Paradigms
Print ISSN 1996-2800, Online ISSN 2410-0854
2020, Vol. 14, No. 1 Page 94-101
DOI: 10.24312/1930140115

Estimating the Willingness to Pay for Reliable Electricity and Welfare Effects: Aggregated and Disaggregated Analysis

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Cite this paper: Naeem, M. K. Anwar, S. & Nadeem, A. M. (2020). Estimating the willingness to pay for reliable electricity and welfare effect: Aggregated and disaggregated analysis. *Paradigms, 14*(1), 94-101.

Electricity is provided by eleven distributional companies in Pakistan and dwellings are attached with the national or mini grids. Government has attained a reasonable amount of people having electricity access but still there are problems of reliability and outage exist in consumer perspective. Therefore, people are looking for reliable electricity sources (RES). The current study is designed to determine the factors affecting the willingness to pay (WTP) for RES in Pakistan and to measure the welfare effect upon providing electricity to unconnected dwellings. World Bank Survey 2016 containing 8461 households is used for contingent valuation (CV) analysis and welfare effects. Aggregated and disaggregated analysis is conducted keeping in view the socioeconomics, lifestyle and climatic factors of the country. Aggregated analysis of CV shows that monthly income, expenditures on electricity, female respondent, non-agriculture income source, ownership & usage of television, solar awareness, feature of availability and cost saving are positive and significant factors for WTP. But, usage of non-electric sources for lighting, ownership & usage of fluorescent tube lights are negative and significant factors for WTP. However, there are province wise variations in CV analysis. Thereof, marginal effects of selected variables are calculated. Welfare analysis shows the positive gain by connecting the dwellings with the grid in selected major city of each province. The study shows the variation in factors of WTP at different provinces which has strong policy implications. It also suggests the renewable potential and feasibility of connecting the new dwellers with renewable energy sources by the government.

Keywords: Reliable Electricity, WTP, Marginal Effects, Welfare, Pakistan and Province Level

INTRODUCTION

In Pakistan, about 71% population has electricity access and is connected to either national or mini grid (World Development Bank, 2017). The government provides electricity to people through 11 electric supply companies in the country. These electric supply companies are facing issues like generation capacity, transmission losses and less recovery. Since 2014, generation capacity has been increased by 45% whereas transmission and distribution capacity have increased by 20% and 24% respectively. The circular debt of these companies has been raised up to Pak Rupees 1,000 billion till the end of 2018 (State of Industry Report, 2018). Due to these issues, households are facing problems like planned and forced outage, low voltage and high cost of electricity. Meanwhile, households are seeking for alternate electricity sources other than national or mini grid. Rest of 29% population in Pakistan is not connected to national or mini grid. They fulfill their energy needs from individual generators, batteries, firewood, animal dung, lamps and solar energy sources. These households spread all over Pakistan, but they are centered to rural areas (Harijan et al., 2008; Harijan et al., 2015). Usage of firewood and animal dung for energy purpose emit hazardous gases which deteriorates the human health and causes respiratory health problems (Reyes et al., 2015). Connecting these households with national grid can solve the health problems in rural areas.

Pakistani people have large diversity in their lifestyle due to many factors like variety of seasons, rural-urban living standards, gender disparities and inequality in terms of income and education. Parker (2003) observed that climate and locality are the major factors which determine the lifestyle of people. Longitudinal extent of Pakistan starts from Arabian Sea to Himalayan Mountains and major proportion area of the country is located on sub-tropical regions. There are four seasons in Pakistan i.e. summer, winter, autumn and spring where life in rural and urban areas is entirely different. Country's average annual temperature is continuously rising since the start of 20th century (Farooqi et al., 2005). However, there is substantial difference across provinces. Accordingly, requirement of electricity during summer and winter seasons is different (Yılmaz, 2007). Areas of severe climate consume more electricity as compared with temperate areas. Moreover, five major languages are spoken i.e. Punjabi, Pashto, Sindhi, Saraiki and Urdu. Gini Coefficient Index of Pakistan is 33 (World Development Bank, 2015), literacy rate is 57%, population growth rate is 2.4% (Economic Survey of Pakistan 2018-19).

Providing "reliable" electricity to the people is itself a challenge for Pakistani government. Reliability can be measured through electric interruptions, load shedding, voltage, consumer complaints and safety of electricity system. Figure 1 depicts the reliability of electricity system in Pakistan. Average interruptions can be calculated through interruption frequency and interruption duration. Average interruptions percentage in Punjab and Sindh increased while KPK and Baluchistan decreased since the last five years. Average interruption duration remained the highest in KPK province. Daily load shedding (hours) during 2017-18 was 3.6, 3.3, 2.4 and 5.8 in Punjab, KPK, Sindh and Baluchistan, respectively. Voltage complaints were high at KPK province but Sindh province experienced negligible amount of voltage complaints. There were very little customer service complaints at KPK province. Every province has

experienced safety issues which caused deaths of employees and public.

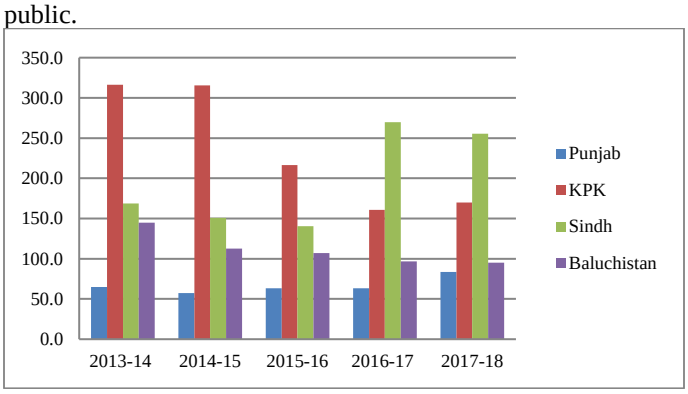

Figure 1: Average interruptions frequency index (SAIFI-No)

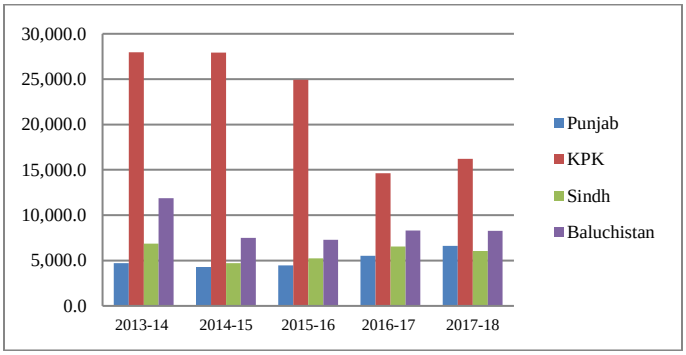

Figure 2: Average interruptions duration index (SAIDI-minutes)

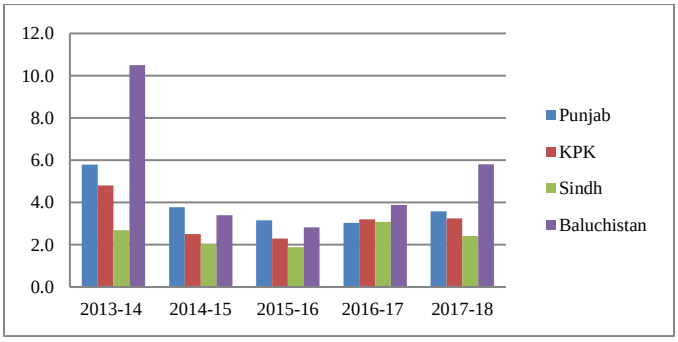

Figure 3: Average daily load shedding (Hr)

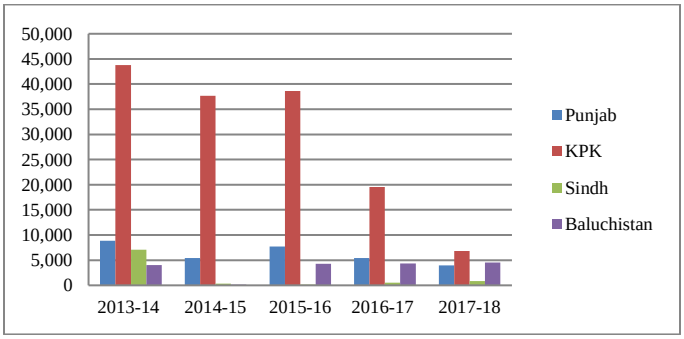

Figure 4: Nominal voltage (number of consumers who made complaint about voltage)

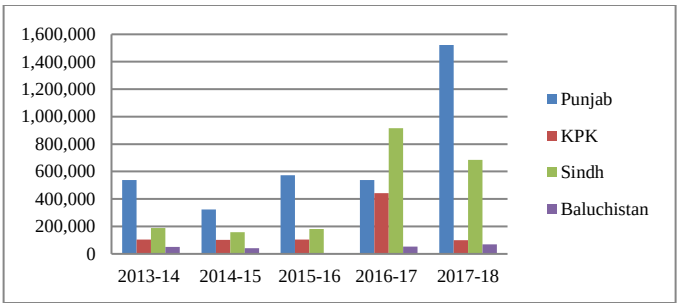

Figure 5: Customer service complaints (No)

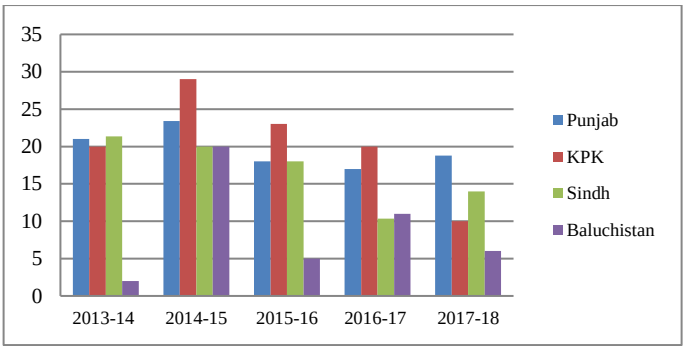

Figure 6: Safety (number of fatal accidents by employees and public)

There is diversity in the lifestyle of people in Pakistan as mentioned earlier. On the basis of heterogeneous factors, an aggregate analysis of household study could not give practical results. Therefore, current research is designed to conduct aggregated as well as disaggregated analysis at province level for Pakistan. The current study has two specific objectives. First objective is to estimate the determinants of consumers' WTP for reliable electricity sources. Second objective is to measure the welfare effect of connecting the unconnected households with the national grid.

LITERATURE REVIEW

WTP for electricity can be divided into five sections. Firstly, studies related to WTP for grid electricity (Bose & Shukla, 2001). Secondly, previous studies related to WTP for green and renewable electricity (Arega & Tadesse, 2017; Roe et al., 2001; Sundt & Rehdanz, 2015; Xie & Zhao, 2018; Yoo & Kwak, 2009; Zorić & Hrovatin, 2012). Thirdly, studied are conducted for renewable electricity by source like wind, solar etc (Borchers et al., 2007; Ma et al., 2015; Sundt & Rehdanz, 2015). Fourthly, studies stressed about air quality, environmental issues and green house gases (Hansla et al., 2008; Roe et al., 2001; Zorić & Hrovatin, 2012). Lastly, studies concerned with the reliability, availability, outage, power failure of existing electricity sources and WTP for better and reliable electricity sources (Kennedy et al., 2019; Ozbafli & Jenkins, 2015, 2016).

Bose and Shukla (2001) measured WTP for grid electricity at Gujarat India. They used survey data comprising of 700 consumers which covered the residential, agricultural and industrial consumers. WTP was measured through cost of meeting the energy needs from alternate sources of energy like diesel. They suggested some tariff policy guidelines for Gujarat

Electricity Board. Specifying the residential consumers, they concluded that tariff increase by Rs. 1/kWh may be absorbed by resident consumers who spent about 3-4% of income on electricity. They proposed to charge lower price for those households who consume electricity up to 20kWh/ month.

Yoo and Kwak (2009) estimated the WTP for green electricity in South Korea. Mean WTP measured from parametric and non-parametric were 1.8 USD and 2.2 USD, respectively. They observed that spike model may be used for zero response for WTP and non-parametric for measuring welfare effects of WTP. Zhang and Wu (2012) identified market segmentation and WTP for green electricity in urban areas of Jiangsu Province, China. They measured WTP US$ 1.15-1.51/month. Measured factors of WTP are education, income and locality. WTP did not affect by price. They suggested promotion of green-e regulated markets in developing regions of the world need to be explored. In this regard, environmental awareness among society can support the green-e regulated markets. Guo et al. (2014) also measured WTP for renewable energy in Beijing China. They estimated average WTP 2.7 USD to 3.3 USD. They concluded that education, income, electricity consumption and bid were significantly affected the WTP. Xie and Zhao (2018) used contingent valuation method to measure the WTP for green electricity in Tiajin, China. They found 67.3 percent people were willing to pay for green electricity and average WTP was 32.63 CNY. Awareness about renewable energy, age, gender, education, behaviour and history of respiratory diseases were the key factors affecting the WTP. Some policy implications to mitigate environmental issues are transparency of government, improvement in pricing mechanism and awareness programs.

Many studies estimated WTP by sources like Borchers et al. (2007) estimated and compared the WTP for green electricity by different sources at New Castle Country, Delaware. They estimated that people preferred solar energy over generic green and wind power. Biomass and methane were the least preferred sources of renewable energy. They suggested that policy makers should know the market of renewable energy and people's preference about renewable energy and access to renewable energy source. Ma et al. (2015) also studied the WTP for various types of renewable energy. They conducted meta-analysis and concluded that factor of WTP were common as type of renewable energy, socioeconomic factors of household and their energy consumption pattern. People presented higher WTP for solar and wind energy whereas lower WTP for hydropower and biomass. Willing to pay for renewable energy was also positively associated with the penetration of renewable energy in total energy consumption but negatively associated with electricity consumption level. Sundt and Rehdanz (2015) conducted meta-regression analysis to measure WTP for green electricity by different sources where hydropower had lowest value in those countries where hydropower share of generating electricity is more. Generally, developed countries were willing to pay for green electricity than the developing countries. Awareness about willing to pay, income and education are positively affect the WTP.

Many studies stressed about emissions, green house gases and environmental challenges regarding use of energy and electricity. Sundt and Rehdanz (2015) observed that environmental issues and greenhouse gases emission induce the economies to promote renewable energy to mitigate these issues. Roe et al. (2001) estimated the consumer WTP for green electricity in United States. Results suggested that US consumers were very concerned about the air emission and air quality therefore higher WTP induce the policy makers to make efforts for the promotion of green electricity. Hansla et al. (2008) found WTP increased with the positive attitude of people towards green electricity and environmental issues whereas decreased WTP was found for electricity cost. Zorić and Hrovatin (2012) analyzed WTP for green electricity sources, household attitude and willingness to participate for green electricity programs at Slovenia. Household attitude towards green electricity programs was mainly depend on age, household income, education and environmental awareness.

Reliable electricity is another area of WTP. Abdullah and Mariel (2010) conducted choice experiment study in rural areas of Kenya to measure WTP for electricity having frequent power outage and blackouts. They used data of Kisumu District Kenya and concluded that on one side unemployed, older and large dweller households did not show much intention to pay more than their average electricity expenditures for better service reliability and on the other side, bank account holders, farming and large family households preferred to pay extra amount for service reliability of electricity. Ozbafli and Jenkins (2015) estimated the WTP for better reliability of electricity service in North Cyprus. Sample size of 350 respondents was collected through personal interview. They employed cost benefit analysis on the contingent valuation data. The respondents were willing to 13.8% increase in their electricity bill in case of improving the service by less outage and greater reliability. Cost benefit analysis showed positive benefits by residential sector. The study highlighted the electricity issues of many developing countries of Asia and Africa like inefficiency and political interference etc. They concluded that increasing the reliability of electricity service in the study area would give fruitful results. The study proposed to replace the old electricity plants and install new ones having reliable electricity. Ozbafli and Jenkins (2016) conducted choice experiment and measured WTP for improved electricity service in North Cyprus. They used data sample of 350 respondents collected through in-person interview. They calculated the estimates of compensating variation that are 3.02 USD in summer and 11.74 in winter. Moreover, for the uninterrupted supply of power, households are willing to pay 3.6% and 13.9% increase in their monthly electricity bills during summer and winter months, respectively. They suggested that new generating plants may be launched for residential sector in order to improve the service reliability and for proving uninterrupted power supply. Kennedy et al. (2019) estimated the WTP for quality of service of electricity in rural areas of India. They found the importance of quality service in WTP and employed Heckman selection model for the purpose. They corrected the selection bias procedure and found the nighttime

importance in the WTP for electricity service. Improving the quality of service and cost recovering prices were important implications of distributional companies. They suggested that by improving the quality of service, the financial issued faced by the electricity generating, transiting and distributional companies may be fulfilled through greater revenue.

Welfare effect of WTP is also an important aspect. Arega and Tadesse (2017) calculated welfare effects in rural and peri-urban areas of Tigray, northern Ethiopia. Data sample of 300 households was collected for the study and bivariate probit model was employed for analysis. Producer and consumer surplus were used to calculate welfare. Mean WTP was measured 0.66 USD/month/household. Income, gender and distance of wood and charcoal markets were important determinants of WTP. They suggested that there would be positive welfare gain in term of consumer welfare for households as well as in term of producer for government. Therefore, green electricity sources should be encouraged for the societal welfare.

RESEARCH METHODOLOGY

World Bank Survey data containing 8461 households is used in the study. Data containing two types of households i.e. households (HH) connected to national or local mini grid (6360 HH) and households not connected to national or local mini grid (2101 HH). In the current study, data sample of 6360 HH is used for contingent valuation analysis and data of 1201 HH is used for welfare analysis. Many previous studies employed contingent valuation method to determine the factors of WTP like (Akcura, 2013; Guo et al., 2014; Ozbafli & Jenkins, 2015; Xie & Zhao, 2018; Zhang & Wu, 2012). In the current, study contingent valuation method is employed.

Multinomial Logistic (MNL) function is used in the current study as used by Rahut et al. (2014). MNL technique is used when the dependent variable is nominal (having more than 2 categories). In the current study, dependent variable is WTP having three categories therefore application of MNL is justified.

FINDINGS OF THE STUDY

Descriptive of Data

As far as data sample of 6360 HH are concerned, average monthly income for Punjab, KPK, Sindh and Baluchistan were PKR 22456, 26660, 21512 and 30266 respectively. Monthly electricity expenditures of Punjab, KPK and Sindh provinces remained 9-10% of their monthly income leaving Baluchistan province aside having monthly electricity expenditures remained 2.9% of monthly income. Overall in Pakistan, 27% households were selected from peri-urban areas in which percentage of Punjab, KPK, Sindh and Baluchistan were 32%, 33%, 24% and 10% respectively. About 45% respondents were female respondents in which percentage of Baluchistan province was minimum (16%). Agriculture is the main source of income in Pakistan which was depicted in the sample as well having 57% household's main source of income was agriculture.

As regard with appliance ownership and usage are concerned, some studies used "ownership" of appliance as factor of use (Halvorsen & Larsen, 2001; Larsen & Nesbakken, 2004; Louw et al., 2008; Nielsen, 1993; Wiesmann et al., 2011) and other studies used "usage" of appliance (Bedir et al., 2013; Munley et al., 1990; Zhou & Teng, 2013). In the current study, "interaction term" is used for appliance which is calculated by multiplying the dummies of ownership with frequent use of that appliance. About 37%, 25% and 54% households have and use the incandescent bulbs, fluorescent tube lights and color television in the sample. However, there was substantial difference among provinces. More than 60% households complained about low voltage constraint. Load shedding frequency remained the highest in KPK province and lowest in Baluchistan province. Usage of non-electric sources for lighting was greatest in Baluchistan province followed by KPK province. High level of solar awareness was observed in KPK and Baluchistan provinces. As the potential source of electricity, households were very concerned about "availability" (81.9%) and "cost saving" (63.3%).

Results of Multinomial Logistic Regression

Dependent variable (willingness to pay) divided into three categories i.e. 1-99 PKR, 100-199 PKR and more than 200 PKR. Category having WTP 1-99 PKR is taken as reference category. Aggregate analysis showed that monthly income is significant determinant for estimating WTP. Household having income category 15001 to 25000 are 1.477 times more likely to pay 100-199 PKR per week and 1.765 more likely to pay more than 200 PKR per week when compared with reference category (1-99 PKR per week). Similarly, households having income category more than 35000 are 2.245 times more likely to pay 100-199 PKR per week and 4.752 times more likely to pay more than 200 PKR per week as compared with reference category. Punjab province also showed similar analysis. Whereas, in KPK province, only the income category above 35000 is significant and odds ration value is 3.188 for WTP 100-199 PKR and 5.859 for WTP more than 200 PKR per week. Positive effect of income on WTP was observed in previous studies (Akcura, 2013; Guo et al., 2014; MacPherson & Lange, 2013; Rowlands et al., 2003; Xie & Zhao, 2018; Zhang & Wu, 2012; Zografakis et al., 2010; Zorić & Hrovatin, 2012). Monthly expenditures on electricity is also significant factor in the analysis. Less than 500 PKR is taken as reference category. Households having monthly expenditures 500-1000 PKR are 1.643 times more likely to pay 100-199 PKR per week and 2.647 times more likely to pay more than 200 PKR per week as compared with reference category. Odds ratio values for Punjab are higher as compared with Pakistan. However, there are difference in odds ratio values in KPK, Sindh and Baluchistan. Guo et al. (2014) also observed the significant and positive affect of electricity consumption on WTP.

Odds ratio for WTP for peri-urban households are positive and significant for Pakistan and Sindh province. The same is significant and positive for WTP more than 200 PKR for KPK and WTP 100-199 PKR for Baluchistan. But, it is non-significant for Punjab. Odds ratio of female respondents shows that they are more willing to pay for RES in Pakistan, Punjab, KPK and Sindh provinces. But, they are 0.74 times less likely to pay 100-199 PKR per week for RES as compared with male respondents. Other than agriculture as main source of income is also significant and positively affected the WTP. Households having major source of income is other than agriculture are 1.258 times

more likely to pay 100-199 PKR per week and 1.461 times more likely to pay more than 200 PKR per week. Across provinces, its odds ration value varies from 2.296 (for KPK) to 1.583 (for Punjab).

Interaction term of incandescent bulbs show odd ratios for WTP for more than 200 PKR 1.250, 1.319 and 2.202 for Pakistan, Punjab and KPK. Whereas, odds ratio for WTP for 100-199 PKR per week is observed 0.639 for Sindh province. Usage of incandescent bulb consume more electricity and hence high electricity bills so that the households are looking for alternate electricity sources. Interaction term for fluorescent light shows negative and significant affect on WTP. In Pakistan, households having interaction florescent are 0.218 and 0.184 times less likely for willing to pay 100-199 PKR and more than 200 PKR respectively. Fluorescent lights consume less electricity as compared with the incandescent bulbs so that these people are comparatively satisfied with their existing lighting solutions. Interaction term for television also shows the positive effect on the WTP in Pakistan and provinces as well.

Aggregate analysis of households who are facing low voltage constraint with their existing electricity sources induces the disaggregated analysis for clarity of results among provinces. In Punjab, KPK and Baluchistan households are 1.88, 3.316 and 4.214 times more likely to pay more than 200 PKR for alternate electricity source. Odds ratio for Sindh province is 0.426 for WTP 100-199 PKR per week. The clarity of results also shows when disaggregated analysis was carried out for load shedding frequency. Households at Punjab, KPK and Baluchistan provinces are 1.214 to 1.586 times more likely for willing to pay 100-199 PKR or more. Similar with low voltage constraints, Sindh province shows the different results where odds ratios are 0.814 and 0.634 for willing to pay 100-199 PKR and more than 200, respectively. Ozbafli and Jenkins, (2015) estimated that people are willing to pay 13.8% higher electricity bill to overcome load shedding. Ozbafli and Jenkins (2016) estimated WTP for uninterrupted electricity by 3.6% and 13.9% increase in monthly bill during summer and winter months, respectively in North Cyprus.

More use of non-electric sources for lighting has negative effect on WTP which shows odds ratios 0.850 and 0.728 for willing to pay 100-199 PKR and more than 200 PKR, respectively. Obviously, people who are looking for alternate electricity sources are more willing to pay for reliable electricity sources. They have positive effect on WTP. Similarly, households who have more solar awareness are more likely to pay for alternate electricity sources. Previous studies advocates that awareness about environmental issues, air quality and green house gases affect the WTP as conducted in Sweden (Hansla et al., 2008), Slovenia (Zorić & Hrovatin, 2012) and meta analysis (Sundt & Rehdanz, 2015). Ma et al. (2015) also found higher WTP for solar and wind power as compared with hydropower and biomass.

Feature of "availability" and "cost saving" positively and significantly affect the WTP in the current study. Abdullah and Mariel (2010) analyzed this variable and stated that WTP for various surveys is more for those where better quality and services are available for electricity producing agents where WTP remained low where quality of service is poor, and price is already high.

Table 1: **Odds Ratio**

Variable	Pakistan		Punjab		KPK		Sindh		Baluchistan	
	100-199	200 >	100-199	200 >	100-199	200 >	100-199	200 >	100-199	200 >
Monthly income										
Above 35000 PKR	2.245***	4.752***	1.495*	4.942***	3.188***	5.859***	2.710***	3.047***	2.966***	11.709***
25001 to 35000 PKR	1.472***	2.417***	1.428**	2.872***	1.196	1.587	2.999***	3.198***	1.156	3.408***
15001 to 25000 PKR	1.477***	1.765***	1.687***	2.394***	0.907	0.834	2.469***	1.361	0.897	2.602**
Less than 15000 PKR (RC)										
Monthly expenditures on electricity										
Above 2001 PKR	3.607***	7.440***	4.147***	14.995***	2.0132*	11.172***	2.256***	3.459***	2.647***	5.788***
1001 to 2000 PKR	3.739***	6.355***	4.559***	11.587***	1.603	5.307***	2.014***	1.934*	5.911***	14.584***
500 to 1000 PKR	1.643***	2.647***	1.971***	3.447***	1.001	3.081**	0.916	0.639	4.290***	6.103***
Less than 500 PKR (RC)										
Dummy for peri-urban locality	1.287**	1.393**	1.268	1.212	1.491	2.339***	2.528*	10.768**	4.433**	1.457
Dummy for female respondent	1.827***	6.916***	2.616***	7.997***	3.537***	3.506***	3.949***	25.379**	0.258***	2.206
Dummy for "other than agriculture" as major source of income	1.258***	1.461***	1.094	1.583***	2.296***	1.482	0.964	2.171***	2.015***	1.335
Ownership and regular use of incandescent bulbs	0.993	1.250**	1.006	1.319***	1.332	2.202***	0.639**	1.432	1.284	1.107
Ownership and regular use of tube lights	0.782***	0.816**	0.798	0.784	0.979	1.167	0.598	0.322***	1.029	2.357***
Ownership and regular use of color TV	1.276***	2.686***	1.415***	3.299***	1.304	1.835***	1.086	2.258***	1.065	1.732
Low voltage constraint with existing electricity source	0.780***	1.795***	0.877	1.885***	1.471**	3.316***	0.426***	1.560	0.825	4.214***
Load shedding frequency	1.286***	0.837***	1.585***	1.586***	1.214**	0.894	0.814**	0.634***	1.654***	1.140
Usage of non-electric sources for lighting	0.850***	0.728***	0.707***	0.486***	.979	.928	1.015	1.341**	.921	0.633***
Intention for using alternate electricity source	2.299***	2.218***	1.519***	2.458***	3.569***	2.515***	2.073***	0.814	12.144***	2.653**
Solar awareness	1.144***	1.208***	1.304***	1.233***	1.050	1.263***	0.997	1.496***	1.046	1.021
Feature of "availability" for alternate source	1.056*	1.763***	1.072	2.483***	1.440	1.158	0.941	0.703	1.763**	1.399
Feature of "cost saving" for alternate source	1.277***	1.677***	1.472***	1.889***	1.268	1.315	0.907	1.553*	1.302	3.131***

Reference category of dependent variable (Willingness to pay) is 1-99 PKR, *** 1% level of significance, ** 5% level of significance, * 10% level of significance

Marginal effects

After conducting multinomial logistic model, marginal effects of continuous variables like monthly income, monthly expenditures on electricity, load shedding frequency, usage of non-electric sources for lighting and solar awareness are estimated. Income, expenditures on electricity, load shedding

and solar awareness have positive marginal effect on WTP whereas use of non-electric sources has negative effect on WTP. Ten thousand PAK Rupee increase in monthly income would increase the WTP 100-199 PKR and more than 200 PKR by 1.1729 and 2.8486 percent, respectively. Similarly, one thousand PAK Rupee increase in monthly expenditures on electricity would increase the WTP 100-199 PRK and more than 200 PKR by 5.4957 and 5.9024, respectively. Marginal effect of load shedding is significant for 100-199 PKR only. Three times increase in frequency of load shedding would increase the willing to pay 100-199 PKR by 5.5754 percent. Increase in one source of lighting source other than electric would decrease the WTP 100-199 PKR and more than 200 PKR by 2.034 and 0.355 percent, respectively. One percent increase in solar awareness would increase the WTP 100-199 PKR and more than 200 PKR by 2.4113 and 1.1003 percent, respectively.

Table 2: Marginal effect

Variable	WTP 100-199 PKR	WTP 200 > PKR
	dy/dx	dy/dx
Monthly Income (10000 PKR)	0.012*	0.028*
Monthly expenditures on electricity (1000 PKR)	0.055*	0.059*
Load shedding frequency (times)	0.056*	-0.009
Usage of non-electric sources for lighting (No.)	-0.020*	-0.104*
Solar awareness (Index)	0.024*	0.011*

* denotes 1% level of significance

Welfare effect

Welfare effect of selected districts of Pakistan is calculated. Households which are not connected with national or mini grid are selected for the analysis. Four districts each from one province are selected as Karachi (Sindh), Multan (Punjab), Peshawar (KPK) and Quetta (Baluchistan). These households are WTP nothing, 1-99 PKR, 100-199 PKR, 200-299 PKR, 300-399 PKR and more than 400 PKR.

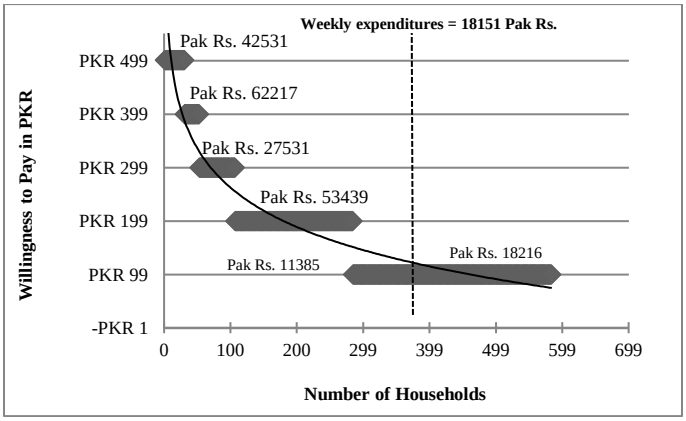

Figure 2: Welfare effects

The expected revenue of each district is calculated on the basis of household's respective WTP. Total revenue per week of Karachi, Multan, Peshawar and Quetta are 41552, 17314, 21298 and 24584 PAK Rupees per week. Whereas, the current expenditures per week of each district is subtracted from the gross revenue and difference in net welfare is calculated. Gross net revenue of four districts per week is calculated as 86598 in which each district has positive welfare gains. Arega and Tadesse (2017) estimated positive welfare gain was estimated in term of consumer surplus.

Table 3: Welfare Effect

Sr. No	District	Expected Total Revenue (Pak Rs.)	Net Revenue	Gain/ loss
1	Karachi	41552	37097	+
2	Multan	17314	13828	+
3	Peshawar	21298	16394	+
4	Quetta	24584	19278	+
Total		104748	86598	

CONCLUSION

The current study is conducted to estimate the determinants of WTP for reliable electricity and welfare effects by providing the unconnected dwellers with the national grid. Determinants of WTP are analyzed at country level as well as at province level. The analysis shows province level socioeconomics, lifestyle and behavioral factors which are very helpful to learn about WTP. Aggregate analysis shows that income, expenditures on electricity, female respondent, non-agriculture income source, ownership & usage of television, solar awareness, feature of availability and cost saving are positive factors for WTP but, usage of non-electric sources for lighting, ownership & usage of fluorescent tube lights are negative factors for WTP. Distinctive features of the analysis are; households at KPK starts responding to WTP significantly above income level 35000, no significant WTP difference between peri-urban and rural households at Punjab and female respondents are willing to pay less likely at Baluchistan, difference in province level analysis about interaction of incandescent bulbs, fluorescent tube lights, low voltage constraints and load shedding frequency. Marginal analysis also shows positive effect of income, expenditures on electricity, load shedding frequency, solar awareness and negative effect of non-electric sources for lighting on WTP. There is welfare gain of PAK Rs. 86598 per week by providing the electricity to unconnected households at major districts of each province.

Recommendations

The analysis suggests that WTP by source should be measured to look at the preference of people for individual alternate sources of energy. Potential for renewable energy source can be explored further in the country. Awareness program about solar energy should be launched for better energy decision by the people. Moreover, service reliability in terms of load shedding frequency, low voltage, time and duration of electric supply should keenly observe by the government and accordingly provide the electricity to respective areas to gain welfare among society.

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