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Willingness to Pay for Energy Efficient Appliances: The Case of Lebanese Consumers

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Abstract: A contingent valuation study was conducted to elicit the willingness to pay (WTP) of Lebanese citizens for five types of energy-efficient home appliances: washing machines, air conditioners, televisions, light bulbs, and refrigerators. A face-to-face survey is designed to this end, with data collection achieving a sample of 605 households geographically representative of the Lebanese population. A multivariate Tobit model was used to gauge the effects of socio-demographic characteristics, attitudes, perceptions, behavior, and experience on the WTP across all these appliances, while accounting for potential correlations between these WTP values. Findings provide evidence of the importance of several socio–demographics in determining WTP for more energy efficient appliances, such as income, education, and age, and the importance of perceptions and experience covariates, not least the implementation of energy labelling and the cost of electricity. In terms of policy implications, this study highlights the need to legally enforce a shift in payment mode from renting per capacity (kW) to purchasing per power (kWh) consumed for electricity in the back-up power sector, and the immediate introduction of a local labelling scheme for home appliances.

Keywords: Energy efficiency; household appliances; multivariate Tobit; purchasing decisions; willingness to pay

Highlights

- A survey of 605 citizens has been conducted across Lebanon
- Energy purchasing behavior is investigated for five types of home appliances
- A multivariate Tobit model is used to assess various variables on the WTP
- The immediate introduction of a local appliance labelling scheme is recommended
- The modification of payment terms for back-up generators is recommended

1. Introduction

Energy efficiency is regarded as one of the more effective means of alleviating energy demand and facilitating the transition towards a low carbon future [1]. Lebanon is a signatory of the 2016 Paris Agreement, and as such is committed, through the Intended Nationally Determined Contributions (INDCs) framework, to unconditionally reducing by 3 percent its power demand through energy efficiency measures, or conditionally reducing it by 10 percent. With this, Lebanon is aiming to unconditionally reduce its greenhouse gas (GHG) emission by 15 percent (or conditionally by 30 percent) by 2030 compared to the business-as-usual scenario, together with similar renewable energy commitments [2]. Up-to-date data on the Lebanese residential sector's share of electricity demand is lacking [3]; however, earlier studies have indicated that it is approximately 29 percent, surpassing any other sector in terms of energy consumption [4].

Understanding and targeting the behavior of citizens governing private household energy consumption and conservation is critical for meeting energy efficiency targets [5,6]. However, this is a challenging task, not least in view of the 'Energy Efficiency Gap'. This reveals a divergence between, on the one hand, the potential for making cost-effective energy-efficient choices, as described in energy-economic models, and, on the other hand, the actual levels of adoption [1], bringing into focus the 'irrational' side of individual decision-making [7]. In other words, even when energy efficient investments pay off in the short-term, they are often not taken up by the consumer when purchasing products. Insights from behavioral economics suggest that people's knowledge, values, attitudes, and intentions deviate substantially from the neo-classical economic axioms of rational choice and utility maximization [6,8–12]. This gap has led some researchers to appeal for the inclusion of 'behavioral capital' as a key component to drive forward sustainable development goals [13].

Two types of energy efficiency behavior can be distinguished: habitual behavior and maintenance of appliances (not covered in this study), and occasional purchasing decisions [14–16]. Research into what motivates Lebanese consumers towards more energy-efficient choices are important for the identification of ensuing policy responses. This is the focus of this study. Lebanon has yet to enact regulation on home appliances which sets the minimum standards for energy performance and labels appliances with respect to their energy performance. The National Energy Efficiency Action Plan [17] has revealed the intention of the Ministry of Energy and Water (MEW) to introduce, first, a labelling program for home appliances, followed by minimum standards below which the manufacture and/or import of these appliances would be prohibited.

A large body of research treats of the links between the socio–demographic characteristics, norms, and attitudes of consumers, on the one hand, and their energy-efficient behaviors and choices, including the choices of home appliances, on the other. Yue et al. [18] explore households' willingness to pay (WTP) to adopt various energy-saving behaviors (ESB) in China, including purchasing appliances, and find that ESB is influenced by demographic characteristics, awareness, knowledge, social norms, and the price of appliances. Results revealed that socio–demographic characteristics such as age, gender, income, household structure, and education, are all strong determinants of energy-saving behavior, while situational factors, such as energy-saving awareness, are moderate determinants. Reynolds et al. [19] examine consumers' WTP for energy-saving fluorescent light bulbs in Saint Lucia. Their results show that geographic location, low income, and age have an effect on WTP for compact fluorescent lighting. Furthermore, they find that energy efficiency knowledge is associated with higher WTP for energy-efficient bulbs. Hori et al. [20] investigate the extent to which global warming consciousness, environmental behavior, social interaction, age, and income determine ESB through studies conducted in five Asian cities. Their results indicate that awareness of global warming, environmental behavior, and social interaction significantly affect ESB. Social interactions were also shown to have strong links to ESB. Jacobsen [21] focuses on how the propensity of consumers to buy high-efficiency commodities is influenced by energy prices, finding no evidence for this. Examining the determinants of energy conservation patterns among Greek households, Sardianou [22] finds that several socio–demographic (particularly income and being a part of an extended family structure) and environmental consciousness traits are relevant. Dutch households' energy use and savings are examined by Abrahamse and Steg [23], and their results highlight the importance of psychological factors in determining behavior in this arena.

Numerous other studies investigate the impacts of different determinants of, and/or willingness to pay for, purchasing various types of appliances that have energy-efficiency labels. Newell and Siikamäki [24] found that providing simple information on the value of energy savings was the most effective element in driving investments in cost-efficient energy efficiency investments. Sammer and Wustenhagen [25] found that ecological and energy labels and ratings command substantial premiums for washing machines. Their analysis reveals a significant willingness to pay for A-labelled energy-efficient products. In a similar vein, Shen and Saijo [26] find that energy efficiency ranks on energy labels significantly increase the propensity of consumers to purchase energy-efficient air

conditioners and refrigerators. They also find that labels indicating saving in electricity bills further increase consumers' willingness to purchase such appliances. For their part, Zhou and Boukenya's [27] analysis reveals that not only does the presence of information on energy consumption increase WTP for energy-efficient technology, but also increases the ease with which consumers can understand the content of this information. Finally, Ward et al. [28] find a significant WTP among consumers for refrigerators with Energy Star labels. Moreover, they find that this WTP was motivated both by the promise of private gains from energy savings, and public benefits to the environment.

In the Middle East in general, and Lebanon in specific, research on consumer behavior with respect to energy saving behavior, let alone purchasing decisions governing energy-consuming household appliances, is scarce to non-existing. Published national statistics on household appliances, specifically with respect to their types and prices, is lacking. Two current projects are aiming to fill this void. The Lebanese Ministry of Energy and Water, through the Lebanese Center for Energy Efficiency, and the Ministry of Environment, through the United Nations Development Program and the Kigali Energy Efficiency Cooling Program (https://www.k-cep.org/where-we-work/), are both working to collect and disseminate various types of baseline information on household appliances, in order to establish a set of policy recommendations for the uptake of more efficient appliances.

Several studies have examined the distribution of appliances' use and their energy consumption patterns among Lebanese households [29–31]. However, assessing households' WTP for energy efficiency appliances and its determinants was not part of the scope of these studies. The only attempt to elicit WTP in the energy context was for renewable energy systems [32,33]. This study attempts to close this gap in the literature through an assessment eliciting the WTP, and the main drivers behind it, for the adoption of more energy efficient appliances; namely, washing machines, air conditioners, televisions, light-bulbs, and refrigerators, in Lebanon.

This paper is structured as follows: Section 2 overviews the contingent valuation (CV) survey design, empirical model, field interviews, and sample characteristics; Section 3 presents and discusses the model and WTP estimates; and finally, in Section 4, we conclude.

2. Methodology

2.1. Survey Design and Questionnaire Development

A face-to-face CV survey instrument was designed to collect information on the WTP of Lebanese citizens for five types of energy-efficient home appliances: (1) washing machines, (2) air conditioners, (3) televisions (TVs), (4) light bulbs, and (5) refrigerators. The instrument collected information about a variety of attitudes, perceptions, behaviors, knowledge, and socio–demographics that could influence WTP for such appliances and assist in understanding its systematic variation. The core of the questionnaire is composed of five questions that elicit respondents' WTP for each of these appliances. WTP values are elicited by means of the payment card (PC) method, which simplifies the task of the respondent stating their WTP compared to the open-ended (OE) format by offering a large variety of bid values from which he could choose the closest to his 'true' WTP.

Contingent valuation (CV) methods are a powerful survey-based technique for estimating consumer preferences and monetary values attached to environmental changes. For approximately 40 years, CV methods have been widely used among both academics and policymakers [34,35]. This is especially the case in instances where revealed preference methods cannot be employed, since the real-life transactions in actual or surrogate markets on which they would normally rely simply do not exist, as is often the case with environmental and public goods. Attribute-based choice modelling techniques, most notably choice experiments (CE), have been proposed by some researchers as a 'superior' alternative to CV methods for non-market valuation [34]. However, CV methods remain better suited for cases where the value of interest is that of the whole good, rather than its component parts or attributes [36]. We argue that this is indeed the case with energy-efficient appliances under study in this paper. If this comes with the added benefit of relieving respondents from the complex

task of evaluating repeated CE scenarios comprising multiple options and attributes, then in such cases, CV becomes a preferred method to employ for WTP valuation.

The CV survey included two information disclosure treatments: (1) in the first treatment, respondents were asked how much extra they are WTP for an energy-efficient appliance that is 50 percent more energy-efficient than a standard one, while (2) in the second treatment, they received, in addition to the energy efficiency information above, additional cost savings information to the effect that an energy-efficient washing machine, air conditioner, TV, light bulb, and refrigerator would save the buyer \$18, \$120, \$13, \$42, and \$23 per year, respectively, in terms of electricity bills and expenses. These monetized saving values were informed by a prior survey of existing and 'most sold' appliances across a broad range of appliance stores in Lebanon undertaken by the European Union funded and UNDP implemented CEDRO project's team, using the current average cost of electricity of \$0.16/kWh. CEDRO is a European Union funded UNDP project (www.cedro-undp.org) and is currently in its fourth phase.

By way of example, the CV scenario for washing machines that did not include information on energy efficiency (treatment 1) read as follows: 'How much are you willing to pay extra to buy a new washing machine that is 50% more energy efficient than a standard one?' In contrast, the CV scenario that included information on energy efficiency savings read as follows: 'How much are you willing to pay extra to buy a new washing machine that is 50% more energy efficient than a standard one, saving you on average \$18/year on operation?' The proposed price values in the payment card were then exactly the same in both treatments. The scenarios for the remaining appliances were constructed analogously for both treatments.

In the framework of this study, it is important to acknowledge the possibility of our results being subject to 'hypothetical bias', especially when it comes to the magnitude of our WTP estimates. Hypothetical bias in stated preference surveys has long been observed among researchers and practitioners. It occurs when stated preference survey respondents inflate their stated WTP as a result of the hypothetical nature of the good to be valued and the absence of real economic commitments following their stated choices [37,38]. In contingent valuation (CV), meta-analyses [38–40] suggest that hypothetical bias is widely present in CV surveys. Moreover, hypothetical bias tends to be larger with public goods and certain elicitation types, such as the widely used dichotomous choice.

The literature suggests various sources of bias in stated preference surveys (see Mitchell and Carson and Bateman et al. [35,36] for a comprehensive review). Information disclosure is proposed as a major source of bias, for example, if the respondents have no experience with or knowledge of the valued good, and this is very often the case with public goods such as environmental protection or energy conservation [41–44]. The biasing impact of information provision may be further compounded if respondents are primed rather superficially by altruistic cues in the provided information [41]. In such cases, respondents may state choices in ways they believe others, such as the interviewer or peer, expect them to, without internalizing such social norms into normative beliefs [45]. This has been termed 'social desirability' bias [46–48]. It tends to be particularly problematic in face-to-face surveys in which the interviewer is thought by the respondent to represent the perceived social norms.

Admittedly, our CV data may well exhibit hypothetical bias. However, we argue that the implications of this hypothetical bias may not be so important as to undermine the purpose of our study. We argue, on the one hand, that the thorough design and piloting of our survey questionnaire have helped us strengthen the credibility of the CV scenario within this questionnaire in the eyes of respondents. This is very important for mitigating hypothetical bias. On the other hand, the main focus of our study is comparative in the main, focused as it is on investigating attitudinal, behavioral, and socio–demographic determinants of WTP for energy-efficient home appliances. For this reason, the issue of overstated WTP estimates becomes secondary in importance.

2.2. Empirical Model

With WTP for the five appliances being driven in large proportion by common underlying drivers, correlations across them are expected to arise. For example, consumers who are enthusiastic about energy-efficient appliances may state generally high WTPs across all types of appliances, while others, indifferent to them, may state generally low WTPs. Therefore, we expected that WTP values would be positively correlated for all ten pairwise combinations of appliances. This warrants the joint (i.e., multivariate) estimation of the WTP equations to account for correlations between the different equations' error terms. Moreover, the extent of censoring at zero in the WTP data—18.0, 13.4, 21.7, 21.8, and 16.7 percent of stated WTP values for washing machines, air conditioners, televisions, light bulbs, and refrigerators, respectively—warrants the joint estimation of these equations in a Tobit framework. Indeed, univariate Tobit models are recommended for fitting models with limited dependent censored variables and are sometimes referred to as 'corner-solution' models [48,49]. Moreover, a multivariate generalization of the Tobit has been developed [50] with wide applications in transportation and economics research [51–55].

To explain systematic variation in WTP for each appliance, a set of key covariates describing socio–demographic status and relevant attitudes, perceptions, behavior, and experience were selected, and each was reduced, if need be, into a manageable *K*-level categorical variable with no less than 70 observations in each category. These categorical variables were each then translated into *K*-1 indicator variables, for which coefficients were estimated; a base level was assigned for each variable and excluded from the analysis (by setting its coefficient's value to 0) in order to avoid the dummy variable trap. A list of the socio–demographic, attitudinal, perceptional, and behavioral covariates can be found in Tables 1 and 2. In view of the large number of covariates, two models were estimated: (1) a model which includes the socio–demographic covariates listed in Table 1 (labeled 'SD' hereafter), and (2) a model which includes the attitudes, perceptions, behavior, and experience covariates listed in that Table 2 (labeled 'APBE' hereafter). In addition, a covariate accounting for the effect of the information provision treatments is incorporated in the APBE model.

Table 1. Socio–demographic characteristics.

Covariate	*N*	Mean	Std. Dev.
Monthly personal income category			
<$1500/month (base level)	233	0.385	0.487
$1500–$3,000/month	197	0.326	0.469
>$3000/month	175	0.289	0.454
Socio-economic grade			
D or E (base level)	134	0.221	0.416
C1 or C2	400	0.661	0.474
A or B	71	0.117	0.322
Surface area of residence			
40–100 m^2 (base level)	35	0.058	0.234
100–160 m^2	305	0.504	0.500
160 m^2 or more	265	0.438	0.497
Age group			
18–30 (base level)	170	0.281	0.450
31–45	244	0.403	0.491
>45	191	0.316	0.465
Gender			
Male (base level)	296	0.489	0.500
Female	309	0.511	0.500
Level of education			
High school or less/Technical school (base level)	300	0.496	0.500
University/College 1st degree level	234	0.387	0.487
University higher degree (MSc/PhD)	71	0.117	0.322
Area of residence			
Beirut & Mount Lebanon (base level)	308	0.509	0.500
North, South, & Beqaa	297	0.491	0.500

Table 2. Attitudinal, perceptional, and behavioral characteristics.

Covariate	*N*	Mean	Std. Dev.
Importance of EE label to purchasing decision			
Not important/Neither	278	0.460	0.499
Important	327	0.540	0.499
Exposure to awareness campaigns to reduce energy consumption			
No	483	0.798	0.402
Yes	122	0.202	0.402
Opinion about current energy situation in Lebanon			
Poor	514	0.850	0.358
Average/Good/Excellent	91	0.150	0.358
Belief that government will make electricity available 24/7			
Unlikely/Neither likely nor unlikely	490	0.810	0.393
Likely	115	0.190	0.393
Perception of total amount paid for electricity			
Reasonable	196	0.324	0.468
Average/Costly	409	0.676	0.468
WTP more for EE appliances			
Not at all/Not really	160	0.264	0.441
Depends on appliance	237	0.392	0.489
Yes, very possible/Definitely	208	0.344	0.475
Reading or talking about the environment			
Never/Occasionally	120	0.198	0.399
Sometimes	205	0.339	0.474
Often/V. often	280	0.463	0.499
Turning off lights when leaving room			
Never/Occasionally	133	0.220	0.414
Very often	232	0.383	0.487
All the time	240	0.397	0.490
Recycling practices			
Never	388	0.641	0.480
Only when available/Active	217	0.359	0.480
Water conservation practices			
Never/Occasionally	161	0.266	0.442
Very often	178	0.294	0.456
All the time	266	0.440	0.497
Hours of blackout per day			
<6 h	203	0.336	0.473
6–9 h	184	0.304	0.460
>9 h	218	0.360	0.480
Average monthly expenditure on backup solution			
<$50/month	253	0.418	0.494
$50–$90/month	230	0.380	0.486
>$90/month	122	0.202	0.402
Average monthly electricity bill			
<$40/month	198	0.327	0.470
$40–$80/month	318	0.526	0.500
>$80/month	89	0.147	0.355
Presence of renewable energy source at place of living			
No	417	0.689	0.463
Yes	188	0.311	0.463

2.3. Field Interviews and Descriptive Statistics

Data collection was undertaken by Nielsen (http://www.nielsen.com/lb/en.htm) between November 2016 and January 2017, with a sample of 605 households that was geographically representative of the Lebanese population. This sample size was determined by standard sample size calculations to achieve a confidence interval of 4 percent with a confidence level of 95 percent,

and given a population size probably over-estimated at 3,000,000 households (Lebanon has not had a population census since the 1930s).

Data were collected by means of computer-assisted personal interviews (CAPI), where Nielsen's interviewers recorded the data on tablets instead of using pen and paper techniques. The CAPI approach eliminates errors while filling up questionnaires and allows interviewers to export the data immediately for further analysis, thus cutting down the time required for data editing, punching, and cleaning and reducing human error. Sample descriptive statistics based on the multivariate Tobit models' covariates are presented in Tables 1 and 2. Note that in the case of socio–economic grade, we follow the UK's National Readership Survey (NRS) social grading system for demographic classification that is based on occupation. In this system, grade A (upper middle class) are interviewees with occupations that are either higher managerial, administrative, or professional; B (middle class) intermediate managerial, administrative, or professional; C1 (lower middle class) supervisory or clerical and junior managerial, administrative, or professional; C2 (skilled working class) skilled manual workers; D (working class) semi-skilled and unskilled manual workers; and E (non-working) casual or lowest grade workers, pensioners, and others who depend for their income on the welfare state.

3. Results

3.1. Model Fit and Specification Diagnostics

In terms of model specifications (Table 3), both the SD and the APBE specifications yield models that significantly explain the joint variation in the WTPs by systematic variation of covariates, as attested by the highly significant LR tests in both cases. It is worth mentioning here that comparatively, the APBE model generally fares better in explanatory power than the SD model. This is attested by the higher log-likelihood and lower Akaike Information Criterion (AIC) of the APBE model; the only exception to this picture is the Bayesian Information Criterion (BIC), which penalizes the number of model parameters to a larger extent than the AIC. Yet even here, the BIC for the APBE is only slightly larger than for the SD model. This higher performance of the APBE is partly explained by the fact that it is based on a larger number of estimated parameters, but also by the fact that attitudes, perceptions, behavioral patterns, and experiences related to energy-efficient appliances are more proximate determinants of WTP for energy-efficient appliances. This assertion is supported by the literature on energy saving behavior [23,56].

Table 3. Model specification diagnostics. (SD=socio–demographic covariates, APBE=attitude, perceptions, behavior, and experience covariates, AIC=Akaike Information Criterion, BIC=Bayesian Information Criterion).

	SD	**APBE**
Respondents	605	605
Parameters	80	130
LL (0)	−11,347.77	−11,347.77
LL (β)	−11,162.22	−11,016.42
LR χ^2	371.08	662.69
P-value	0.000	0.000
AIC	22,484.45	22,292.84
BIC	11,418.43	11,432.76

In terms of the correlations among the WTP's Tobit error terms of all pairwise combinations of appliances, we present those of the superior APBE model (see Table 4). As expected, all correlations turn out to be positive, indicating a general tendency for WTP to increase (or decrease) jointly across all appliances. Moreover, correlations between all pairwise appliance combinations, except those including light bulbs, were relatively high, with values close to or higher than 0.6 apiece. As for light

bulbs, the relatively low, but still positive, correlations of its WTPs' errors with other appliances is likely because it is a much lower-cost item.

Table 4. Correlation between willingness to pay (WTP) equations' error terms in the attitude, perception, behavior, and experience covariates (APBE) model.

	Washing Machine	Air Conditioner	TV	Light Bulb	Refrigerator
Washing machine	1.000				
Air conditioner	0.579	1.000			
TV	0.723	0.612	1.000		
Light bulb	0.177	0.200	0.232	1.000	
Refrigerator	0.718	0.643	0.763	0.213	1.000

3.2. Model Estimates

Tables 5 and 6 show the SD and APBE model estimates, respectively. Beginning with income, the estimates from the SD model indicate that WTP increases as expected with income for all appliances. These results are in line, at least partially, with several published studies [16,28,57,58]. Yue et al. [18] shows that income is positively correlated with energy efficiency promotion behavior, but not with energy usage reduction behavior.

Table 5. Socio–demographic (SD) model estimates.

Covariate	Washing Machine	Air Conditioner	TV	Light Bulb	Refrigerator
Constant	−17.021 **	10.985	−21.891 ***	−3.933 ***	−24.307 ***
Monthly personal income category					
<$1500/month (base level)	-	-	-	-	-
$1500–$3000/month	6.811 *	10.500 **	12.722 ***	1.103	9.427 *
>$3000/month	4.046	10.077 *	16.015 ***	1.237	5.628
Socio-economic grade					
D or E (base level)	-	-	-	-	-
C1 or C2	13.636 ***	13.303 **	12.957 ***	1.399 *	16.567 ***
A or B	27.116 ***	25.568 ***	22.461 ***	1.945 *	27.948 ***
Surface area of residence					
40–100 m^2 (base level)	-	-	-	-	-
100–160 m^2	16.311 **	9.751	23.171 ***	5.124 ***	27.102 ***
160 m2 or more	29.453 ***	22.761 ***	28.830 ***	6.928 ***	44.790 ***
Age group					
18–30 (base level)	-	-	-	-	-
31–45	−0.587	−7.407 *	−3.291	−1.084 **	−0.593
>45	0.512	−8.078 *	−5.922	−1.567 ***	0.878
Gender					
Male (base level)	-	-	-	-	-
Female	2.475	−1.574	−0.333	0.493	2.261
Level of education					
High school or less/Technical school (base level)	-	-	-	-	-
University/College 1st degree level	4.645	4.771	−1.614	−0.655	1.129
University higher degree (MSc/PhD)	16.338 ***	27.897 ***	9.980	−0.618	24.463 ***
Area of residence					
Beirut & Mount-Lebanon (base level)	-	-	-	-	-
North, South & Beqaa	5.325 *	−7.884 **	9.325 ***	2.036 ***	4.634

Legend: * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$.

Table 6. Attitude, perception, behavior, and experience covariates (APBE) model estimates.

Covariate	Washing Machine	Air Conditioner	TV	Light Bulb	Refrigerator
Constant	−9.686 *	13.707 **	1.505	1.272	−2.038
Information treatment					
With cost savings information (base level)	-	-	-	-	-
Without cost savings information	0.664	−6.960 **	−1.591	−1.585 ***	1.700
Importance of EE label to purchasing decision					
Not important/Neither (base level)	-	-	-	-	-
Important	10.670 ***	11.253 ***	10.742 ***	1.691 ***	13.001 ***
Exposure to awareness campaigns to reduce energy consumption					
No (base level)	-	-	-	-	-
Yes	−3.902	−0.556	−0.609	−1.310 **	−6.798
Opinion about current energy situation in Lebanon					
Poor (base level)	-	-	-	-	-
Average/Good/Excellent	−1.322	−4.162	2.435	2.969 ***	−0.025
Belief that government will make electricity available 24/7					
Unlikely/Neither likely nor unlikely (base level)	-	-	-	-	-
Likely	1.797	7.452 **	1.160	0.607	2.899
Perception of total amount paid for electricity					
Reasonable (base level)	-	-	-	-	-
Average/Costly	−9.362 ***	−5.890	−8.816 **	−0.875 *	−5.911
WTP more for EE appliances					
Not at all/Not really (base level)	-	-	-	-	-
Depends on appliance	28.213***	28.109 ***	23.086 ***	2.850 ***	27.189 ***
Yes, very possible/Definitely	36.439 ***	37.298 ***	32.014***	2.843 ***	38.319 ***
Reading or talking about the environment					
Never/Occasionally (base level)	-	-	-	-	-
Sometimes	−1.339	−3.266	2.457	1.213 **	−5.245
Often/V. often	−0.963	−4.698	0.567	1.513 **	1.036
Turning off lights when leaving room					
Never/Occasionally (base level)	-	-	-	-	-
Very often	2.611	−3.908	−1.843	0.278	−1.490
All the time	−3.406	−9.362 **	−6.335	−0.889	−12.899 **
Recycling practices					
Never (base level)	-	-	-	-	-
Only when available/Active	−8.292 ***	−2.486	−3.729	0.818*	−4.024
Water conservation practices					
Never/Occasionally (base level)	-	-	-	-	-
Very often	1.026	2.053	−6.269	−1.494 **	1.200
All the time	0.559	−5.947	−6.661	−1.711 ***	−1.933
Hours of blackout per day					
<6 h (base level)	-	-	-	-	-
6–9 h	5.315	3.800	2.816	−1.793 ***	3.827
>9 h	1.916	−4.152	−6.322	0.322	−2.772
Average monthly expenditure on backup solution					
<$50/month (base level)	-	-	-	-	-
$50–$90/month	3.513	3.295	5.551	0.488	6.635 *
>$90/month	10.351 **	13.821 ***	5.812	1.162 *	11.728 **
Average monthly electricity bill					
<$40/month (base level)	-	-	-	-	-
$40–$80/month	14.445 ***	10.488 ***	13.469 ***	0.384	18.685 ***
>$80/month	32.131 ***	36.567 ***	30.671 ***	2.120 ***	33.060 ***
Presence of renewable energy source at place of living					
No (base level)	-	-	-	-	-
Yes	−2.160	−4.044	−6.941 *	−0.381	−3.106

Legend: * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$.

Stronger associations and lower p-values are generally observed for the '$1500–$3000/month' income category in comparison to the higher '>$3000/month'; indeed, coefficients for the former group were even substantially higher for washing machines and refrigerators. Note that for light bulbs, the coefficients were insignificant across all income brackets, probably due to this appliance's low unit price of, and therefore the limited impact on, income of paying extra for it. This result is supported in the literature. For example, Reynolds et al. [19] show that even households with the highest income

levels displayed no significant increase in WTP for CFL bulbs, giving the explanation that as income increases, electricity expenditure, and thus lighting costs, dwindle in importance.

As for socioeconomic grade, WTP increases significantly in the move from the D/E to the C1/C2 grades, and likewise from this latter to the A/B grades, and this across all appliances except light bulbs. For this appliance, this increase was significant only at the 10 percent significance level. Surface area of residence, on the other hand, registers the highest association with WTP, with WTP highly, significantly, and substantially increasing in response to it across all appliances.

Where age had a highly significant effect, it was to reduce WTP. This can be observed for air conditioners and light bulbs, which again are the two appliances that had the highest yearly savings due to energy efficiency. This seems to result from the fact that 'young households prefer up-to-date technology, which is more efficient, while older households accept their old appliances and replace them more seldom' [22,59]. Another explanation is that the younger generation may be more sensitive when it comes to environmental issues [16,60–62].

As for gender, in none of the appliances were WTP differences significant between females and males. This is common in the literature [16,18]. Education, on the other hand, had a significant impact limited to the highest level, namely, a higher university degree (MSc and PhD) for which coefficients were highly significant and positive for all appliances except TVs and light bulbs. This indicates a significantly higher WTP than at other educational levels. Similar results were obtained in Yue et al. [18].

Finally, area of residence had an interesting variegated effect across appliances. In the case of air conditioners, the parameter estimate for 'North, South, & Beqaa' is highly significant and negative. This indicates that the WTP for energy-efficient appliances is lower among residents of these regions in comparison to Beirut and Mount Lebanon. This may reflect the fact that the North, South, and Beqaa regions tend to be more rural in character, and as such, relatively less interested in air conditioning, including energy-efficient air conditioning. Indeed, respondents from Beirut and Mount Lebanon reported having an average of 3.2 split AC units in their residences, while those from North, South, and Beqaa reported only 2.8. For TVs, light bulbs, and washing machines, on the other hand, the parameter estimates were significant and positive (though only at the 10 percent significance level for washing machines), indicating that residents of the North, South, and Beqaa regions have higher WTP values for these appliances when contrasted with Beirut and Mount Lebanon. Similar differences between rural and urban areas have been indicated in the literature (e.g., Hori et al. [20]). However, it is to be kept in mind that many studies show contradictory results with respect to the various socio–demographic determinants as predictors to environmental behaviors [16].

With respect to the APBE model estimates, coefficients for the disclosure of actual cost savings information treatment are significant for air conditioners and light bulbs only, with signs being negative in both cases. Interestingly, these two types of appliances had the highest savings per year, which suggests that respondents were rational in the way they reacted to this information, with WTP increasing significantly with information about the extent of energy efficiency. This mixed result on the implications of monetary value information provision is not unobserved in the literature [1,63–65]. Moreover, respondents who indicated that EE labels were important to their purchasing decisions had WTP increases that were highly significant for all appliances, suggesting that WTP for EE efficiency is largely motivated by a wish to reduce energy usage rather than a mere uncritical 'warm glow' effect of contributing to a 'good cause'.

Surprisingly, respondents who thought the current energy status in Lebanon was average, good, or excellent (15 percent of the sample) stated a WTP that was significantly larger for energy efficient light bulbs compared to the majority of respondents who thought that the status was poor. Similarly, an optimistic belief that the government is likely to render electricity available 24/7 (around 19 percent of the sample) results in a significantly higher WTP for energy efficient air conditioners (albeit only at the 10 percent level) compared to the pessimistic or agnostic majority. This suggests a stronger conviction in the benefits of EE appliances on the part of respondents who have a positive outlook

on energy and electricity prospects in Lebanon. We may further speculate that this outlook may be accompanied with the belief that in the near future, reliance on backup generators which are paid for in the form of a fixed periodical sum will gradually decrease in favor of the metered consumption of electricity supplied by the national grid.

In terms of financial considerations related to energy efficiency and electricity, the respondents who think that the amount paid for electricity is 'average' or 'costly' are willing to pay a significantly lower amount for all appliances, except for refrigerators and air conditioners, compared to respondents who see this amount as reasonable. This, no doubt, reflects the fact that respondents are discounting what they would construe as an additional electricity-related financial burden. On the other hand, as expected, we see that WTP increases highly significantly for all EE appliances when respondents' belief that they will have to pay more for such appliances is stronger and more unqualified.

As for the impact of activities motivated by energy and/or environmental concerns, we do find some evidence that these impact WTP for various types of appliances, though not always in the expected direction. Reading or talking about the environment, a proxy for environmental concern, 'sometimes', 'often', or 'very often' significantly increases WTP for EE light bulbs only compared to 'never' or 'occasionally' engaging in such an activity. Although this seems counter-intuitive, as other assessed appliances have greater potential for cost savings, a similar result can be found in Poortinga et al. [58], where respondents whose environmental concern was high found solutions with smaller energy savings more agreeable than ones with larger energy savings. However, with more physical activities such as consistently turning off lights when leaving a room, WTP significantly decreases for both air conditioners and refrigerators. In a similar disposition, WTP for washing machines and for light bulbs seem to decrease with recycling in the former case and water conservation practices in the latter case. These findings show again the importance of the difference between energy 'curtailment' behavior (or habitual behavior) and occasional purchasing decisions, where the latter seems to be less impacted by environmental attitudes.

In terms of the factors related to experience with energy and electricity issues, hours of blackout experienced per day do not appear to be strong drivers of the magnitude of WTP for EE appliances, except when respondents face 6–9 h per day of blackout. For these respondents, WTP is significantly lower in comparison to those experiencing both shorter and longer daily blackout durations.

WTP for EE appliances increases significantly with expenditure on backup solutions. This is especially the case when expenditure exceeds $90 per month, except for TVs. Moreover, the strongest positive strongest with WTP can be noted for the average monthly national electricity bill. As mentioned earlier, backup generators in Lebanon are largely paid for in the form of a fixed periodical sum. As such, they offer a weaker incentive for households to buy EE compared to households whose metered electricity consumption from the national grid provides them with most of their energy needs. The evidence in the literature on the implications of energy prices on the decision to purchase energy efficient appliances is mixed. A study by Dillman et al. [66] on 8392 US households found that a higher energy price encouraged wealthy households to make energy conservation investments, whereas less well-off households were forced to roll back their expenditures in all areas [14,22]. Jacobsen [21], on the other hand, analyzed the impacts of energy prices on air conditioners, clothes dryers, dishwashers, and refrigerators between 2000 and 2009 in the United States, and found "no evidence that electricity prices affect the propensity for consumers to select energy efficient appliances". Finally, the presence of a renewable energy source at the place of living has a negative coefficient for all appliances, but is only significant at the 10 percent level for TV sets. This suggests that having a renewable energy source has no sizable impact on WTP for EE appliances.

3.3. Willingness to Pay (WTP) Estimates

Overall per unit WTP estimates for each of the five appliances are presented in Table 7, along with associated standard errors, p-values, and 95 percent confidence intervals. To gain a perspective on these WTP values, average sample prices paid for each appliance as reported by respondents were also

tabulated, and percent WTP values derived. All WTP estimates are positive and very highly significant, and by implication have very narrow confidence intervals. Relative to the average reported prices for each appliance, percent WTP seems to be largest for the appliance with the lowest average unit price—34.5 percent for light bulbs—and decreases in magnitude with increasing unit price to reach 3.2 percent for refrigerators.

Table 7. Overall willingness to pay (WTP) estimates ($/unit).

Appliance	Mean WTP	Std. Err.	z	P-Value	95% Conf. Int.	Average Reported Price	% WTP
Washing machine	$29.66	$1.03	28.73	0.000	$27.64–$31.69	$614.93	4.8%
Air conditioner	$41.20	$1.26	32.63	0.000	$38.72–$43.67	$451.33	9.1%
TV	$28.56	$1.08	26.49	0.000	$26.45–$30.68	$875.08	3.3%
Light bulb	$4.13	$0.15	26.85	0.000	$3.83–$4.43	$11.96	34.5%
Refrigerator	$38.59	$1.33	28.92	0.000	$35.98–$41.21	$1,205.69	3.2%

Finally, WTP segmentation was undertaken for each of the SD and APBE covariates. Expected values of the censored WTP were therefore estimated for each of the covariate's categories holding all other covariates at their respective sample means. We also conduct pairwise comparisons of these expected WTP values. Results are presented in Table 8. These results are very much in line with the model estimates from which they directly derive. Suffice it to add that for socio–demographic variables, the widest variations in WTP tend to be in response to closer correlates of income, such as income itself, but even more so education, area of residence, and socioeconomic grade. On the other hand, age and gender are very limited in their ability to determine WTP for energy-efficient appliances.

The WTP variation in response to cost savings information disclosure, if any (i.e., air conditioners and light bulbs), is modest at best. This seems to suggest that informative EE labeling may be limited in its potential as value-adding activity, as aforementioned. In general terms, the widest variations in WTP are registered in association with expenditure on electricity supplied by the national grid, and to a lesser extent, on backup electricity solutions, as well as the general commitment to pay more for EE appliances. Also, a notable impact on WTP is the effect of EE labeling, where respondents indicate a positive WTP for all assessed appliances, should such labelling be provided to facilitate information of respective energy use of household appliances.

All this highlights the importance of experience and attitudes in shaping WTP for EE appliances. Indeed, our results suggest that variation in these 'soft' characteristics determines to a larger extent WTP values compared to the 'hard' socio–demographic characteristics.

Table 8. Expected willingness to pay (WTP) values by covariate ($/unit) *. (APBE=attitude, perceptions, behavior, and experience covariates).

Covariate	Washing Machine	Air Conditioner	TV	Light Bulb	Refrigerator
Information treatment (APBE model)					
With cost savings information (base level)	$29.40 [a]	$44.13	$29.15 [a]	$4.75	$37.93 [a]
Without cost savings information	$29.94 [a]	$38.09	$27.93 [a]	$3.50	$39.32 [a]
Socio-demographics (SD model)					
Monthly personal income category					
<$1500/month	$28.05 [a]	$36.47 [a]	$23.17	$3.80 [a]	$35.58 [a]
$1500–$3000/month	$33.51 [a]	$45.34 [b]	$32.44 [a]	$4.62 [a]	$43.12 [a]
>$3000/month	$31.25 [a]	$44.97 [a,b]	$35.07 [a]	$4.73 [a]	$40.01 [a]
Socio-economic grade					
D or E (base level)	$21.64	$32.16	$21.58	$3.50 [a]	$28.62
C1 or C2	$31.88	$43.03	$30.74 [a]	$4.51 [a]	$41.15 [a]
A or B	$43.53	$53.99	$38.39 [a]	$4.94 [a]	$50.82 [a]
Surface area of residence					
40–100 m^2	$16.03	$29.83 [a]	$14.10	$1.22	$17.12
100–160 m^2	$26.96	$37.45 [a]	$28.56 [a]	$3.96	$34.45
160 m^2 or more	$37.68	$48.63	$32.89 [a]	$5.36	$48.89
Age group					
18–30	$30.78 [a]	$46.55 [a]	$31.86 [a]	$5.05 [b]	$39.23 [a]
31–45	$30.31 [a]	$40.16 [a]	$29.34 [a]	$4.21 [a,b]	$38.76 [a]
>45	$31.19 [a]	$39.59 [a]	$27.39 [a]	$3.86 [a]	$39.94 [a]
Gender					
Male	$29.71 [a]	$42.43 [a]	$29.54 [a]	$4.14 [a]	$38.34 [a]
Female	$31.70 [a]	$41.08 [a]	$29.29 [a]	$4.51 [a]	$40.15 [a]
Level of education					
High school or less/Technical school	$27.80 [a]	$37.46 [a]	$29.00 [a,b]	$4.58 [a]	$36.65 [a]
University/College 1st degree level	$31.47 [a]	$41.44 [a]	$27.80 [a]	$4.08 [a]	$37.54 [a]
University higher degree (MSc/PhD)	$41.46	$62.44	$36.87 [b]	$4.11 [a]	$57.49
Area of residence					
Beirut & Mount-Lebanon	$28.65 [a]	$45.08	$26.06	$3.61	$37.46 [a]
North, South & Beqaa	$32.92 [a]	$38.37	$33.07	$5.14	$41.17 [a]
Attitudes, perceptions, behavior & experience (APBE model)					
Importance of EE label to purchasing decision					
Not important/Neither (base level)	$25.11	$36.03	$24.26	$3.44	$33.05
Important	$33.77	$45.77	$32.47	$4.76	$43.58

Table 8. *Cont.*

Covariate	Washing Machine	Air Conditioner	TV	Light Bulb	Refrigerator
Exposure to awareness campaigns to reduce energy consumption					
No (base level)	$30.31 [a]	$41.29 [a]	$28.66 [a]	$4.34	$39.72 [a]
Yes	$27.16 [a]	$40.81 [a]	$28.19 [a]	$3.35	$34.28 [a]
Opinion about current energy situation in Lebanon					
Poor (base level)	$29.82 [a]	$41.74 [a]	$28.28 [a]	$3.79	$38.60 [a]
Average/Good/Excellent	$28.75 [a]	$38.16 [a]	$30.17 [a]	$6.29	$38.58 [a]
Belief that government will make electricity available 24/7					
Unlikely/Neither likely nor unlikely (base level)	$29.38 [a]	$39.97 [a]	$28.39 [a]	$4.04 [a]	$38.15 [a]
Likely	$30.86 [a]	$46.55 [a]	$29.29 [a]	$4.52 [a]	$40.52 [a]
Perception of total amount paid for electricity					
Reasonable (base level)	$35.00	$44.70 [a]	$33.31	$4.61 [a]	$41.90 [a]
Average/Costly	$27.23	$39.55 [a]	$26.40	$3.91 [a]	$37.05 [a]
WTP more for EE appliances					
Not at all/Not really (base level)	$13.43	$22.66	$15.24	$2.64	$21.48
Depends on appliance	$33.54	$44.97	$30.94	$4.74 [a]	$41.37
Yes, very possible/Definitely	$40.81	$53.38	$38.37	$4.74 [a]	$51.04
Reading or talking about the environment					
Never/Occasionally (base level)	$30.40 [a]	$44.08 [a]	$27.73 [a]	$3.30	$39.66 [a]
Sometimes	$29.30 [a]	$41.21 [a]	$29.62 [a]	$4.21 [a]	$35.44 [a]
Often/V. often	$29.61 [a]	$39.97 [a]	$28.16 [a]	$4.45 [a]	$40.51 [a]
Turning off lights when leaving room					
Never/Occasionally (base level)	$29.95 [a]	$45.81 [b]	$31.09 [a]	$4.33 [a,b]	$43.33 [a]
Very often	$32.12 [a]	$42.34 [a,b]	$29.63 [a]	$4.55 [b]	$42.07 [a]
All the time	$27.21 [a]	$37.64 [a]	$26.21 [a]	$3.64 [a]	$32.91
Recycling practices					
Never (base level)	$32.13	$41.97 [a]	$29.60 [a]	$3.90 [a]	$39.78 [a]
Only when available/Active	$25.45	$39.82 [a]	$26.75 [a]	$4.55 [a]	$36.52 [a]
Water conservation practices					
Never/Occasionally (base level)	$29.22 [a]	$42.96 [a,b]	$32.34 [a]	$5.11	$39.00 [a]
Very often	$30.05 [a]	$44.78 [b]	$27.42 [a]	$3.90 [a]	$39.99 [a]
All the time	$29.67 [a]	$37.82 [a]	$27.13 [a]	$3.73 [a]	$37.43 [a]
Hours of blackout per day					
<6 h (base level)	$27.80 [a]	$41.49 [a,b]	$29.67 [a,b]	$4.47 [a]	$38.46 [a]
6–9 h	$32.16 [a]	$44.85 [b]	$31.90 [b]	$3.12	$41.62 [a]
>9 h	$29.34 [a]	$37.93 [a]	$24.91 [a]	$4.74 [a]	$36.23 [a]

Table 8. *Cont.*

Covariate	Washing Machine	Air Conditioner	TV	Light Bulb	Refrigerator
Average monthly expenditure on backup solution					
<$50/month (base level)	$26.92 [a]	$37.74 [a]	$26.09 [a]	$3.81 [a]	$34.70 [a]
$50–$90/month	$29.74 [a,b]	$40.55 [a]	$30.33 [a]	$4.18 [a]	$40.03 [a,b]
>$90/month	$35.52 [b]	$49.96	$30.54 [a]	$4.73 [a]	$44.32 [b]
Average monthly electricity bill					
<$40/month (base level)	$20.36	$32.14	$20.32	$3.74a	$27.46
$40–$80/month	$31.42	$40.85	$30.02	$4.03a	$41.90
>$80/month	$47.25	$65.02	$44.68	$5.47	$54.56
Presence of renewable energy source at place of living					
No (base level)	$30.21 [a]	$42.29 [a]	$30.24	$4.22 [a]	$39.38 [a]
Yes	$28.46 [a]	$38.80 [a]	$24.99	$3.93 [a]	$36.87 [a]

* For each covariate, WTP values sharing the same letter are insignificantly different at the 5 percent level. For example, with a covariate with three levels, if all three WTP values share the letter 'a', then they are all insignificantly different. If, however, one has next to it the letter 'a', the second 'b', and the third 'a,b', then the first two are significantly different, while each is insignificantly different from the third. Finally, if no letters are found next to any of the three values, this means that any two of three WTP values are significantly different.

4. Conclusions

A face-to-face survey of 605 citizens was conducted to collect information on the determinants of WTP among Lebanese citizens for five types of energy-efficient home appliances: (1) washing machines, (2) air conditioners, (3) televisions (TVs), (4) light bulbs, and (5) refrigerators. The instrument collected information on a variety of attitudes, perceptions, behaviors, knowledge, and socio–demographic characteristics that could potentially help explain variations in WTP for such appliances. Given common underlying drivers of WTP for all five appliances, a joint (i.e., multivariate) estimation of the WTP equations through a multivariate Tobit model was conducted. Two separate models were estimated: (1) one which included socio–demographic characteristics, and (2) another which included attitudes, perceptions, behavior, and experience related to energy use and efficiency. In addition, a covariate accounting for the effect on WTP of disclosing information on cost savings from using energy efficient appliances was included in the analysis.

Several policy recommendations can be proposed based on this study's findings. The first of these recommendations is national and/or broad in character. In specific, the ongoing situation in Lebanon of structured blackouts, and the subsidized tariffs that households in the country pay for electricity provided by the national grid, erect a strong barrier against healthy adoption rates of energy efficient appliances. The higher the households' national electricity bills, the higher their WTP for most of the investigated energy efficient appliances. Therefore, subsidized tariff rates dilute the potential of this important factor. Monthly payments for backup diesel generator has a positive relation to WTP for more efficient appliances only for approximately 20% of the Lebanese surveyed who pay over $90/month for backup power capacity. This can be attributed to the fact that, as aforementioned, payments for backup power are mostly done for capacity power as opposed to actual energy use (i.e., per kW capacity as opposed to kWh). Increasing national tariff rates while not delivering 24-h electricity and enabling the elimination of the need for backup power is politically and socially challenging. Legally imposing and enforcing that the backup generator sector charge consumers for the power they actually consume, as opposed to a periodical flat rate for the capacity they rent out, can be a short-to-medium term alternative solution that would provide households with an incentive to purchase more energy efficient appliances. Indeed, in the longer term, it remains imperative that the Government of Lebanon secure a reliable 24-h electricity.

Another policy recommendation would be to introduce energy performance labelling for home appliances. Lebanon is still a long way from creating awareness of the existence and purpose of energy labelling in appliances. In fact, 79 percent of our sample stated that they have not witnessed any awareness campaigns around energy efficiency labelling (Table 1), and 60 percent rarely or never 'talk to others or read' about energy efficiency in home appliances. However, the results from our study suggest that respondents are WTP more for appliances with energy performance labels. This presents a strong case for overcoming the 'bounded rationality' by enhancing the purchaser's knowledge at minimal effort [67]. As Table 6 shows, the average relative premiums for energy efficient vary in range, from over 3 percent for televisions and refrigerators and just under 5% for washing machines, to over 9 percent for air conditioners and 34 percent for light bulbs. These values can be taken as a starting point for implementing the necessary fiscal instruments to forge a solid market for energy efficient appliances, such as tax credits or subsidies, which are used in several countries [64]. Specifically, Lebanon has a 5% customs tax rate and 10% value added tax. Incentivizing the purchase of more energy efficient appliances can start by combining the above indicated additional premiums that citizens are WTP for them with the necessary remaining reduction of existing tax rates to bring down total purchase costs of more efficient appliances to levels closer to less efficient ones, per respective appliance and ceteris paribus.

As for the determinants of WTP, the higher the income and the larger the residence surface area, the more citizens are WTP a premium for energy efficient appliances. The younger generation seems also more inclined to pay more for more efficient light bulbs and air conditioners, whereas individuals with higher education (Master's and/or PhD) were WTP more for washing machines, air

conditioners, and refrigerators. Awareness campaigns that proceed in tandem with the introduction of labelling schemes for energy performance in appliances can be more effective in targeting these relatively financially 'better-off', younger, and more educated citizen groups. Furthermore, awareness campaigns would be more effective if differentiated by the type of appliance and region. Households in the more urbanized areas (specifically Beirut and Mount Lebanon) seem to have a higher propensity to pay more for energy efficient air conditioners compared to rural areas, whereas in the latter, they tend to be more concerned with the energy performance of washing machines, televisions, and light-bulbs.

Finally, the disclosure of actual cost savings information was significant only for air conditioners and light bulbs, suggesting the use of actual monetary saving information for these two appliances when a local labelling scheme is set up. However, the WTP variation is modest in this regard. We recommend further research on how Lebanese consumers would perceive and respond to various designs and information disclosure formats of energy labelling on household appliances, which have been shown to play a critical role in the success of any labelling scheme [68].

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