent between the improved but imperfect level of service and the cost of the service. In general, we expect the ratio relative to the maximum WTP to be below one. However, this is not necessarily the case, since respondents might value the service and their demand is not sensitive to its attributes. On the other hand, if respondents took the previous CV scenario and bidding game seriously, we should not observe many values above one. In the case where the ratio is relative to current electricity costs, the ratio can take a wider range of values if demand for electricity is inelastic with respect to these values. Respondents were independently randomly assigned to different proportions of the stated WTP in the previous game to trace out the demand for this level of service.

Connected households experience one or two outages per day (Figure 29). Table 24 shows the distribution of duration of outages; 40 percent of the household sample reports outages of 20–60 minutes. In addition, 61 percent of connected households report experiencing low voltages. This information suggests that the improvements in outages and low voltages presented in the scenario are plausible and respondents can relate to them.

TABLE 24 AVERAGE DURATION OF OUTAGES IN HOUSEHOLD SAMPLE

	Freq.	Percent
0–10 minutes	530	29.5
11–20 minutes	342	19.0
21–30 minutes	420	23.4
31–60 minutes	301	16.7
1–2 hours	118	6.6
2+ hours	88	4.9
Total	1,799	100

FIGURE 29 DISTRIBUTION OF POWER OUTAGES IN HOUSEHOLD SAMPLE

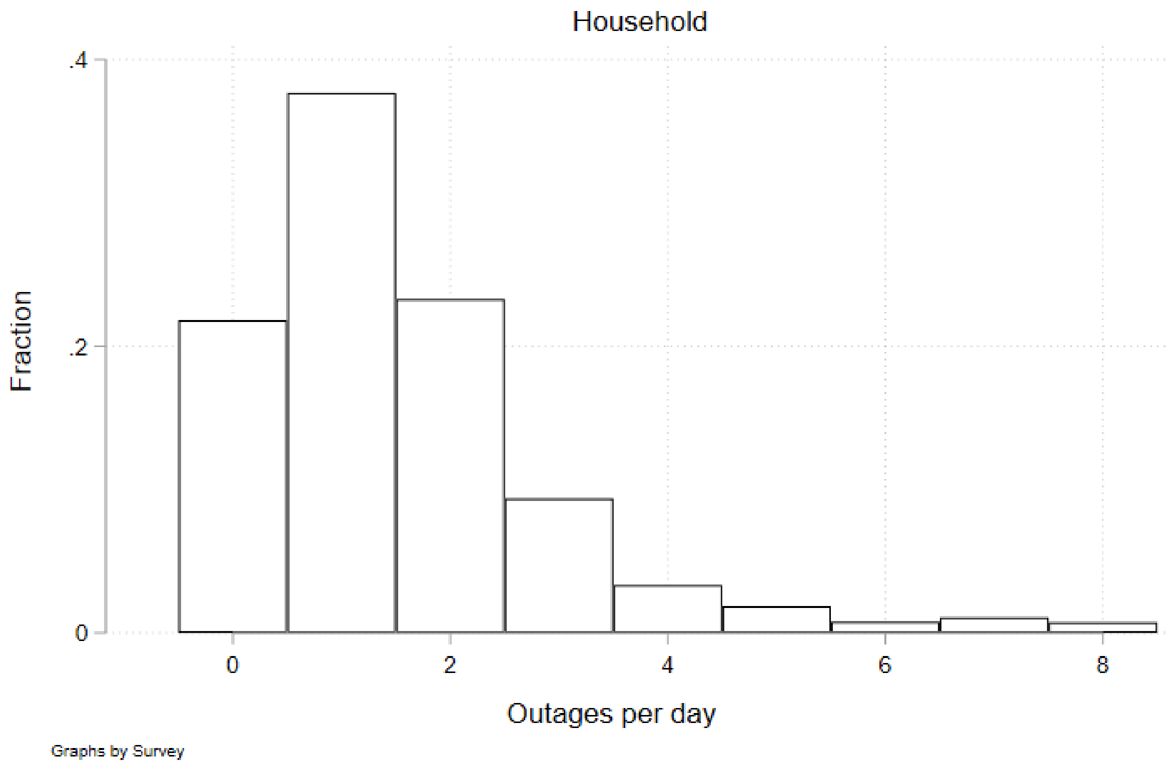


Table 25 reports the estimated WTP for improvements in outages and low voltages. The average WTP for one-half of the current outages for men and women, respectively, is estimated at 29.60 USD and 29.27 USD every two months; the median WTP is an estimated 18 USD for both men and women. On average, WTP for one-half of the current outages is 20 percent lower than the maximum WTP for 24/7 service. In comparison to current electricity costs, the average male respondent breaks even, and the average female respondent requires a 5 percent discount to break even. Women's WTP for one-half of the current outages is lower than their current cost, revealing that they are overpaying given their preferences. Comparing the median ratios relative to current electricity cost, these differentials are larger: 10 percent for the median male respondent and 20 percent for the median female respondent.

The average WTP for one-half of the current low voltages for men is estimated at 28.65 USD every two months and 28.26 USD for women; the medians are estimated at 18.0 USD for men and 17.4 USD for women. On average, WTP for one-half of the current low voltages is 22 and 23 percent lower than the maximum WTP for 24/7 service for men and women, respectively. In comparison to current electricity costs, the average male respondent requires a 4 percent discount to break even given his preferences, while the average female respondent requires a 9 percent discount. WTP for one-half of the current low voltages is lower than respondents' current costs across gender, revealing that they are overpaying given their preferences. Comparing the median ratios relative to current electricity costs, these differentials are larger: 10 percent for the median male respondent and 20 percent for the median female respondent, similar to the WTP found for outages.

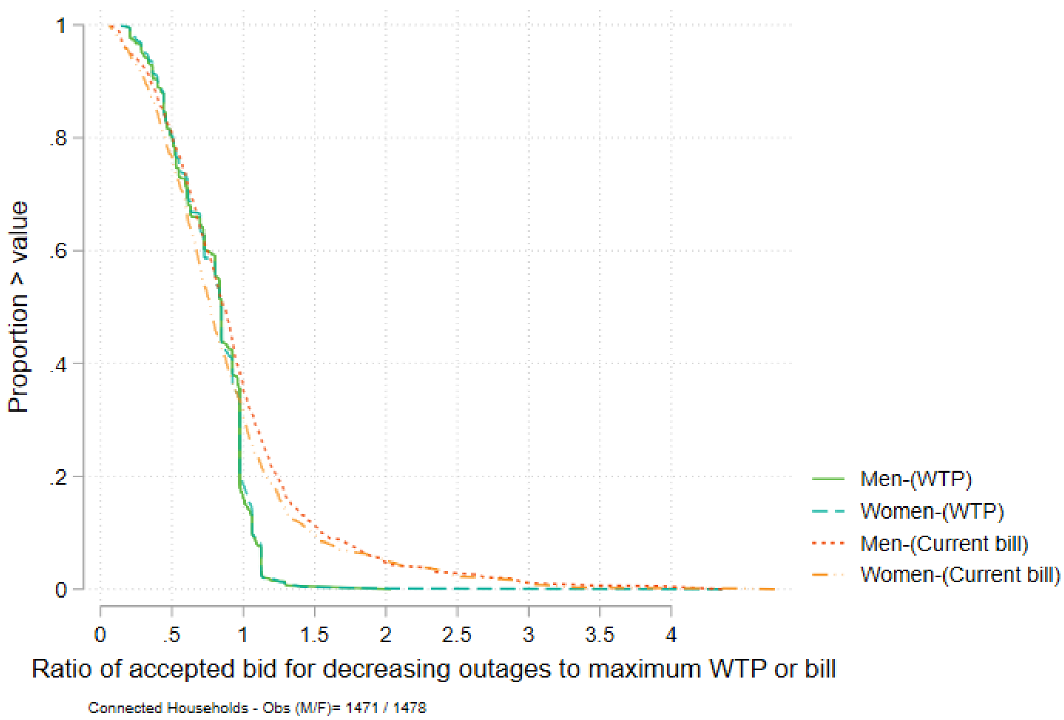
Figure 30 presents the cumulative distribution of the ratio of maximum WTP for one-half the current outages or low voltages relative to maximum WTP for 24/7 service and relative to current electricity costs for both male and female respondents. The top panel shows the WTP ratios for one-half of the current outages level of services; the bottom panel shows the one-half low voltages level of services. As mentioned in the initial discussion of this section, the ratio relative to maximum WTP in Figure 30 is below one for most male and female respondents. The cumulative distribution across genders is very similar throughout the range. About 15 percent of respondents state a WTP for improved services for one-half the outages or one-half the low voltages above their reported WTP for 24/7 of no outages and no low voltages. The ratio relative to current electricity costs has a larger proportion above the cutoff of one. For example, around 40 percent of male and female respondents have a WTP for service with one-half the outages that is above their current costs.

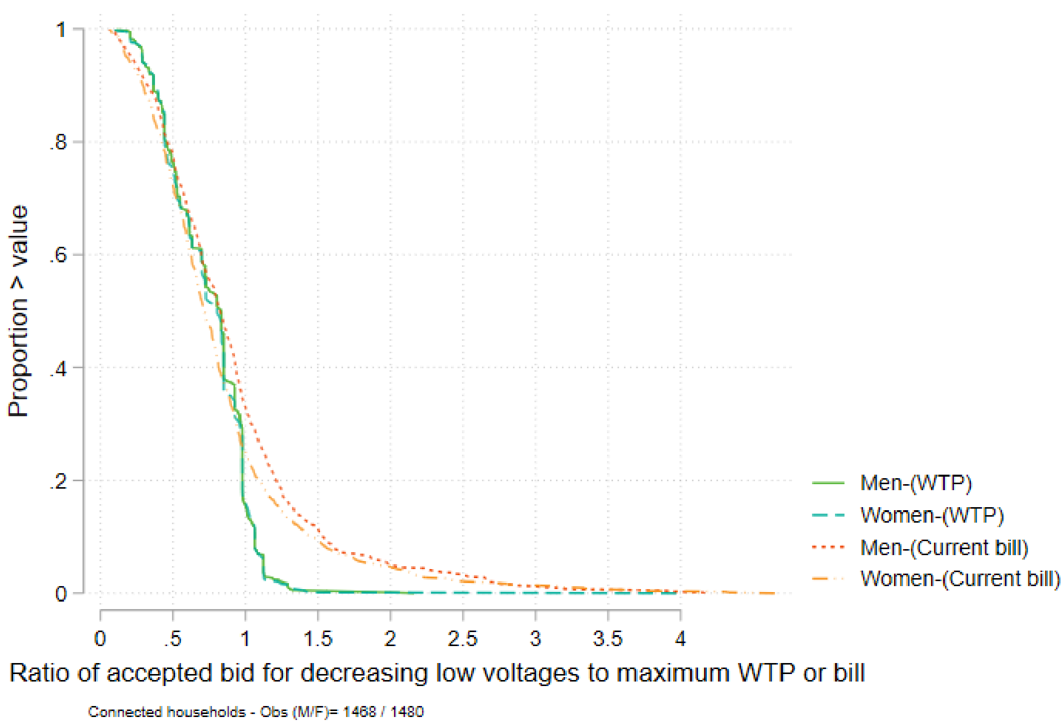
The gap in the figure across genders support our findings in the earlier analysis of the averages and medians. Female respondents' demand is more elastic in the one-half low voltages scenario. Together, the estimates suggest that average respondents' WTP is more sensitive to changes in low voltages than to changes in outages, and the effect of changing both outages and low voltages is stronger for women; female respondents' demand is more elastic with respect to changes in these attributes of electricity services.

TABLE 25 MAXIMUM WTP FOR CONNECTED HOUSEHOLDS WITH ONE-HALF THE OUTAGES OR LOW VOLTAGES, BY GENDER

	Men					Women				
	Mean	Std. Dev.	Median	P75	Obs.	Mean	Std. Dev.	Median	P75	Obs.
WTP for one-half the outages currently (USD bimonthly)	29.60	46.9	18.0	36.0	1,474	29.27	66.8	18.0	35.2	1,484
Ratio of accepted bid for decreasing outages to WTP for 24/7	0.81	0.3	0.9	1.0	1,474	0.80	0.3	0.9	1.0	1,484
Ratio of accepted bid for decreasing outages to bill	1.00	0.6	0.9	1.2	1,471	0.95	0.6	0.8	1.1	1,478
WTP for one-half the low voltages currently (USD bimonthly)	28.65	44.9	18.0	34.8	1,474	28.26	65.9	17.4	34.4	1,484
Ratio of accepted bid for decreasing low voltages to WTP	0.78	0.3	0.8	1.0	1,474	0.77	0.3	0.8	1.0	1,484
Ratio of accepted bid for decreasing low voltages to bill	0.96	0.6	0.9	1.1	1,468	0.91	0.6	0.8	1.1	1,480

FIGURE 30 MAXIMUM WTP TO DECREASE OUTAGES AND LOW VOLTAGES RELATIVE TO CURRENT ELECTRICITY COSTS – CONNECTED HOUSEHOLDS





5 Conclusions

This paper estimates WTP for improved electricity services and the factors influencing WTP for reliable electricity in Senegal's residential and business sectors. It uses data from three nationally representative surveys contracted by MCC and implemented in Senegal by SMJ Data from March to May 2018 to illustrate households' and businesses' preferences for reliable and improved electricity services, their views about their current services, and the constraints current services pose. To characterize preferences, the WTP survey included a CV scenario and a multiple bid game of stated preferences.

The sample and game were designed to estimate the valuation or WTP for men and women in the same household, and for informal and formal businesses in Senegal. The estimates gauge the incremental value of providing electricity services 24 hours per day, 7 days per week (24/7), without outages, interruptions, or low voltages from (1) the status quo level of service for connected households and businesses, and (2) a no-electricity initial condition for households not connected to the grid or those outside the zones where electricity is available.

The household sample provides intrahousehold estimates that allow us to measure differences in demand across gender. For the nonconnected household sample, the maximum WTP for the initial connection fee is 33 USD for men and 26 USD for women. In nonconnected households, men's maximum WTP for an improved electricity supply in Senegal is estimated at 27 USD billed every two months and at 23 USD for women. In connected households, maximum WTP for men is 37.79 USD and 38.18 USD for women billed every two months. Men have higher maximum WTP for improved electricity services than women, but this difference is not statistically significant. Using hypothetical electricity consumption data for nonconnected households, on average the maximum WTP per kWh is 0.31 USD for men and 0.22 USD for women. Using the electricity consumption data in their previous bill for connected households, on average the maximum WTP per kWh is 0.24 USD for men and 0.22 USD for women. The median is estimated at 0.20 USD per kWh for both men and women.

In addition, we estimate WTP for different levels of improvements by changing the attributes of electricity services in sequential bidding games. Namely, we propose CV scenarios with one-half of the outages or one-half of the low voltages that respondents currently experience. We then compare WTP for these different levels of service to respondents' current electricity costs and to their maximum WTP for improved 24/7 electricity services. We estimate WTP for a service with one-half the outages at 30 USD and 29 USD every two months for men and women, respectively, in connected areas. On average, WTP for one-half of the current outages is 19 percent lower than the maximum WTP for 24/7 service. In comparison to current electricity costs, men on average are not willing to pay more than their current bills even if outages are decreased by one-half. The average woman requires a 5 percent discount to break even. Women's WTP for one-half of the current outages is lower than their current costs, revealing that they are overpaying given their preferences. Comparing improvements in outages to improvements in low voltages indicates that the latter are less valuable, given these households' preferences.

The average maximum WTP for one-half of the current low voltages is 29 USD and 28 USD billed every two months for men and women, respectively. On average, WTP for one-half the level of the current low voltages is 22 and 23 percent lower than the maximum WTP for improved 24/7 service for men and women, respectively. When compared to their current bill, WTP is 96 percent for men and 91 percent for women, implying that decreases in the number of low voltages are less valuable than decreases in the number of outages. Thus their choices reveal they are overpaying given their preferences.

In the business sample, we measure differences across formal and informal businesses in Senegal. For nonconnected informal businesses, the maximum WTP for the initial connection fee is estimated at 33 USD. The average cost for informal businesses in connected areas is 145 USD billed every two months, with a maximum WTP of 80 USD billed every two months. Formal businesses in connected areas have a maximum WTP of 456 USD, while their current costs are 803 USD on average. The estimates imply a price per kWh of 0.47 USD and 0.35 USD for informal and formal businesses, respectively. The estimates show that businesses' WTP is below their current cost structure.

The estimates presented allow policymakers and stakeholders to compare the value and cost per unit of electricity service used in their cost-benefit analyses to evaluate projects with goals to expand electrification in Senegal. Indeed, MCC used the WTP estimates from these surveys to estimate the economic rate of return of its planned investments in Senegal. The estimates show that demand exists for improved electricity services in the range of expected tariffs (0.10–0.25 USD per kWh) in Senegal after improvements in the electricity infrastructure planned by the government and MCC are achieved.

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Appendix A – Description of Contingent Valuation Scenario

The scenario presented to nonconnected households is as follows:

Initial Connection Cost

Question J.9.a *Would you be willing/ready to pay 100.000 CFA* ***to be connected to the electricity grid*** *with SENELEC?*

1. *Yes.*
2. *No.*

J.9.b *What is the maximum you would be willing/ready to pay to be connected to the grid_____ CFA?*

(If J.9.a ==YES then J.9.b >= 100.000 CFA)

Electric Service 24/7 for hypothetical list of appliances, bimonthly costs

Question J.16 *Taking into account your* ***current expenses*** *and that your household* ***is not connected to the electricity grid*** *and that the electricity bill would be in addition to your current monthly household expenditures.*

If you were to receive "satisfactory electricity services" that give you electricity 24/7 without outages or low voltages and ***have the equipment mentioned before in [J.13]*** *in the home.*

The electricity will be metered and you will be ***billed every 2 months****. You would probably use more electricity for the equipment that are turned on at night (like lights) and those that might be always on (like fridges). Note that if you are paying money to purchase electricity from a source other than SENELEC, that amount would be deducted from your current monthly household expenditures.*

Would you be willing/ready to pay every 2 months ***[B = Random- 2 month bill]*** *CFA to have* ***the equipment mentioned in [J.13] and*** *have* ***electricity 24H/7J****?*

Answers:

1. *Yes → go to (1.Y)*
2. *No → go to (1.N)*

(1.Y) *Would you be willing/ready to pay __1.15*B___ CFA every 2 months to have* ***electricity 24/7****?*

1. *Yes → Increase bill amount by 15% until obtaining a NO answer or arriving at Maximum Price in the table.*
2. *No*

(1.N) *Would you be willing/ready to pay __0.85*B___ CFA/Kwh?*

1. *Yes*
2. *No → Decrease bill amount 15% until obtaining a YES answer or arriving at the minimum price*

Note: Up to 12 increases or decreases suffice before asking the Max/Min question

Connected Households

For connected households, we use three different bidding games to elicit respondents' WTP for improved electricity services, decreases in outages by one-half, and decreases in low voltages by one-half.

The bidding games are close-ended, Yes/No, discrete choice, with a final open-ended option after the twelfth proposed bid is accepted or denied. For the improvement in outages and low voltages games, the open-ended followed the fifth accepted or denied bid.

In this case the CV scenario describes the hypothetical service, but the respondent has experience with a given level of electricity service and the respondent is asked whether or not he would buy an improved (24/7) service at a specified price.

Since the elicitation procedure needs a specific quantity of the service, for nonconnected, we use the consumption from their last bill, and inform them that they could be using more electricity with the 24/7 level of service. The bids were presented as bimonthly consumption charges for 24/7 electricity service using their past level of consumption and the price per kWh that was being used. One-fifth of the respondents in the sample received a bidding game with a sequence of Yes/No questions starting at one of five prices (85, 95, 120, 140, or 160 CFA/kWh) based on the existing tariff/price schedule of SENELEC.

The scenario presented to connected households is as follows:

Electric Service 24/7 for consumption in the previous bill, bimonthly costs and prices

Question K.5 *Taking into account your **current expenses** and that your household currently pays :*

[D.18.a] *FCFA for* ***[F.4]*** *Kwh. The average price is* ***[D.18.b]*** *CFA/Kwh and you experiment* ***[H.1]*** *outages per week.*

If you were to receive "satisfactory electricity services" that give you electricity 24H/7J without outages or low voltages, would you be willing/ready to pay: ***[R=Random price from price list]*** *CFA/Kwh?*

The electricity will be metered and you will be billed every 2 months.

Your current bimonthly bill would be ***[F.4]*R*** *but you would probably use more electricity than you use at the moment.*

Note that if you are paying money to purchase electricity from a source other than the SENELEC or Concessionaires, that amount would be deducted from your current monthly household expenditures.

Answers/ Bidding Game:

1. *Yes → go to (1.Y)*
2. *No → go to (1.N)*

(1.Y) *Would you be willing/ready to pay __1.15*R__ CFA/Kwh or* ***[F.4]*1.15*R*** *every two months for your current consumption and have* ***electricity 24H/7J****?*

3. *Yes → Increase price by amount by 15% until obtaining a NO answer or arriving at Maximum Price in the table.*
4. *No*

(1.N) *Would you be willing/ready to pay __0.85*R__ CFA/Kwh or* ***[F.4]*0.85*R*** *every two months for your current consumption and have* ***electricity 24H/7J****?*

3. *Yes*
4. *No → Decrease price by amount 15% until obtaining a YES answer or arriving at the minimum price*

Question K.6: *Max WTP = Last accepted : Price ______________ CFA/Kwh* **Or** *Last accepted : Bill ______________ CFA every 2 months*

If arrived at 12th bid ask: What is the (Min/Max) price/bill that you are willing to pay for an electricity service 24/7 without outages of low voltages?

Electric Service 24/7 for consumption in the previous bill, bimonthly costs and prices with half the outages or half low voltage

THE FIRST OFFER will is randomly selected and the person could review up or down up to 5 times then receives an open-ended question. Use multiplicative increments or decrements of 15 percent (as above).

Question K.7/K8:

*Taking in to account the outages and low voltages you experiment per week and that you would be willing to pay __**[K.6]**__CFA/Kwh or ______________ CFA every 2 months for 24h/7j service without outages or low voltages.*

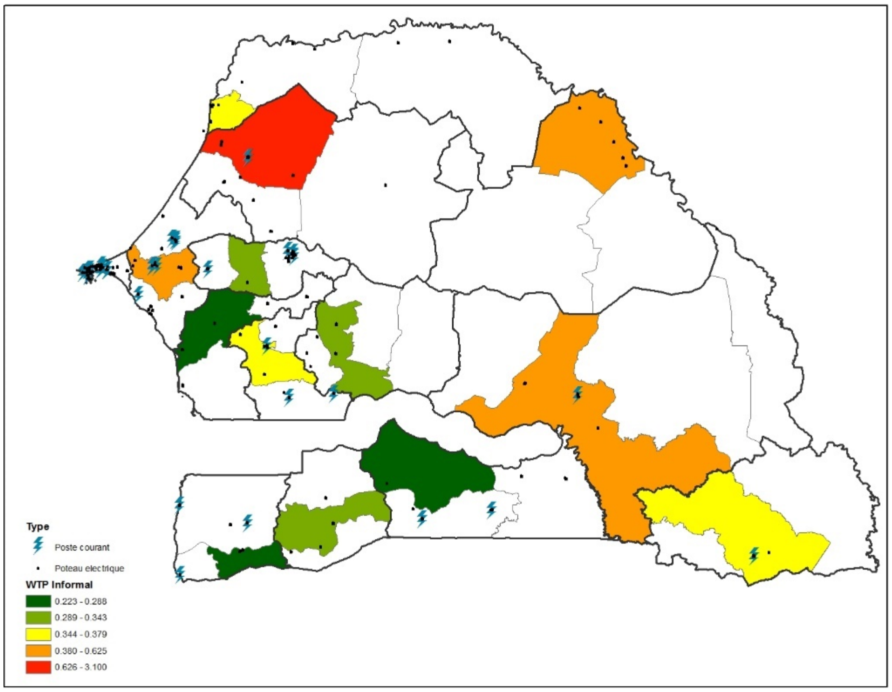
How much would you be willing/ready to pay ***to reduce [outages/low voltages] to half of the number per week you experience****?*

1. *0.40*****[F.4]*K.6 CFA*** *every 2 months. If not, how much _________ CFA every 2 months?*
2. *0.55*****[F.4]*K.6 CFA*** *every 2 months*
3. *0.70*****[F.4]*K.6 CFA*** *every 2 months*
4. *0.85*****[F.4]*K.6 CFA*** *every 2 months*
5. *1.00*****[F.4]*K.6 CFA*** *every 2 months. If yes, what is the maximum amount _________ CFA?*

Appendix B – Additional Results

Geographic Distribution of WTP for Electricity Services for Businesses

FIGURE 31 GEOGRAPHIC DISTRIBUTION OF WTP FOR INFORMAL BUSINESSES



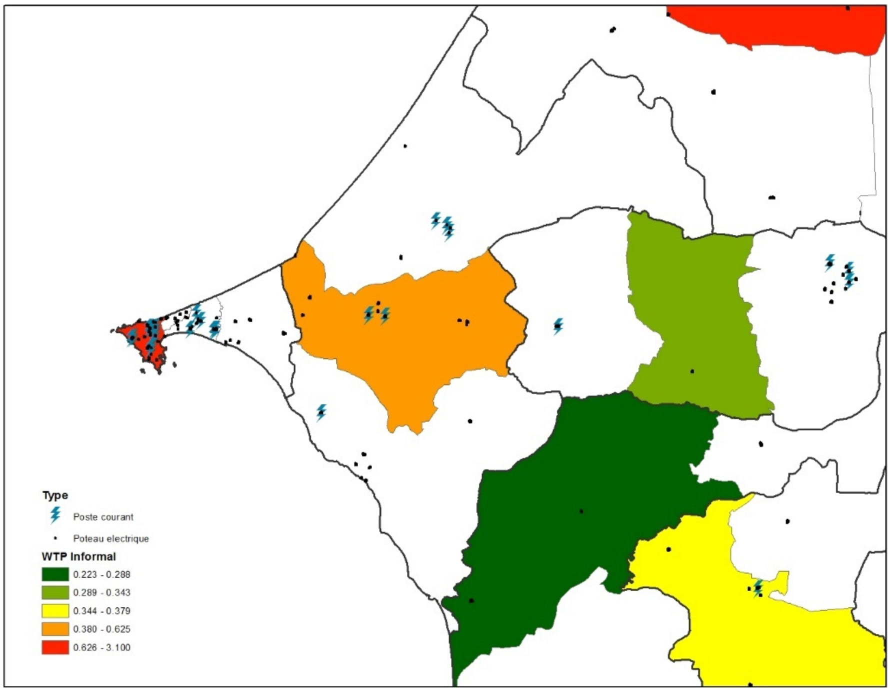
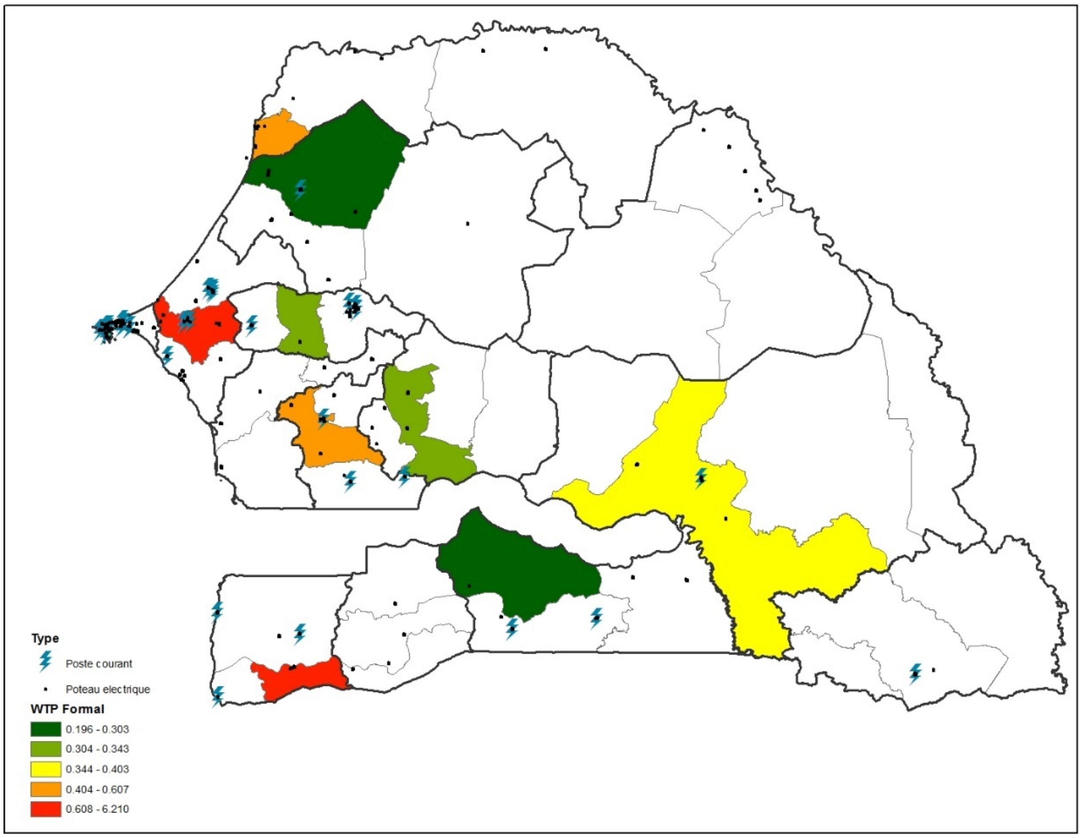
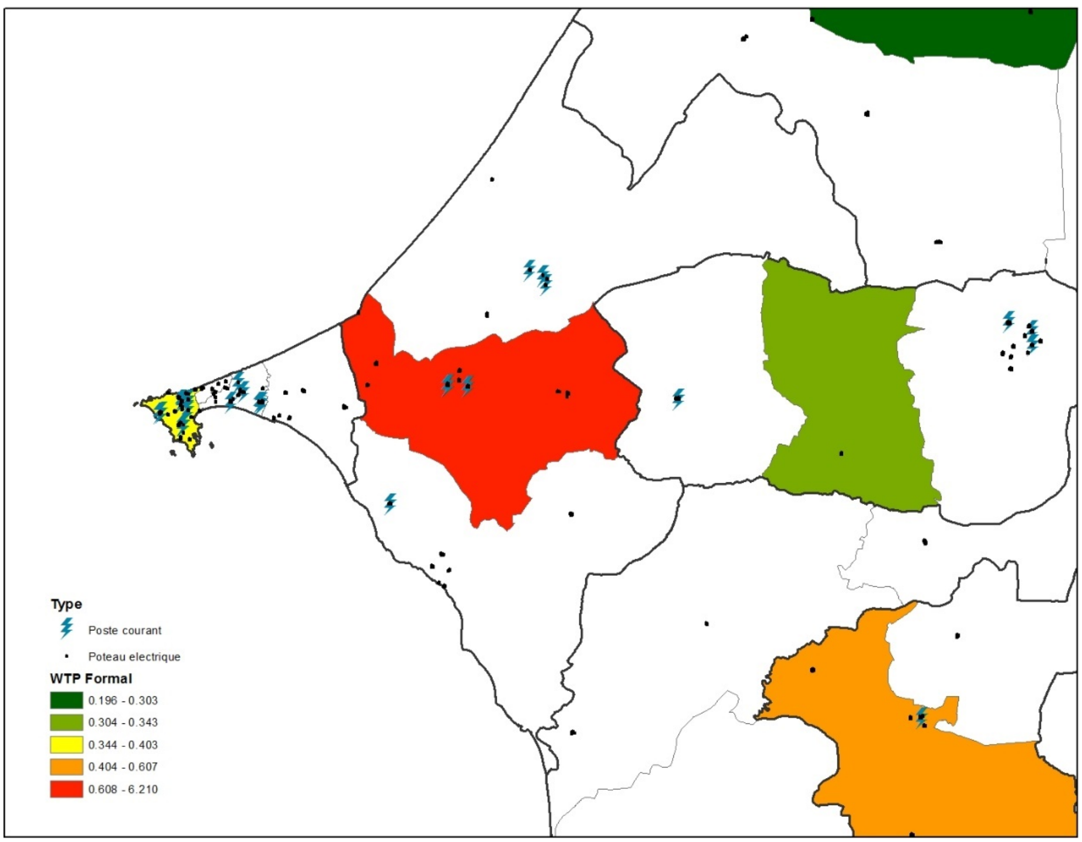


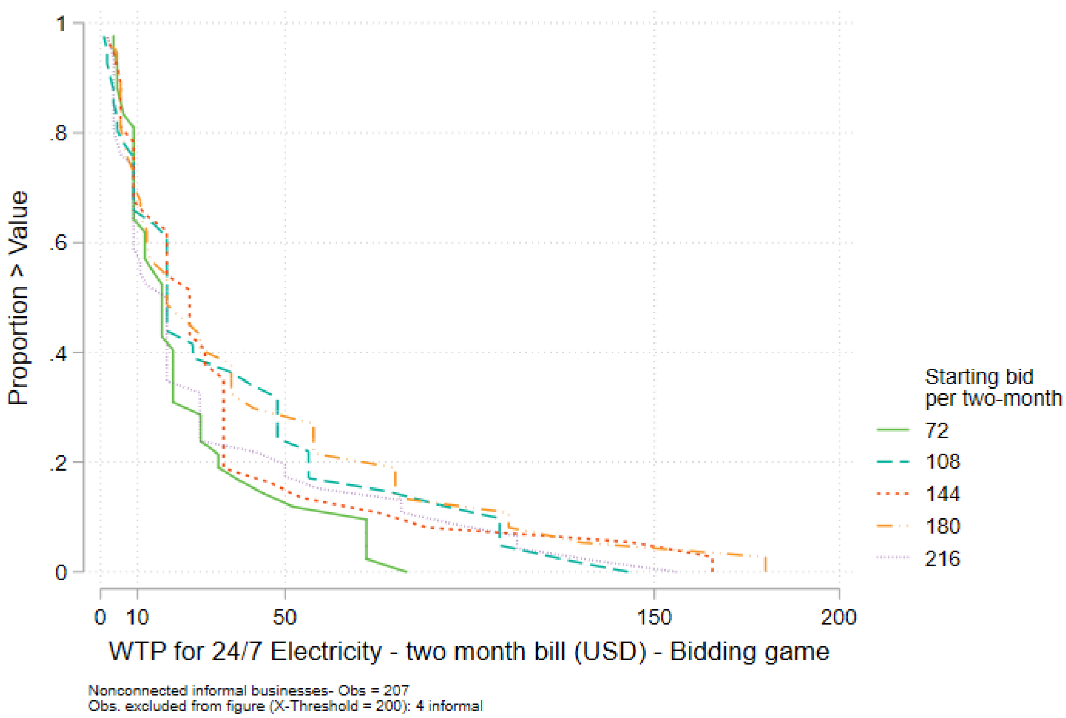
FIGURE 32 GEOGRAPHIC DISTRIBUTION OF WTP FOR FORMAL BUSINESSES

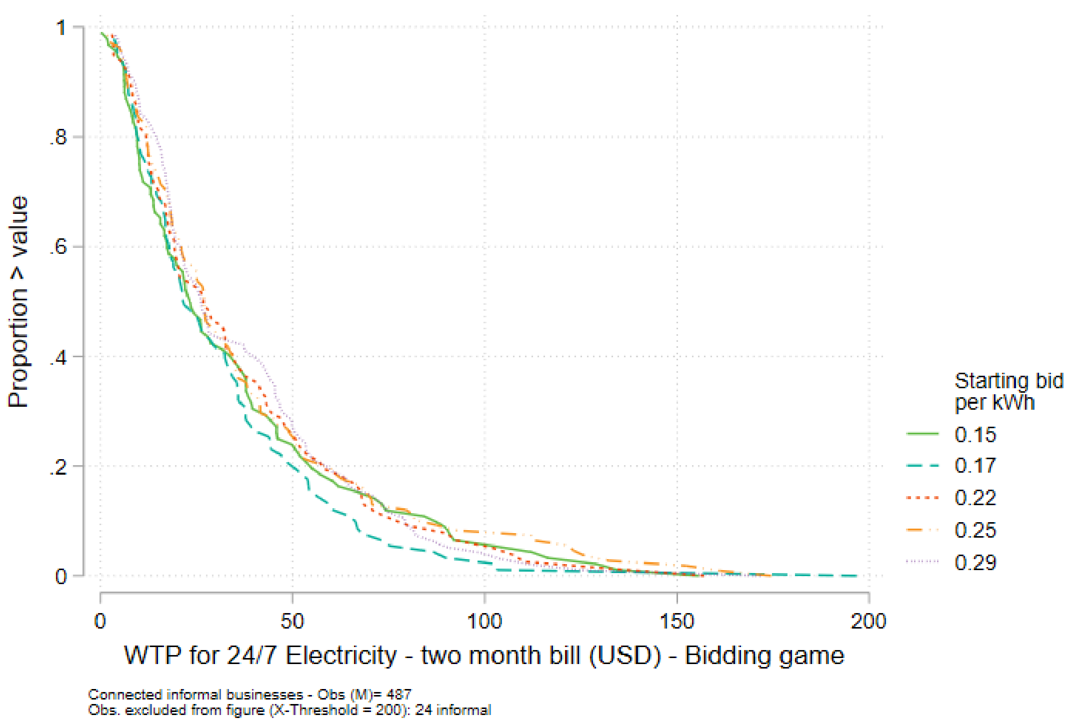




Starting Point Bias ICDF for Informal Businesses

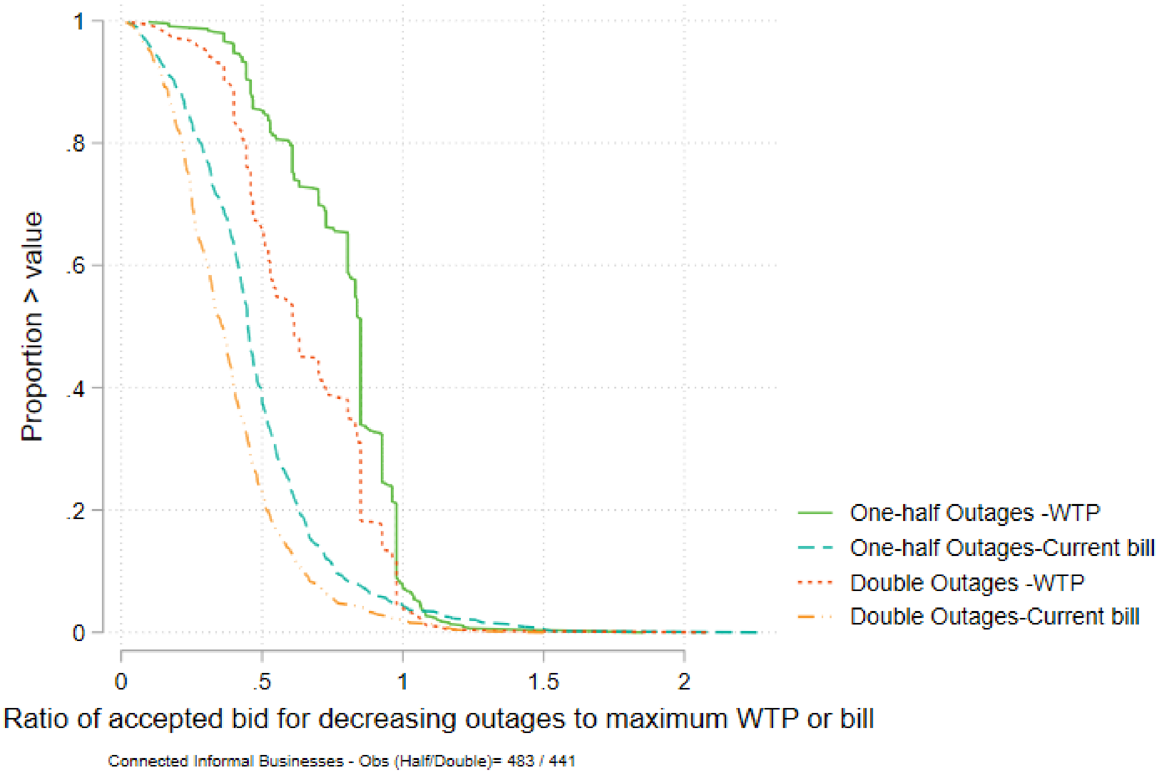
FIGURE 33 ICDF OF MAXIMUM WTP BY STARTING POINT AND CONNECTION STATUS – INFORMAL BUSINESSES





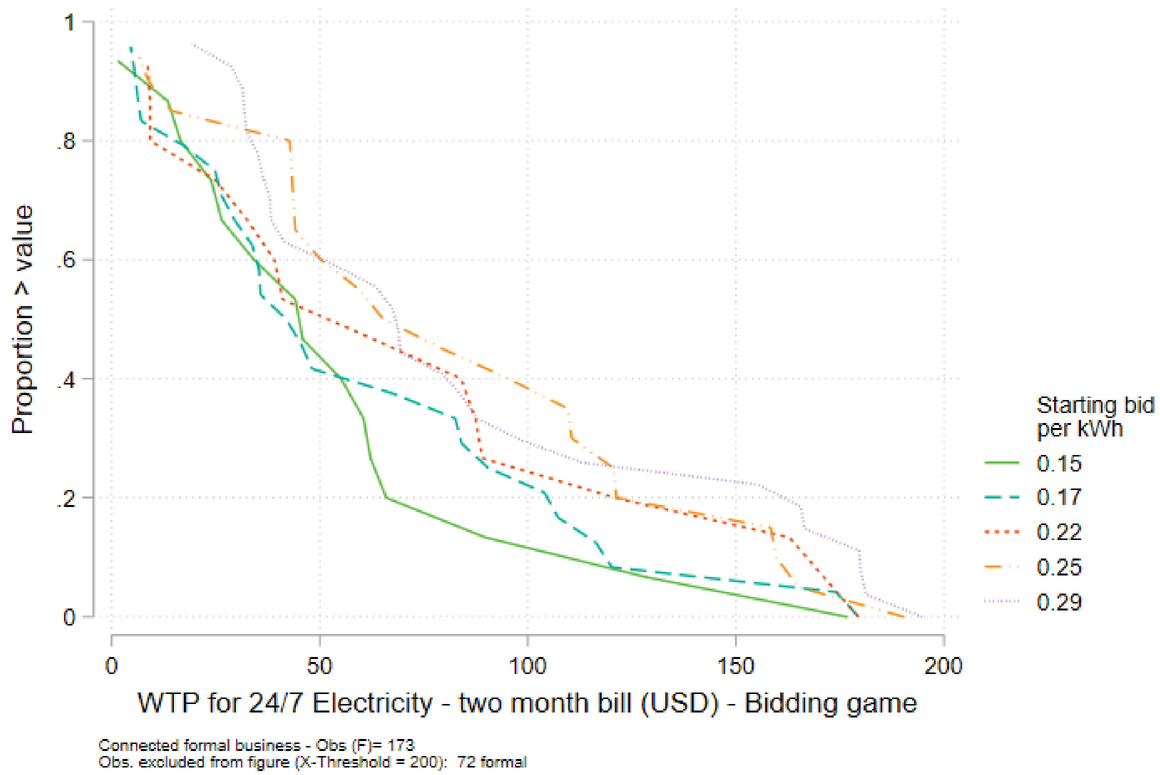
Outages and Low Voltages for Informal Businesses

Figure 34 Maximum WTP to Changes in Outages Relative to Current Electricity Costs and Maximum WTP for 24/7 Service– Informal Businesses



Starting Point Bias - ICDF for Formal Connected Businesses

FIGURE 35 CDF OF MAXIMUM WTP BY STARTING POINT –CONNECTED FORMAL BUSINESSES



Outages and Low Voltages for Formal Connected Businesses

FIGURE 36 MAXIMUM WTP TO CHANGES IN OUTAGES RELATIVE TO MAXIMUM WTP FOR 24/7 SERVICE – FORMAL BUSINESSES

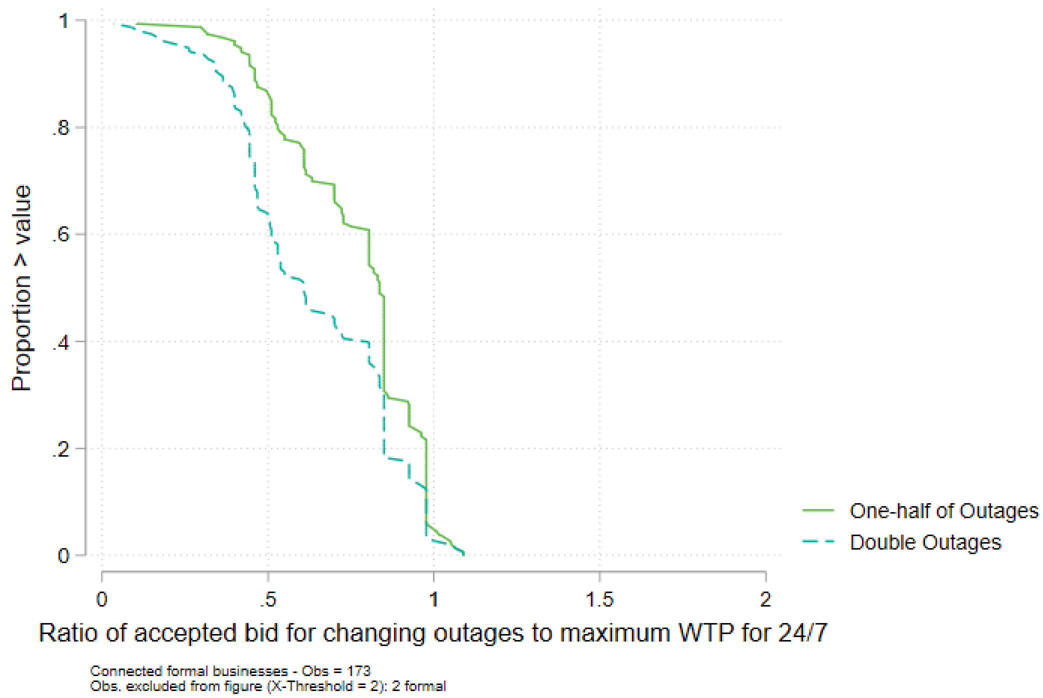


FIGURE 37 MAXIMUM WTP TO CHANGES IN OUTAGES RELATIVE TO CURRENT ELECTRICITY COSTS –FORMAL BUSINESSES