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Does it Matter When a Power Outage Occurs?
- A Choice Experiment Study on the Willingness to Pay to Avoid Power Outages

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Abstract
Using a choice experiment survey, the marginal willingness to pay (WTP) among Swedish households for reductions in power outages is estimated. The results from the random parameter logit estimation indicate that the marginal WTP increases with the duration of the outages, and is higher if the outages occur during weekends and during winter months. Moreover, the random parameter logit model allows us to estimate a sample distribution of WTP and we find a significant unobserved heterogeneity in some of the outage attributes. Given that households have negative welfare effects from outages, it is important that policy makers consider these negative impacts on household utility when regulating the Swedish electricity market.

Keywords: Choice experiment; Power outages; Random parameters; Willingness to pay

JEL-classification: C25, C93, D12, Q41

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1. Introduction

In 1996, the reformation of the Swedish electricity market began when the electricity sector changed from being a completely regulated domestic market to a now completely liberalized Nordic-wide market with the major exception being the transmission of electricity. One part of the electricity bill paid by households relates to the tariff for the transmission of electricity, and the level of the tariff is determined by the network companies, since there is no market for the transmission of electricity. However, the tariffs charged by the network companies have to be "reasonable" according to Swedish Law, and in order to judge whether or not the tariff charged is reasonable, the so-called network performance assessment model has been developed; see STEM (2004). In this model, the actual tariffs charged are divided by the calculated value of the services from the network performance assessment model. If the obtained ratio exceeds unity, then the network company has charged more than the value of the services provided to its customers and vice versa. In cases when the network companies have over-charged their customers, they have had to pay back the same amount to their customers. One important component of this model is power outages. If the actual number of outages exceeds expected outages based on a reference case a certain quality adjustment of the tariff is made. The present design of the network performance assessment model does not consider when the outage occurs, instead there are fixed adjustments based only on the duration of the outage. The current quality adjustment is based on a large outage cost study made in 1994 (Svenska Elverksföreningen, 1994). However, it is likely that customers have different costs at for example different times of the day or week. For example, an outage at midday during a weekday will results in high costs for the industry while many households would face no or very small costs. In this paper we measure the welfare effects of outages at different times of the day, week and year for households. The information provided from this study could be used in a regulation model such as the network performance assessment model, but it could also be used for decisions when planned outages should occur and by network companies for their pricing decisions.[1]

We use a stated preference study in order to elicit the willingness to pay (WTP) for avoiding outages. Most previous studies have applied some form of stated preference method because this allows for non-monetary effects of outages on the households to be included such as lack of heating and not being able to watch TV or cook food during the outage.[2] Both the contingent valuation method and the choice experiment method have been used for valuation of power outages, but the contingent valuation method has been the most used method (see e.g. Svenska Elverksföreningen, 1994; Beenstock et al., 1998; Doane et al., 1988b; Goett et al., 2000; Layton and Moeltner, 2004). There are several components of a power outage that may affect the valuation, where both the timing of the outage as well as the duration are likely to be important. In this paper we estimate the marginal willingness to pay (WTP) for reducing unplanned power outages among Swedish households by using a choice experiment. In the experiment we vary both the timing and the duration of an outage. The main contribution is thus that we allow for a simultaneous valuation of several possible characteristics of an outage: the duration of the outage (4, 8 and 24 hours), time of the

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[1] Needless to say, our study of households should be complemented by a study of the costs for the industry. Not the least since it is likely that they would have a different distribution of the costs than the households.
[2] There are also a number of studies that have asked the respondents to state the hypothetical monetary costs of power outages, see for example Wacker et al. (1985), Doane et al. (1988a) and SINTEF (2003). However, this approach neglects any non-monetary effects of power outages. In principle one could also use revealed preference data to measure the WTP, for example by studying households' investments in equipment such as UPS equipment and backup power to reduce the effects of outages. This would require

week (working day and weekend) and the time of the year (winter months and the rest of the year). In a choice experiment, we do not directly observe the marginal WTP, but only the respondents' choices in certain situations. In the econometric analyses we therefore apply a random parameter logit model that accounts for unobserved heterogeneity by allowing the parameters of the utility function to have a distribution rather than being fixed, and considers that each respondent makes choices in more than one choice situation. Although we do not observe the WTP, we can estimate the respondents' WTP from the random parameter model. Furthermore, we are able to obtain individual specific parameters and consequently WTP values for each respondent. As shown in this paper, this is an interesting strength of the random parameter model; it also allows us to investigate in more detail the sample distribution of WTP on sub-groups of the underlying population.

The rest of the paper is organised as follows. Section 2 contains a description of the choice experiment and the econometric approach applied. In Section 3 we present the results from the study and finally in Section 4 we conclude the paper.

2. The Choice Experiment

In a choice experiment, individuals are asked to make repeated selections of their preferred alternative in the choice sets presented to them.[3] Since power outages affect the whole household, we explicitly stated that the respondents should answer for their entire household. Each choice set consists of several alternatives, and each alternative is described by a number of attributes. We introduced three groups of attributes in the

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rather detailed information about the extent of the expected power outages that would be avoided in the household during the lifetime of the equipment being bought.

[3] For overviews on the choice experiment method see for example Louviere et al. (2000) and Alpizar et al. (2003).

choice experiment: duration of the power outage (4, 8 and 24 hours), the day of the week that the outage occurs (working days and weekends) and the connection fee to a back-up electricity board, which needs to be paid in order to guarantee the number of power outages to the levels stated. This means there are in total seven attributes in each alternative, since for each time of the week there are three different durations in addition to the cost attribute. We focused on unplanned outages, and therefore the number of planned outages remained unaffected.[4] Moreover, each respondent answered two different parts, each containing six choice sets: one part covering outages during the winter months (November-March) and the other part covering outages during the rest of the year (April-October). The attributes, attribute levels and the scenario were chosen and designed in collaboration with experts in this area and with industry representatives. In addition, focus group studies were conducted followed by a large pilot study. The outage levels were selected to be both policy relevant and of relevance for households. This meant, for example, that shorter outages of say 1 minute were excluded, since the expected impact on most households is very small, which would often be limited to resetting electronic devices without battery back-ups. We are mainly interested in valuing outages at different times. Thus, we only included three different outage lengths; two of a medium duration and one of a long duration, which differs from Layton and Moeltner (2004) who focused on the ability to forecast for a large set of durations.[5] Since our main interest is the timing of outages we choose to only include three different outage durations. 4 and 8 hour outages are included because of the

[4] A planned outage in Sweden is described as an outage that has been announced at least 3 working days in advance by the network company. There is a possibility of negative correlation between the number of planned and unplanned outages. Therefore we stated that the number of planned outages remained the same during the period.

interest by policy makers to allow for an explicit comparison to the previous study conducted in 1994. The focus on 24 hour outage is due to a new law in Sweden that will be introduced in 2011 allowing no outage to last more than 24 hours. In principle our experiment could have included several more durations, and in principle we could then make forecast for a large set of durations. The timing of the outage was in turn described by the two other attributes: (i) timing in terms of time of week and (ii) timing in terms of the time of year. The levels of the cost attribute were based both on previous studies and on the results from the pilot study. In particular, we focused on the attribute levels in the cost attribute in that the respondents were asked to make trade-offs between alternatives, i.e. we wanted to avoid excessively large cost differences between alternatives so that we could avoid choice sets where the cost was the only deciding factor between the alternatives.[6] In Table 1 we summarise the attributes and attribute levels used, where the levels refer to the number of outages over the next five years except the last row that show costs. We decided to use a period of five years so that we could avoid describing the outages in fractions and use integer numbers instead.[7]

>>> TABLE 1

[5] For an alternative approach to measure the WTP of outage cost as a function of the outage length see Carlsson and Martinsson (2007) and Layton and Moeltner (2004). In both papers the estimated WTP is based on each respondent being asked repeated contingent valuation questions.
[6] It should be noted that the attribute levels for all attributes, except those of the cost, were determined with what is relevant for households and policy-makers. Thus, in order to obtain some degree of utility balance, the attribute levels of cost can be chosen so as to fulfill, at least to some degree that criterion.
[7] In Sweden, households in built-up areas experienced on average 0.08 planned and 0.39 unplanned power outages per year during the period 1998-2000, with an average duration of 12 and 23 minutes respectively (Svenska Kraftnät, 2002). The corresponding figures for power outages in sparsely populated areas of Sweden are 0.60 planned with an average duration of 83 minutes and 1.54 unplanned power outages per year with an average of 203 minutes.

Given the number of attributes and attribute levels, a large number of choice sets containing two alternatives can be constructed. However, time constraints and perhaps cognitive abilities as well[8] restrict the number of choices that a respondent can make. Thus, the choice sets to be included must be carefully selected. The choice sets were selected by using a cyclical design principle (Bunch et al., 1996). A cyclical design is a straightforward extension of the orthogonal approach. First, each of the alternatives from a fractional factorial design is allocated to different choice sets.[9] The attribute level in the new alternative is the next higher attribute level to the one used in the previous alternative. If the highest level is attained, the attribute level is set to its lowest level. In this way we obtained a set of possible choice sets to use. From this set we deleted all strictly dominating choice sets. Moreover, we wanted to avoid excessively dominating choice sets. This was done by calculating so-called code sums for each alternative (Wiley, 1978). In order to calculate the code sum, we order the levels of the attributes from worst to best case, assigning the value 0 to the lowest attribute level, 1 to the next and so on.[10] The code sum is the sum of all these values for each alternative. By comparing the code sums, one can get an indication of whether a pair of alternatives is particularly dominating in a choice set.[11] In our case, we deleted all design alternatives with a code sum difference larger than eight; in total there were 78 such design alternatives. From the remaining 584 choice sets, 36 choice sets were drawn with a linear D-optimal design. These were then blocked into 6 different blocks of choice sets, which were randomly allocated to the respondents. Before they answered the

[8] For example, Hensher et al. (2001) tested whether a different number of choice sets (4, 8, 16, 24 and 32) affected the estimated elasticity for choosing between flights, and they found small differences relating to the number of choice sets, while Hensher (2003) found that the number of choice sets had a statistically significant impact on the valuation of travel time savings.

[9] A fractional factorial design contains a sub-set of all combinations of levels of attributes.

[10] In our case we assigned a 24 hour outage a code value of 3.

choice experiment, the respondents were instructed to read a short scenario describing the attributes and some facts regarding power outages. The scenarios presented to them are found in the Appendix. An example of a choice set is presented in Figure 1.

>>> FIGURE 1

Two important things should be noted about the design of the choice experiment. First, the respondents are asked to make choices relating to future outages. Since both the historical levels of outages as well as future levels vary a lot, and in most cases are related to random events, it is difficult to include a realistic status-quo alternative in a postal questionnaire such as this. Thus, a more realistic approach is to let the respondents make choices between different alternatives described by expected future levels of outages. As argued by Hensher et al. (2004) for services such as water and electricity it is also not realistic to include an opt-out alternative such as "None of the alternatives". Second, the implied property rights are with the network companies, i.e. the respondent has to pay in order to avoid outages. Respondents may believe that they have the right to electricity and that they should not have to pay for this.[12] The problem with this is that some respondents might react towards the actual scenario as such. One alternative would therefore be to ask willingness to accept (WTA) compensation questions, and actually most network companies in Sweden do pay out compensation to their customers for outages longer than 24 hours. However, there are problems associated with using WTA questions, particularly with incentives to overstate the

[11] This is obviously a crude approach, and in order for the approach to work acceptably well, the utility difference between two levels should not be too different across attributes.

WTA. Empirical finding is that WTA is substantially higher than the WTP both in hypothetical and real situations (Horowitz and McConnell, 2002).

In the analysis of the responses, we assume a linear random utility function, where the indirect utility for household *i* for alternative *j* consists of a deterministic part, v_{ij}, and a random part, ε_{ij},

$$U_{ij} = v_{ij} + \varepsilon_{ij} = \beta' a_j + \gamma(M_i - c_{ij}) + \varepsilon_{ij}, \tag{1}$$

where a_j is a vector of the attributes in alternative *j*, β is the corresponding parameter vector, M_i is income, c_{ij} is the cost associated with alternative *j*, γ is the marginal utility of income and ε_{ij} is an error term. Since the utility function is linear in income, the marginal WTP for an attribute is the ratio between the parameter of the attribute and the cost parameter such that

$$MWTP = \frac{\beta}{\gamma}. \tag{2}$$

In the econometric analysis we wish to consider unobserved heterogeneity explicitly and therefore we apply a random parameter logit model (e.g. Train, 2003). This means that the random parameters are the sum of the population mean, $\overline{\beta}$, and a respondent deviation, $\tilde{\beta}_i$, i.e. $\beta_i = \overline{\beta} + \tilde{\beta}_i$. These deviations are assumed to be normally distributed with mean zero and a standard deviation. More formally, we assume that the coefficient vector β varies among the population with density $f(\beta \mid \theta)$, where θ is a vector of the true parameters of the taste distribution. If the $\varepsilon' s$ are IID

[12] Actually this was also indicated in both the pilot study and our final study, where few respondents noted that they thought that they had the right to an outage-free delivery of electricity. This is based on comments by the respondents in the end of the survey where they could make comments.

type I extreme value, the conditional probability of alternative j for individual i in choice situation t is

$$L_i(y_{jt} \mid \beta) = \frac{\exp(v_{jt})}{\sum_{k \in \mathbf{A}_t} \exp(v_{kt})}, \tag{3}$$

where $\mathbf{A}_t$ is the choice set. The conditional probability of observing a sequence of choices, denoted y_i, from the choice sets is then the product of the conditional probabilities

$$P(y_i \mid \beta) = \prod_t L_i(y_{it} \mid \beta). \tag{4}$$

The unconditional probability for a sequence of choices that individual i makes in the choice experiment is then the integral of the conditional probability in equation (4) over all values of β such that

$$P(y_i \mid \theta) = \int P(y_i \mid \beta) f(\beta \mid \theta) d\beta. \tag{5}$$

In this simple form, the utility coefficients vary among individuals, but are constant between the choice situations for each respondent. This reflects an underlying assumption of stable preference structure for each respondent during the course of making the choices in the choice experiment. Since the integral in equation (5) cannot be evaluated analytically, we have to rely on a simulation method for the probabilities. Here we will use a simulated maximum likelihood estimator, using Halton draws, in order to estimate the models (see Train, 2003). One interesting aspect of random parameter logit models that has only recently been explored is the possibility of retrieving individual-level parameters from the estimated model by using Bayes Theorem (Revelt and Train, 2000). This means that we can obtain an estimate of the location of a specific respondent in the estimated distribution.[13] Let us denote the distribution of β conditional on a sequence of choices (y_i) and the population parameters (θ) by $h(\beta \mid y_i, \theta)$.[14] Train (2003) shows that the mean β for an individual *i* making a specific choice is:

$$E[\beta_i \mid y, \theta] = \int \beta \cdot h(\beta \mid y_i, \theta) = \frac{\int \beta P(y_i \mid \beta) f(\beta \mid \theta) d\beta}{\int P(y_i \mid \beta) f(\beta \mid \theta) d\beta}. \tag{6}$$

The expression in equation (6) is thus an estimate of the preferences of a particular individual. This estimate in turn comes from the estimated population distribution that we obtain with the random parameter logit model. This expression does not have a closed form and therefore we again have to rely on simulation methods. The simulated approximation to the expression in (6) is:

$$\tilde{E}[\beta_i \mid y, \theta] = \sum_r w^r \beta^r = \sum_r \frac{\beta^r P(y_i \mid \beta^r)}{\sum_r P(y_i \mid \beta^r)}. \tag{7}$$

where β^r is the r-th draw from the population density $h(\beta \mid y_i, \theta)$.

The choice experiment was part of a postal questionnaire on power outages. The questionnaire contained, apart from the experiment, questions about the use of electricity, prevention methods undertaken in order to reduce the effects of power outages, questions related to subjective self-assessed effects of power outages as well as questions about the socio-economic characteristics of the respondents. The

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[13] Another possibility is to look at subgroups. As discussed in Train (2003), policy-makers are often interested in the proportion of the population

[14] By applying Bayes' rule, it can been shown that $h(\beta \mid y_i, \theta) = \frac{P(y_i | \beta) f(\beta | \theta)}{P(y_i | \theta)}$, where $f(\beta \mid \theta)$ is the distribution of β in the population. For a detailed description see e.g. Train (2003) page 265-267.

questionnaire was developed using both focus groups and pilot tests and discussions with representatives from the industry.

3. Results

The main survey was sent out to 1,200 randomly selected individuals aged 18-74 in Sweden in 2004. Eight of these were returned because of "address unknown".[15] In total 473 individuals returned the questionnaires, which is a response rate of 40%.[16] Due to non-item responses 425 questionnaires are available for the analyses.[17] In Table 2 we present the results from the estimations based on a random parameter logit approach, where we assume cost to be a fixed parameter and the other attributes to be normally distributed.[18] For each random parameter, the estimated mean and standard deviation are reported. We also include a set of socio-economic characteristics that interact with the outage attributes. The model is estimated with simulated maximum likelihood using Halton draws with 1000 replications (see Train, 2003), and the econometric software Limdep was used.[19]

>>> TABLE 2

[15] 10 days after the questionnaire was sent out, a reminder was sent out including a copy of the questionnaire.
[16] Comparing the sample statistics with Swedish population statistics (SCB, 2004) shows no statistical difference at the 5% level related to gender composition (p-value=0.76) and geographical representation (based on the postal codes) of the respondents (p-value=0.90). However, there is a significant overrepresentation of older people (95% confidence interval of age is 47.21-48.65 in our sample while the average age in the Swedish population aged 18-75 years is 44.88).
[17] Respondents who answered half or less of the choice sets (for each time of the year) were excluded from the final analysis.
[18] By keeping this parameter fixed we ensure that the distribution of WTP is the distribution of the outage attribute. Furthermore, allowing all parameters to be randomly distributed often leads to problems with convergence and identification (Ruud, 1996).
[19] A standard multinomial logit model gives similar results as the random parameter logit model with respect to sign and significance of the parameters.

Cost as well as all outage parameters except 4-hour outages are significant at the 1% level and about half of the standard deviations of the random parameters are significant. As we will discuss later, an interpretation of the results requires a simultaneous interpretation of both the mean and the standard deviation parameters. Let us first look at observed heterogeneity in terms of the interaction terms. Since we keep the cost parameter the same for all respondents, we can interpret the observed heterogeneity as a difference in WTP. Furthermore, as can be seen from Table 2, it is mainly for longer durations that the interaction terms have a significant effect, and therefore we only comment on these durations. Respondents who live in a *big city* (31% of the sample) are willing to pay less, and respondent who live in a detached or terraced *house* (64% of the sample) are also willing to pay less to reduce outages. Similar effect holds for respondents who *cannot heat* during a power outage (63% of the sample). There is no significant difference between male and *female* (49% of the sample) respondents for longer duration of outages. Finally, the coefficient for *age* (mean age in sample is 28 years) is positive which implies that older respondents have a higher WTP than younger respondents.

Based on the estimated parameters, we calculate the marginal WTP for reducing outages of various durations at different times of the week and year and the results are reported in Table 3, these are calculated using the sample mean of the socio-economic characteristics.[20] The standard errors are obtained by using the Delta method (Greene, 2000).[21]

[20] The corresponding marginal WTPs from a standard multinomial logit model are to a large extent similar in magnitude to those obtained from the random parameter logit model. The only difference is that the marginal WTP for longer outages during winter are somewhat lower.
[21] The exchange rate at the time of the survey was 1 Euro = 9.13 SEK (May, 2004).

>>> TABLE 3

The marginal WTP for avoiding an outage is systematically higher for outages during weekends in winter compared to the rest of the year, and the difference is statistically significant (using a t-test) for all outages except for the 8 hour outage and 4 hour during weekdays. For outages on weekdays, the difference is only significant between the seasons for 24-hour outages, where the marginal WTP is higher during the winter. As expected, the marginal WTP is systematically higher for weekend outages, when on average more household members are at home, compared to weekday outages, and the marginal WTP increases with the duration of the outage. Consequently, from a welfare point of view, it is of importance to consider these differences.

By using the results from the random parameter logit model and conditioning them with the individual choices, it is also possible to obtain individual level parameters using equation (6). From these estimates we can calculate the marginal WTP for each individual; the results of these calculations are presented below in Table 4.

>>> TABLE 4

The mean individual WTPs are similar to the population means we present in Table 3, which also can be seen as diagnostic tool since we expect them to be approximately equal. In order to illustrate the richness of information that we obtain from the individual parameters further, the distribution of some of the individual level marginal WTPs for the attributes is shown in histograms. The largest degree of heterogeneity is for the 24-hour outages, illustrated below in Figures 2 and 3. The figures show the frequency distribution of individual-level WTP in our sample.

>>> FIGURE 2

>>> FIGURE 3

4. Discussion

Power outages have negative welfare effects on households, many of which are non-monetary such as a drop in the indoor temperature and the impossibility of watching TV. In this paper we have applied a choice experiment to investigate the marginal WTP for reducing power outages among Swedish households, which thus includes both monetary as well as non-monetary effects. Our results show that households' marginal WTP to reduce power outages increases with duration, and is, as expected, higher during weekends and the winter months. The random parameter logit model allows us to estimate a sample distribution of WTP and we find significant unobserved heterogeneity in some of the outage attributes, but not in all.

Previous surveys on households' WTP to reduce power outages in Sweden have applied an open-ended contingent valuation survey describing a power outage starting during an afternoon in January (Svenska Elverksföreningen, 1994). The WTPs for reducing unplanned power outages of 4 and 8 hours were 21.54 and 60.60 SEK respectively, when expressed in the price level of 2003.[22] The marginal WTPs during winter that we obtained in our study are in general lower than these values. One likely

[22] In that survey a power outage lasting one hour was also included along with planned outages.

explanation for this difference can be strategic bias in the open-ended contingent valuation survey, where respondents may think that they can affect policy decision by their reported WTP but will not have to pay the cost reported in the future. Furthermore, the former study aimed to obtain a value for the "worst case" while we estimate the WTP for reducing one unspecified outage which could occur at any time of the day, the difference in results is not surprising. As discussed earlier in the paper, the tariffs charged by the network companies have to be "reasonable" according to Swedish law, and in order to judge whether or not the tariff charged is indeed reasonable, the so-called network performance assessment model has been developed. However, the current model only considers the duration of power outages as the relevant dimension to use when evaluating negative welfare effects (Energimyndigheten, 2004). What we find is that the network performance model should differentiate on the timing of the power outages as well. However, in this study we have only collected information about the cost for households. The regulation model should of course also consider costs for other customers. As we have discussed it is likely that the distribution of costs for commercial customers such as heavy industry are rather different than those for the households.

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Table 1. Attribute and attribute levels in the choice experiment.

Attribute	Attribute levels
Weekday: Number of outages of 4 hours’ duration over 5 years	2,1,0
Weekday: Number of outages of 8 hours’ duration over 5 years	2,1,0
Weekday: Number of outages of 24 hours’ duration over 5 years	1,0
Weekend: Number of outages of 4 hours’ duration over 5 years	2,1,0
Weekend: Number of outages of 8 hours’ duration over 5 years	2,1,0
Weekend: Number of outages of 24 hours’ duration over 5 years	1,0
Cost	125, 200, 225, 275, 375

Table 2. Estimation results from the random parameter logit model.

		Parameter	**Stdv. random parameters**	**Interaction terms with duration of outages**				
				Big city	House	Cannot heat	Female	Age in years
Cost		-0.945						
		(0.000)						
April - October	4 hour outages	-0.167	0.0001	-0.082	-0.020	-0.009	0.122	0.001
	weekday	(0.136)	(0.996)	(0.200)	(0.744)	(0.864)	(0.013)	(0.560)
	8 hour outages	-0.473	0.003	0.015	0.123	0.012	0.113	0.002
	weekday	(0.002)	(0.947)	(0.858)	(0.150)	(0.872)	(0.101)	(0.515)
	24 hour outages	-0.959	0.738	-0.227	0.159	0.071	-0.116	0.004
	weekday	(0.000)	(0.000)	(0.007)	(0.061)	(0.344)	(0.088)	(0.074)
	4 hour outages	-0.366	0.051	-0.113	0.049	-0.031	0.011	0.004
	weekend	(0.001)	(0.058)	(0.053)	(0.404)	(0.560)	(0.822)	(0.017)
	8 hour outages	-0.376	0.016	-0.248	0.070	-0.150	-0.016	0.003
	weekend	(0.016)	(0.665)	(0.004)	(0.407)	(0.041)	(0.816)	(0.259)
	24 hour outages	-0.930	0.515	-0.207	-0.218	-0.184	-0.114	0.006
	weekend	(0.000)	(0.000)	(0.013)	(0.007)	(0.014)	(0.095)	(0.009)
November - March	4 hour outages	-0.160	0.047	0.070	0.054	0.036	0.021	0.000
	weekday	(0.159)	(0.092)	(0.270)	(0.383)	(0.532)	(0.674)	(0.993)
	8 hour outages	-0.471	0.009	-0.034	0.224	0.096	-0.007	0.002
	weekday	(0.003)	(0.820)	(0.692)	(0.010)	(0.243)	(0.918)	(0.498)
	24 hour outages	-1.017	0.771	-0.141	-0.277	-0.093	-0.038	0.009
	weekday	(0.000)	(0.000)	(0.122)	(0.002)	(0.251)	(0.599)	(0.001)
	4 hour outages	-0.456	0.020	0.093	-0.114	-0.019	-0.103	0.006
	weekend	(0.000)	(0.493)	(0.128)	(0.065)	(0.740)	(0.052)	(0.002)
	8 hour outages	-0.494	0.550	-0.007	0.032	0.062	-0.010	0.002
	weekend	(0.002)	(0.000)	(0.939)	(0.713)	(0.444)	(0.884)	(0.485)
	24 hour outages	-1.566	0.844	-0.282	-0.245	0.013	-0.015	0.013
	weekend	(0.000)	(0.000)	(0.001)	(0.005)	(0.876)	(0.831)	(0.000)
Number of individuals	428							
Pseudo R2	0.29							

Table 3. Marginal WTP in SEK for reducing power outages (standard errors in parentheses obtained with the Delta method).

	November-March Mean marginal WTP	**April-October** Mean marginal WTP	**Test of H_0: No difference in WTP between seasons (P-values), t-test**
4 hour weekday	7.40	10.72	
	(2.66)	(2.61)	0.366
8 hour weekday	21.11	26.43	
	(3.79)	(3.65)	0.337
24 hour weekday	95.58	77.35	
	(4.12)	(3.70)	0.002
4 hour weekend	29.46	20.05	
	(2.87)	(2.71)	0.013
8 hour weekend	37.76	40.21	
	(3.79)	(3.62)	0.636
24 hour weekend	125.14	105.19	
	(4.40)	(3.84)	0.001

Table 4. Estimated individual WTP in SEK.

		Mean	**Std dev**	**Min**	**Max**
November-March	4 hour weekday	8.53	0.07	8.28	9.14
	8 hour weekday	21.34	0.12	20.73	22.86
	24 hour weekday	94.78	43.36	-54.25	232.45
	4 hour weekend	28.40	1.13	21.86	33.96
	8 hour weekend	37.37	22.56	-66.52	123.02
	24 hour weekend	123.30	53.89	-46.21	242.17
April - October	4 hour weekday	10.98	0.00	10.97	10.99
	8 hour weekday	27.55	0.00	27.54	27.55
	24 hour weekday	77.15	44.84	-27.15	194.98
	4 hour weekend	20.46	0.20	19.29	21.19
	8 hour weekend	40.01	0.47	38.00	42.88
	24 hour weekend	105.17	23.47	30.30	170.59

Figure 1. Example of a choice set.

Number of outages over 5 years	*Alternative A*	*Alternative B*
Weekdays: number of outages of 4 hours duration.	0 during 5 year	1 during 5 year
Weekdays: number of outages of 8 hours duration.	1 during 5 year	0 during 5 year
Weekdays: number of outages of 24 hours duration.	1 during 5 year	0 during 5 year
Weekends: number of outages of 4 hours duration.	1 during 5 year	2 during 5 year
Weekends: number of outages of 8 hours duration.	0 during 5 year	1 during 5 year
Weekends: number of outages of 24 hours duration.	0 during 5 year	1 during 5 year
Connection fee for your household	200 SEK	225 SEK
Your choice		

Figure 2. Histogram of individual marginal WTP to prevent a 24-hour power outage on weekdays in November-March and April-September.

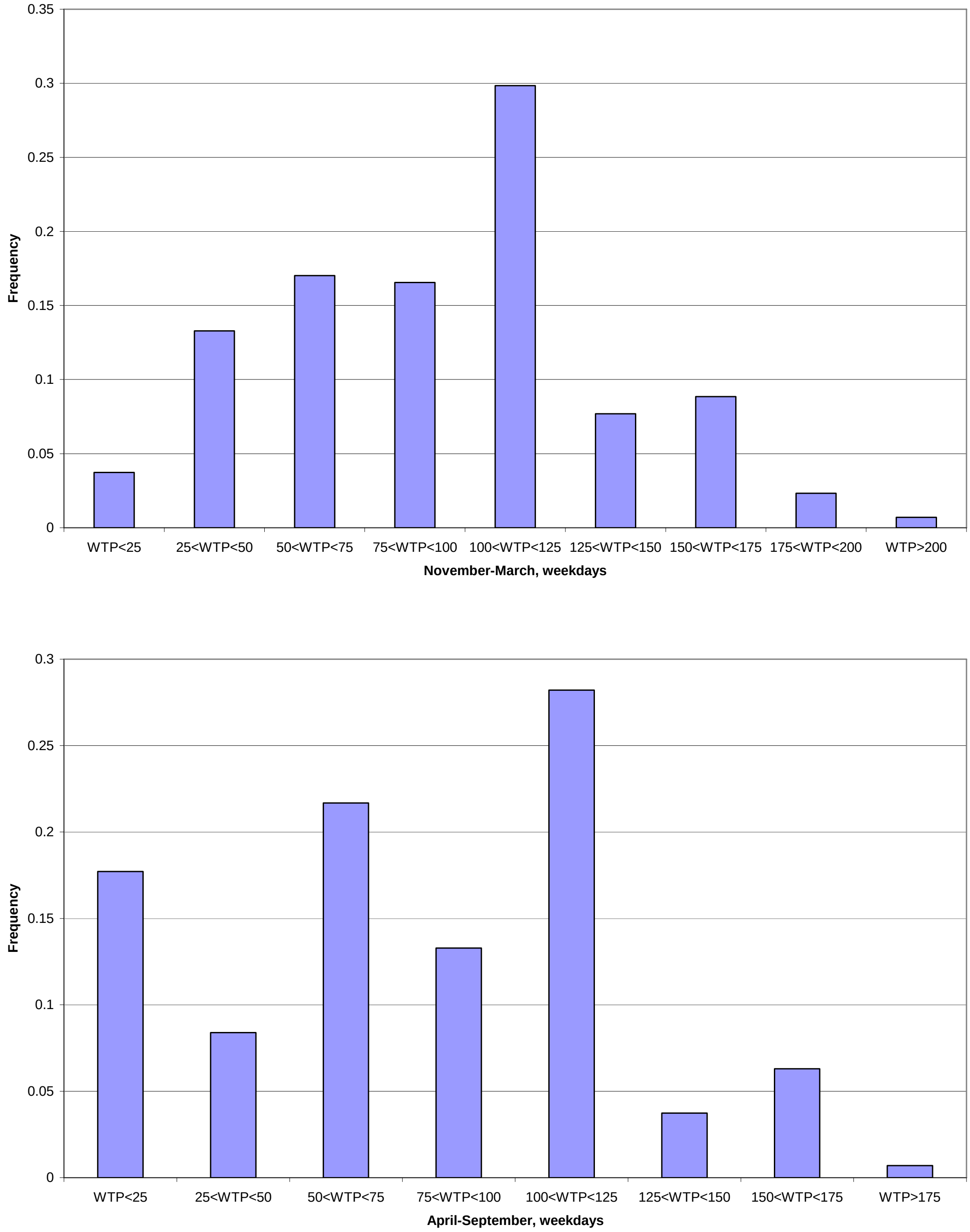
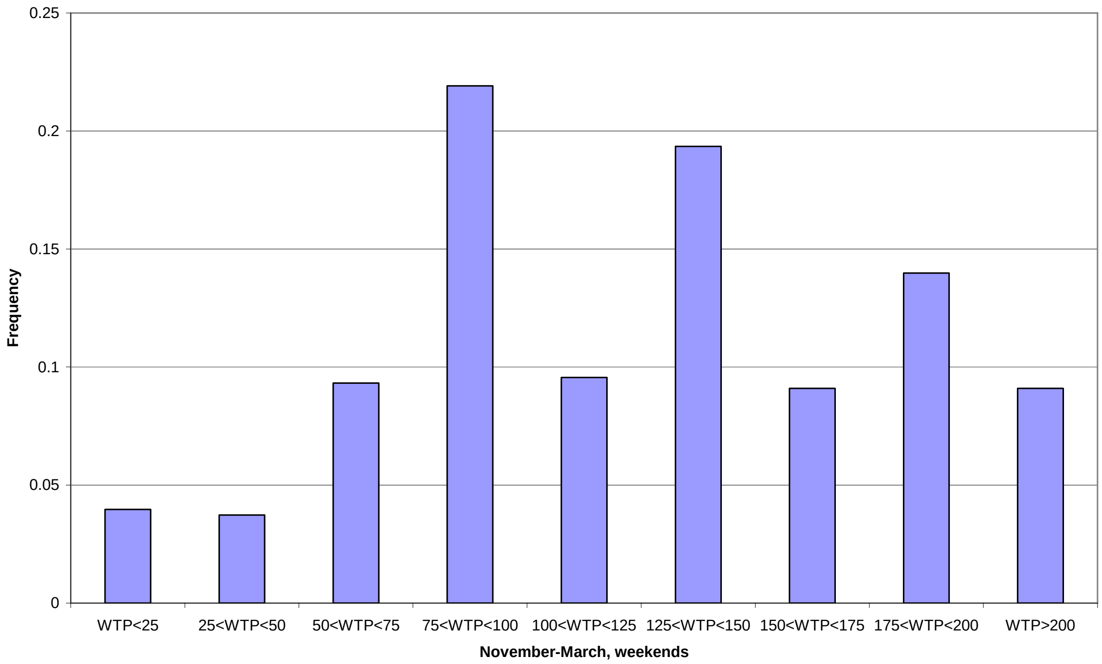
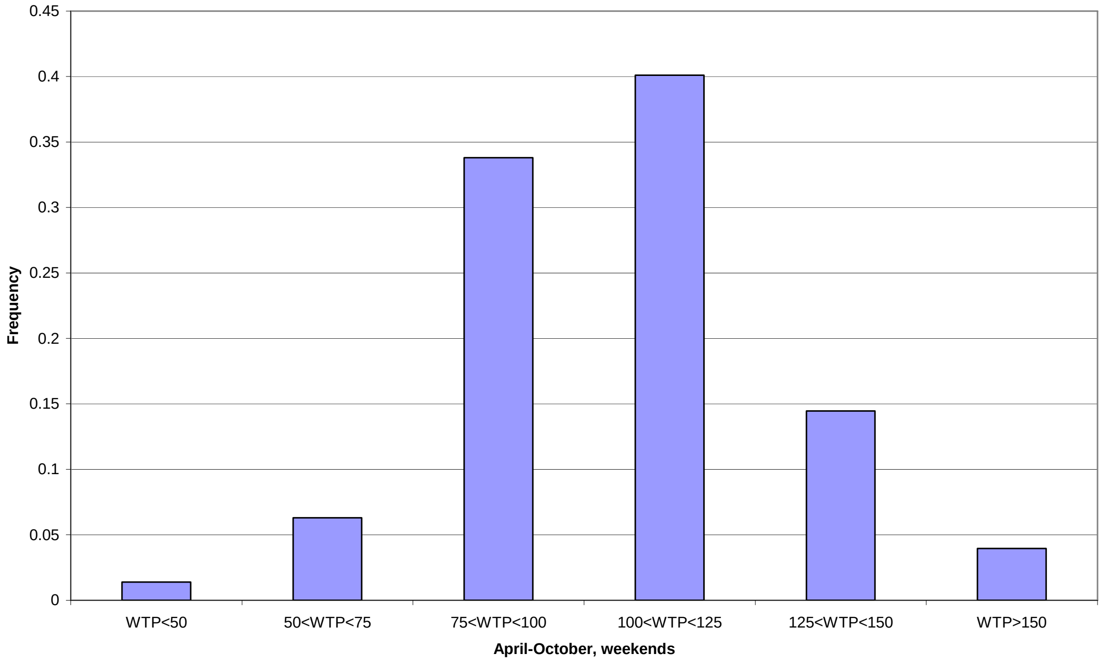


Figure 3. Histogram of individual marginal WTP to prevent a 24-hour power outage on weekends in November-March and April-September.





Appendix. Scenario

We will now ask some questions regarding your household's willingness to avoid power outages. Imagine that there is a possibility of choosing between different contracts with your electricity supplier and that a backup electricity board exists that can be used in the case of a power outage. By connecting to this backup electricity board you can affect the number of power outages that your household will experience. For connection to this service you have to pay a connection fee to the owner of the network. Apart from the stated power outages there will always be a number of power outages that you know about in advance because of the need to conduct maintenance work.

Since power outages are not particularly common, we present the number of outages for a 5-year period. For each alternative we will state the number of power outages of varying durations on working days (Monday-Friday) and weekends (Saturday–Sunday). The time of the year may have an impact on your experience of the power outages. We will therefore ask questions both for power outages during the winter and during the rest of the year.

An example of a choice set is shown below. For each set we want you to state which alternative you think is best for you and your household. Note that your choice will not affect anything other than the number of power outages and your fixed tariff - everything else remains as it is today.

[An example of a choice set was shown below].