Watt's the Price of Keeping the Lights On? Natural Disasters and Willingness to Pay for Reliable Electricity

Abstract

Winter Storm Uri caused widespread electricity outages across Texas in February 2021, revealing significant weaknesses in the state's power system. The aim of this paper is to examine how experience with disaster-related electricity outages shapes individuals' willingness to pay (WTP) for policies that improve electricity reliability, a public good likely to be under-supplied without policy intervention. The paper addresses two related questions: (1) does experiencing a disaster-related electricity outage affect WTP for policies that increase grid reliability? and (2) Do differences in outage duration experiences make individuals more or less willing to pay for such policies? Building on a model of an individual's expenditure (WTP) function for varying levels of a public good, the study implements a discrete choice experiment embedded in a representative survey of Texas residents conducted after the storm to estimate differential valuations across policy choices and individuals. Exploiting the as-if-random variation in outage duration during Winter Storm Uri as a natural experiment, the analysis unveils substantial heterogeneity in WTP across policy interventions and across households with different outage experiences. Households that experienced longer outages exhibit smaller increases in WTP and assign greater responsibility for grid failure to government authorities and electricity producers. The findings suggest that policies to enhance grid resilience must account for heterogeneous willingness to pay, address free-riding incentives inherent in public-good provision, and strengthen institutional credibility to secure support for necessary investments.

1 Introduction

During Winter Storm Uri, between February 14-20, 2021, Texas experienced an unprecedented collapse of its electrical generation and distribution system, leaving more than 10 million Texans without power for multiple days amid freezing and below-freezing temperatures. The cold weather froze natural gas pipelines that were not weatherized to withstand exceptionally low temperatures, reducing fuel supply to a large share of electricity producers. The cold weather also forced some power plants out of the system as demand was expected to peak with consumers bracing for extreme temperatures. At its peak, the storm left 4.5 million homes, spread across the state, without power, killed at least 151 people, and cost at least $195 billion in material losses.

The grid's limited resilience under extreme-weather conditions became broadly and unambiguously evident during and after Winter Storm Uri. The problem is not limited only to the impact of freezing temperatures on the supply of natural gas, which accounts for roughly 50% of the fuel used for electricity production. Higher demand during heatwaves can also strain the ability of producers to supply electricity, putting residents at risk of outages. With extreme weather events expected to increase in frequency in Texas and elsewhere, they will continue to jeopardize a reliable energy supply, leading to widespread disruption and significant losses of life and physical capital. Addressing problems with the grid to secure a more reliable energy supply requires massive investments and regulatory changes that will ultimately raise electricity costs. Similarly to other public goods, individuals – including consumers and producers – face incentives to free ride on other market players' contributions to make the electric grid more reliable, resulting in underinvestment and underprovision of the service (Pigou, 1947; Brainard and Dolbear, 1967; Williams, 1966; Stiglitz and Rosengard, 2015; Abdullah and Mariel, 2010; Bigerna et al., 2024; März, Stelk and Stelzer, 2022). Accordingly, it is important to quantify whether and how much consumers are willing to pay for improvements in electricity reliability, as well as the types of investments and improvements they would support. Because events such as Winter Storm Uri laid bare the consequences of inadequate resilience, this study examines how experiences with large and long outages shape preferences and the willingness to pay for policies that enhance reliability.

To understand public preferences regarding policy interventions and to examine respondents' willingness to financially support such interventions, this paper investigates individuals' WTP for policy interventions and investments aimed at enhancing the reliability of the electricity supply, a public good. The article adapts a theoretical framework from Oh and Hong, 2012 which connects the valuation of public goods, in this case reliable electricity, to WTP. While all respondents in Texas experienced the extreme weather event, which caused widespread outages of long duration, not all households were impacted identically. Households experienced outages of different lengths, and some not at all. The theoretical model is therefore extended to connect past experiences with valuation of the public good, formalizing how experiencing prolonged blackouts negatively affects individuals' assessment of the ability of government and power suppliers to deliver electricity reliably. This negative assessment, in turn, is associated with lower WTP for investments in resiliency. Experiencing shorter blackouts, by contrast, increases individuals' valuation of the public good and their WTP for policies aimed at making the electric grid more resilient to extreme weather.

The empirical strategy in this paper implements a choice experiment (CE) embedded in an online survey of Texas residents fielded three months after Winter Storm Uri. The CE format allows respondents to evaluate joint changes in electricity costs, outage duration, and policy options. Compared with direct WTP questions, the CE design is better suited to capturing trade-offs among multiple attributes and enables us to estimate WTP for each attribute separately.[1] The findings show that

[1]See Section 3 for further discussion and justification of the use of CE over contingent valuation and stated

people prioritize lower electricity costs and reduced power outages, as expected and consistent with the literature. However, respondents are also willing to pay additional costs for policies to safeguard the electricity grid against severe weather events.

To evaluate the impact of past outage experience, our empirical strategy exploits the *as-if-random* assignment of exposure to blackouts of different durations during Winter Storm Uri. While previous studies have used choice experiments to measure how people value reliable electricity supply in hypothetical scenarios, our data come from respondents who actually experienced an extreme weather event. This approach allows us to better evaluate how experiences with natural disasters and long outages influence individuals' WTP for a reliable electricity supply, as respondents do not have to "imagine" hypothetical unplanned outages (see also Carlsson, Martinsson and Akay 2011). Results show that households with longer-than-average power outages were willing to pay significantly *less* for reliable energy compared to those who experienced shorter-than-average outages or no outages at all. These results are robust to a battery of sensitivity checks, including subregion and subsample analyses of electric utilities. Furthermore, those who experienced longer outages were *more likely* to hold the government and electricity producers responsible for the Texas power grid failure.

From a policy perspective, the results provide data or a 'price' on the importance of constant electricity supply to domestic customers. Through engagement with policy makers and industry, these 'price signals' may be used to justify future policy and investment in the electricity sector. In addition, by explicitly incorporating attributes that describe specific policies, the results provide policymakers and utilities with more actionable guidance than estimates of average WTP alone. In particular, the relative support across policy options informs which reliability investments are most publicly acceptable, while the estimated tradeoffs with electricity rates provide evidence on the magnitude of rate increases customers may be willing to tolerate to finance those improvements.

Importantly, the findings highlight the importance of strengthening trust in institutions, since skepticism about the capacity of government and utilities to deliver can undermine support even for technically sound reforms. It demands policy designs that address the underlying public-good nature of reliability, rebuild trust in system governance, and recognize how lived experiences shape willingness to contribute. Policymakers who integrate these elements into resilience planning will be better positioned to implement solutions that are both effective and publicly supported, ultimately fostering a more robust electricity system capable of withstanding future extreme weather events.

The remainder of the paper is structured as follows. Section 2 reviews existing research on factors influencing WTP for electricity reliability, presents the theoretical framework, and extends the model to examine how subjective, disaster-related outage experiences shape preferences, which form the conceptual basis for the empirical analysis. Section 3 outlines the empirical strategy and model setup. Section 4 presents the main results. Section 5 concludes by summarizing the key findings, outlining policy implications, discussing limitations of the research, and offering directions for future research.

2 WTP for reliable electricity

A large body of literature suggests that individuals' WTP for public goods – whether national defense, clean air, or reliable electricity – depend on various factors, including gender (López-Mosquera, 2016; Adebo and Ajewole, 2012; Alozie and McNamara, 2010), income (Horowitz and McConnell, 2003; Flores and Carson, 1997; Baumgärtner et al., 2017), education (Tianyu and Meng, 2020; Zorić and Hrovatin, 2012; Taale and Kyeremeh, 2016), parental status (Olli, Grendstad and Wollebaek, 2001; Wolters, 2014), and risk perception (Huang, 1993; Xu and Shan, 2018). The literature on electricity

preferences.

reliability, which possesses public goods properties, finds that customers are willing to pay to reduce the number and duration of power outages and to improve service quality. The WTP of electricity customers to avoid power outages, especially sudden or unplanned ones, varies with age, family size, location, and type of housing (Carlsson and Martinsson, 2008; Carlsson et al., 2021; Morrissey, Plater and Dean, 2018; Kim, Kim and Yoo, 2019; Hensher, Shore and Train, 2014; Ozbafli and Jenkins, 2016; Cohen et al., 2018; Vennemo, Rosnes and Skulstad, 2022; Sullivan et al., 2009).

WTP to avoid outages also depends on the season (winter or summer), the day (weekend or holiday), and the time (e.g., morning or evening). WTP to avoid power outages has been found to be higher on weekends or weeknights than on weekdays since people are more likely to be home and thus more negatively affected by a power outage (Carlsson and Martinsson, 2008; Morrissey, Plater and Dean, 2018; Hensher, Shore and Train, 2014). Factors related to reliance on and demand for electricity similarly account for some heterogeneity in WTP for reliable electricity, with higher electricity usage associated with greater disutility from power outages. Today, individuals are more sensitive to power outages given their increased dependence on electricity-powered appliances and devices, and a reliable supply of electricity is thus even more critical (Carlsson et al., 2021). In their study on Cyprus, Ozbafli and Jenkins (2016) posit that their finding that higher-income households were willing to pay more in the summer was due to their dependence on electricity for air conditioning at home and work.

Another commonly cited explanation for heterogeneity in WTP across demographic groups is "readiness," the capacity to cope with outages, which can reduce the perceived benefit of paying to avoid future interruptions. Ozbafli and Jenkins (2016) argue that older respondents are not as negatively affected by power outages as younger respondents because older respondents have more "experience coping with such inconveniences" (p. 448). Vennemo, Rosnes and Skulstad (2022) find that house size is negatively related to WTP, positing that larger homes are usually in rural areas and equipped with "alternative heating and cooking facilities," reducing their reliance on electricity and increasing their readiness to endure an outage (p. 5).

Because readiness can be acquired through experience, prior exposure to outages can also affect WTP to avoid future outages. Cohen et al. (2018) find that the WTP to avoid future power outages is lower among individuals who have experienced power outages lasting more than four hours. They argue this is likely due to "the readiness factor" making such individuals better equipped to endure future power outages (p. 39). Cohen et al. (2016) also find that the self-reported number of outages an individual has experienced in the past 12 months is positively and significantly related to WTP to avoid a long outage (12 hour) in the summer but not in other scenarios. However, they find the opposite for outage length, which they attribute to habituation: those who have experienced long-duration power outages may be willing to pay less because they are better prepared to endure sustained power outages (p. 136).

On the other hand, individuals who have experienced extended power outages may be willing to pay more because of their familiarity with the consequences and their desire to avoid large and long outages again. Using the contingent valuation method, Taale and Kyeremeh (2016) find that households that had experienced a power outage lasting several hours in the week preceding their survey were willing to pay more for reliable electricity. Baik et al. (2020) argue that those who have not experienced large outages of long duration will be unfamiliar with the consequences and, given that uncertainty, may be willing to pay more to avoid such large long outages; however, the authors do not find that past experience significantly shaped WTP in their study. Gorman and Callaway (2024) in their study on California found no effect of prior experience with wildfire-related outages on WTP to avoid future ones. Using pre- and post-storm surveys, Carlsson, Martinsson and Akay (2011) evaluated the effect of major storm "Gudrun" on WTP and found that the mean WTP was higher among respondents before the storm. They conclude that this difference stems from the proportion of respondents reporting zero WTP following the major storm. Examining only those that reported a positive WTP, the authors find no significant effect of the storm on WTP.

Scholars have also found that WTP for improved service and the way outage experience affects WTP are shaped by confidence and trust in those responsible for providing and ensuring a reliable supply of electricity. Using a choice experiment, Abdullah and Mariel (2010) suggest that individuals' trust and confidence in service providers can also influence WTP. The authors find that older respondents were less willing to pay more compared to younger ones, arguing that the lower WTP stems from lower confidence in the government among older participants in their study area. Similarly, Taale and Kyeremeh (2016) find that receiving prior notice of power outages is positively associated with WTP, positing that enhanced communication increased trust in electricity service providers and, in turn, influenced respondents' WTP. A recent study by Lambert et al. (2024) surveys US households to estimate WTP for a more resilient and outage-resistant grid. They find that customers' trust in their utility provider positively and significantly affects WTP.

Finally, Amador, González and Ramos-Real (2013) suggest that it is not only past experience but also *perceived experience* that affects WTP. In their study on supplier choice in the Canary Islands, individuals who perceived outages experienced in the previous year as having "significant consequences" were willing to pay more to avoid future outages. Thus, individuals' WTP depend not only on whether they have experienced an outage but also on the intensity of that experience and the perceived consequences of prior outage experience.

2.1 Modeling WTP for public goods

To describe the underlying problem, this section modifies a theoretical framework, originally suggested by Oh and Hong (2012), of an individual's spending behavior on a combination of private and public goods. The model depends on income, prices, and the marginal rate of substitution between private goods and public goods. After characterizing the expenditure function, the model is extended by including a proposed policy intervention aimed at increasing the level or the quality of the public good. Consider the following indirect utility function:

$$V\left(P, Y, I_i\right) = \max_{X_i} \left\{U_i | P X_i \leq I_i\right\}, \tag{1}$$

where U_i is a utility function of individual i over two types of goods: private goods $X_i = [x_{i1}, ..., x_{iJ}]$ and public good Y,[2] and P is a vector of prices for private goods X_i, and I_i be the level of disposable income.[3] Hence, the expenditure $E(\cdot)$ can be represented as the minimum amount that individual i must spend on *private goods* in order to achieve a certain level of utility U_i, given P and Y. The private good expenditure function is presented as follows:

$$E\left(P, Y, U_i\right) = \min_{X_i} \left\{P X_i | U\left(X_i, Y\right) \geq U_i\right\}. \tag{2}$$

Suppose that the public authority proposes a policy to raise the level (quality) of the public good from Y^0 to Y^1, where the change in the level of the public good is defined as $y = Y^1 - Y^0 > 0$. The WTP for the extra level of the public good for individual i can be derived as follows:

$$WTP\left(y_i^e\right) = E\left(P, Y^0, U_i^0\right) - E\left(P, \left(Y_i^1\right)^e, U_i^0\right) > 0, \tag{3}$$

[2]Following Oh and Hong (2012), the public good is not produced by private producers but by a collective entity, a public good provider, a public provider, or public authority, such as the government. Therefore, this paper will use public good provider, public authority, and government interchangeably to describe an entity providing public goods in society.

[3]Without loss of generality, it is assumed that the initial level of public good Y^0 has been paid by the public authority to focus on WTP for changes in the provision of the public good.

where $y_i^e = (Y_i^1)^e - Y_0$, U_i^0 represents the initial utility level, and $(Y_i^1)^e$ the expected level of the public good for individual i after the policy implementation, which is *not* necessarily identical across individuals in society. The linearized function of WTP for the public good can be presented as:

$$WTP\left(y_i^e\right) = -E_Y\left(P, Y^0, U_i^0\right) \cdot y_i^e > 0, \tag{4}$$

where E_Y represents the marginal expenditure on public good and the expected change in the level of public good (y_i^e) for individual i.

2.2 The role of subjective experience on WTP

To capture the effect of individuals' past experience with outages, following Oh and Hong (2012), the expected change in the level of public good is formed based on the probability density function (pdf) for *a posteriori* completion of the public good perceived by individual i, $f\left(\hat{\gamma}_i, y^*\right)$. Here $\hat{\gamma}_i$ is a function of an individual-specific determinant of the pdf γ_i, such as past *undesirable* experiences or knowledge, relative to the average level of experiences in the community $\bar{\gamma}$, such that $\hat{\gamma}_i = \gamma_i - \bar{\gamma}$. Thus, the equation becomes:

$$y_i^e = \int_0^y y^* f\left(\hat{\gamma}_i, y^*\right) dy^* = \Gamma\left(\hat{\gamma}_i\right) y, \tag{5}$$

where $\Gamma\left(\hat{\gamma}_i\right) \in [0, 1]$ represents the subjective valuation of the public good provider's ability to produce the public good as a function of the individual's past relative experience $\hat{\gamma}_i$ for individual i. It is assumed that $\hat{\gamma}_i$ represents the relative undesirable experiences with the public good, such that $d\Gamma/d\hat{\gamma}_i < 0$, for $\hat{\gamma}_i > 0$. This condition implies that if individual i previously experienced *more undesirable state* with the public good relative to the community (i.e., $\hat{\gamma}_i > 0$), the individual will have a lower expected level of public good after a policy intervention such that $y_i^e < y$. On the other hand, if individual i's past experience was relatively *better* than the average in the community (i.e., $\hat{\gamma}_i \leq 0$), the individual-specific pdf $f\left(\hat{\gamma}_i, y^*\right)$ is normalized as $1/y^*$, such that $y_i^e = \int_0^y y^* f\left(\hat{\gamma}_i, y^*\right) dy^* = y$, for $\hat{\gamma}_i \leq 0$. In other words, the individual is confident that the level of public good after the policy intervention will meet the individual's expected standard as they had better-than-average experience(s) in the past. Finally, the following linear WTP function for individual i is obtained by substituting (5) into (4):

$$WTP\left(y_i^e\right) = -E_Y\left(P, Y^0, U_i^0\right) \Gamma\left(\hat{\gamma}_i\right) y. \tag{6}$$

According to Equation (6), one can see that $\partial WTP\left(y_i^e\right)/\partial\hat{\gamma}_i < 0$ for $\hat{\gamma}_i > 0$. Given a better-than-average level of past relative experience, individuals will be willing to pay the amount that is equal to the level of the good proposed by the public authority, i.e., $WTP\left(y_i^e\right) = WTP\left(y\right)$. However, if an individual encountered more *undesirable* experiences relatively in the past, she would have a lower valuation of the public authority (i.e., $\Gamma\left(\hat{\gamma}_i\right)$ decreases) and, as a result, she would be less willing to fund the public good project (i.e., $WTP\left(y_i^e\right)$ decreases). Equation (6) suggests that an individual's WTP for the proposed changes in the level (or quality) of the public good is affected by their experience with the good and their perception of the public agency's ability to deliver the proposed level or quality of the public good. In other words, the model incorporates outage experience as a belief-shifting input that affects individuals' expectations about the public authority's ability to deliver the proposed level of the public good and, consequently, their expected valuation of the improvement. This extension makes the "experience channel" explicit by specifying how experience can moderate WTP through individuals' (un)desirable outage experience relative to others in the community.

3 Methods and data

To assess individuals' WTP for reliable electricity, an online survey was fielded with YouGov between May 13-24, 2021 – three months after the beginning of the winter storm. The survey included a sample of 1,500 respondents representing the distribution of residents from across the state of Texas. The survey asked Texans about their experiences during Winter Storm Uri, their tolerance for power outages and higher prices, the importance of a secure and reliable electricity supply, and their WTP for the policy interventions required to make the grid more resilient to the effects of severe weather events. Table 1 presents the descriptive statistics of the relevant demographic characteristics.

Table 1: Descriptive Statistics for Full Sample

	Count	Mean	Std. Dev.
Married	1500	.52	.49
Family income ($1,000s)	1340	77.11	77.89
Risk Aversion 1	1141	.27	.45
Risk Aversion 2	1499	.24	.43
Democrat	1500	.37	.48
Republican	1500	.22	.41
Female	1500	.56	.49
White	1500	.46	.49
Black	1500	.09	.29
Hispanic	1500	.37	.48
College degree	1500	.36	.48
Children under 18	1500	.27	.44
Liberal	1500	.31	.46
Conservative	1500	.30	.45

Figure 1 presents a map of the survey respondents' average hours without electricity by ZIP code across Texas. The distribution of outage hours does not appear to follow a spatial pattern or clustering in particular areas. Although Throckmorton (93%), Brazoria (92%), and Wharton (90%) were the counties with the highest average share of customers without power, outages occurred throughout the state. Furthermore, outage duration fluctuated from hour to hour between February 10 and February 19, with February 16 the day when the most customers experienced power interruptions.

3.1 Choice experiment

Choice experiments (CE), which are used to elicit respondents' preferences over multiple attributes and levels of those attributes simultaneously, have become increasingly popular due to their realistic representation of market and policy choices. Originally developed for marketing applications, choice experiments have also been used in various valuation areas, including health, environment, and infrastructure. Additionally, CEs have been a widely used method for the purposes of studying residential customers' preferences over electricity suppliers (Ozbafli and Jenkins, 2016; Amador, González and Ramos-Real, 2013; Cai, Deilami and Train, 1998; Goett, 1998; Louviere, Hensher and Swait, 2000; Revelt and Train, 1998). Another important advantage of this method for eliciting respondents' valuations over alternative choices is the ability to assess preferences over values of the attributes involving characteristics that pertain to resources or services rather than the overall value of the resource or service (Hanley et al., 1998).

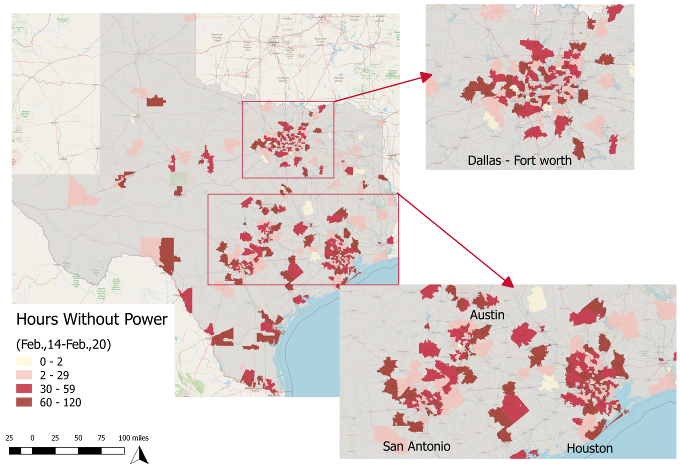

Figure 1: Geographical Distribution of Electricity Outages

Table 2 shows attributes and corresponding levels for the conjoint analysis. The choice experiment employed a fully randomized full-profile paired design. Each respondent was asked to make four sequential choices between two different policy profiles (Policy A or Policy B) with randomly generated attribute levels (see the example in Figure A1 in the Appendix). For each of the four tasks per respondent, attribute levels for cost, outage duration, and policy type were independently and uniformly randomized across alternatives. This approach preserves orthogonality among attributes, avoids reliance on prior assumptions required for D-efficient or Bayesian designs, and ensures a transparent structure appropriate for evaluating preference heterogeneity — particularly across the outage-experience groups central to our analysis.

Each profile featured three attributes: *cost* (additional expenditure), *outage duration*, and *policy*, with randomly assigned attribute levels for each choice. The attributes included in the choice experiment were selected to maximize salience and relevance for respondents in the aftermath of Winter Storm Uri. The three attributes (cost, outage duration, and the type of policy intervention) closely reflect the elements of electricity-grid reform that were most visible in public discussion and policy proposals at the time. Outage duration was especially salient given respondents' recent experiences during the storm, allowing them to evaluate levels in concrete, meaningful terms. Building on previous research (e.g., Abdullah and Mariel, 2010; Carlsson and Martinsson, 2008; Morrison and Nalder, 2009; Ozbafli and Jenkins, 2016), reliability was characterized as the duration of the outage across four attribute levels: (1) *full service (no interruptions)*; (2) *rolling blackouts or intermittent service on and off for up to 2 hours*; (3) *rolling blackouts or intermittent service on and off from 2 up to 12 hours*; and (4) *power outage for more than 12 hours*.

Similarly, the policy options presented in the experiment correspond directly to the set of reforms widely reported and debated in Texas, ensuring that respondents recognized and could differentiate among them. For policy attributes, respondents were presented with five different options, which included the *status quo* - doing nothing or no new investment. The four proposals were: (1) *merging the Texas electrical grid with one of the two national grids*; (2) *requiring the winterization of the electricity system, including at gas wellheads and processing plants*; (3) *maintaining a minimum reserve capacity*; and (4) *increasing the renewable energy supply*.

Table 2: Descriptive Statistics for Conjoint Experiment

	Occurrence No.	**Chosen** No.	**Percent Chosen** %
Cost: Increase in price per kWh required for policy			
a. No increase in price per kWh	2,358	1,448	61.41
b. 1 cent more per kWh (12%)	2,428	1,386	57.08
c. 2 cents more per kWh (23%)	2,397	1,270	52.98
d. 4 cents more per kWh (47%)	2,421	1,040	42.96
e. 6 cents more per kWh (70%)	2,396	856	35.73
Outage: Maximum length of outage in hours when electricity demand exceeds capacity			
a. Full service/no interruptions	3,013	2,077	68.93
b. Rolling blackouts for up to 2 hours	3,022	1,654	54.73
c. Rolling blackouts for up to 12 hours	3,007	1,263	42.00
d. Power outage for more than 12 hours	2,958	1,006	34.01
Policy: policy proposed to protect Texas from effects of severe weather			
a. Do Nothing/no new investment	2,359	843	35.74
b. Merge the Texas grid with one of the two national grids	2,378	1,193	50.17
c. Require winterization / weatherization of the electricity system	2,434	1,430	58.75
d. Maintain a minimum reserve capacity (backup power)	2,437	1,243	51.00
e. Increase the renewable energy supply	2,392	1,291	54.00

Finally, the cost attribute levels were based on the average cost of electricity in the state of Texas in 2019. The cost attribute was expressed as a per-kWh increase, a familiar billing metric that facilitates intuitive trade-offs. The levels of increase in cost per kWh were: (1) *no increase in cost per kWh*; (2) *1 cent more per kWh (12% increase over the average household electricity bill in 2019)*; (3) *2 cents more per kWh (23% increase)*; (4) *4 cents more per kWh (47% increase)*; and (5) *6 cents more per kWh (70% increase)*. Figure A1 in the appendix presents an example choice set from the conjoint choice experiment included in this study. The strong and monotonic effects of all three attributes in the estimated mixed logit models (Table 3, Figures 2 and 3) further indicate that respondents attended to and engaged with the attribute structure in a manner consistent with salience.

3.2 Mixed logit model

The analysis of the data follows the specification and estimation of the discrete choice models that have been adopted to examine respondents' choices among a fixed set of options, suggested by McFadden (1973) random utility theory.[4] In each conjoint experiment trial, respondent i makes a

[4] *Random utility theory* is based on the assumption that individuals make choices by assigning a utility value to different options under consideration, and select the option that provides the highest utility. The choice, however,

decision based on $J = 2$ choices, four times ($T = 4$ experiments). As a result, the utility U derived from respondent i's choice of alternative (profile) j in an experiment t can be written as follows:

$$U_{ijt} = x_{ijt}\beta_i + \epsilon_{ijt}, \tag{7}$$

where x_{ijt} is a vector of alternative-specific variables, and ϵ_{ijt} is assumed to be distributed as *iid* extreme value which is independent of β_i (McFadden and Train, 2000). A mixed logit model is applied, where the coefficient vector β_i in equation (7), called random coefficients, are different across respondents due to unobservable factors, such as tastes and preferences.[5]

The random parameters β_i in the utility function (7) are assumed to be distributed as $\beta_i \sim f(\beta, \theta)$, where θ is a vector of the parameters of the distribution of β. For example, if the random coefficients β_i are distributed as normal, that is, $\beta_i \sim N(b, \Sigma)$, where Σ is the variance-covariance matrix, it implies that the random parameters β_i are assumed to be conditionally drawn from the density function $N(b, \Sigma)$ (see Mehndiratta, 1996; Bolduc and Ben-AkiWand, 1996; Revelt and Train, 1998; Greene, 2011). Intuitively, if β_i is specified to be non-random and identical for all respondents, then $\beta_i = b$ for all respondents. On the other hand, in the mixed logit model, β_i is treated as a random parameter and is specified to be normally distributed across respondents.

Given the error term ϵ_{ijt} is an iid extreme value and independent of $\beta_{i,}$ the conditional probability that respondent i chooses j from a set of J alternatives in experiment t, given β_i, is a standard logit model:

$$P_{ijt|\beta_i} = \exp(x_{ijt}\beta_i) \,/ \sum_{k=1}^{J} \exp(x_{ikt}\beta_i)\,. \tag{8}$$

As β_i is a random coefficient distributed as $f(\beta, \theta)$ across respondent i, the choice probabilities are the standard logistic probabilities integrated over the density $f(\beta, \theta)$:

$$P_{ijt} = \int P_{ijt|\beta_i} f(\beta, \theta)\, d\beta. \tag{9}$$

Equation (9) represents the mixed logit model, where P_{ijt} is defined as the probability of choosing alternative j for respondent i in experiment t. Because there is no closed-form solution for the integral, Equation (9) is approximated by maximum simulated likelihood, where β_i are randomly drawn from the specified distribution.

The mixed logit model was estimated in preference space rather than WTP-space for three reasons. First, the price attribute is log-transformed and precisely estimated, producing stable and monotonic MWTP ratios (see Table 3). This avoids the identification problems that motivate WTP-space models, in which unstable or weakly identified cost coefficients can generate extreme or ill-behaved WTP distributions (Train and Weeks 2005; Scarpa, Thiene and Train 2008). Second, the paper's core interest lies in comparing MWTP across outage-experience groups, and the preference-space specification yields consistent price sensitivity across these subsamples (Table 4), enabling transparent cross-group comparisons (Figures 5 and 6). Third, preference-space models remain the standard in the electricity-reliability literature (e.g., Goett, Hudson and Train, 2000; Carlsson and Martinsson, 2008; Ozbafli and Jenkins, 2016), supporting comparability with prior work and enhancing interpretability for policy audiences accustomed to MWTP expressed in cents per kWh. Given the stability of the estimated price coefficient and the policy-relevant, well-behaved MWTP estimates generated by our model, the expected benefits of re-estimating in WTP-space are limited. The paper, thus, retains the preference-space specification as the primary empirical model because it provides stable MWTP

includes a random component due to unobserved factors or lack of information, which makes the process probabilistic.

[5] See Train (2009) for the detailed discussion of the mixed logit model.

measures, aligns with established practice in the electricity-valuation literature, and offers a more straightforward interpretation within the theoretical framework introduced in Section 2.1.[6]

A potential concern in discrete-choice applications is the endogeneity of regressors, particularly in light of recent discussions in the stated-preference (SP) literature, such as Bigerna et al. (2024). Endogeneity in SP studies commonly arises when respondents' prior experiences or beliefs are correlated with non-randomized attributes or with the policy scenarios being valued (see Section 4.1). In this study, attribute endogeneity is mitigated by design. All attribute levels in the choice experiment are fully randomized across alternatives and choice tasks, ensuring that the cost, outage-duration, and policy attributes are exogenous and orthogonal to respondents' prior outage experiences and other unobserved characteristics. Outage experience does not enter the utility function directly; rather, it is used only to estimate separate models for each experience group and to compare resulting preference parameters (Table 4, Figures 5 and 6). As a result, correlations between outage experience and the estimated coefficients represent genuine heterogeneity in preferences rather than endogeneity or simultaneity. This stands in contrast to the settings examined by Bigerna et al. (2024), where attribute values themselves may be shaped by respondents' past behaviors or market conditions. By relying on fully randomized attribute assignment, the design follows the standard methodological solution to endogeneity in SP experiments and ensures that the estimated coefficients can be interpreted as causal responses to experimentally varied attribute levels.[7]

4 Results and discussion

Table 3 presents the results of the mixed logit model, which estimates respondents' choices regarding policy attributes related to costs, outage duration, and severe-weather-protecting policy options.[8] The baseline conditions for the choice attributes, the status quo, are: *No increase in price per kWh*; *Full service/no interruptions*; and *Do nothing/no new investment* (Table 2). Consistent with previous research in the literature, the costs measured in the mixed logit model are based on the change in annual electricity expenditure of the respondents (in natural log).[9] The significant negative

[6]The paper does not estimate latent class models (LCMs) because the primary source of discrete preference heterogeneity in our setting is directly observed and theoretically grounded: variation in outage experience during Winter Storm Uri. This segmentation aligns with our theoretical framework (Section 2.1) and produces substantively meaningful group differences in preferences as reflected in Table 4 and Figures 5 and 6. Moreover, the mixed logit specification already captures substantial heterogeneity across respondents (Table 4), and exploratory LCMs with two to four classes did not yield stable or interpretable segments or improve model fit. Because LCMs would offer no additional explanatory power beyond the outage-based segmentation, and given their lack of theoretical grounding in this context, the mixed logit was retained as the appropriate modeling approach.

[7]Bigerna et al. (2024) highlight that endogeneity in stated-preference studies often emerges when respondents' prior experiences are structurally linked to unobserved features of the alternatives or when attributes are not experimentally controlled. In such contexts, preference parameters may conflate valuation with exposure or familiarity. Our experiment avoids these concerns because all policy, cost, and outage-duration attributes are assigned experimentally and independently of respondents' prior outage experience. Thus, unlike the settings considered by Bigerna et al. (2024), where attribute endogeneity is inherent to the policy environment, the randomized design adopted in the paper ensures exogeneity of regressors and allows outage experience to be examined solely as a source of heterogeneous preferences rather than as a confounding factor.

[8]Table A2 in the Appendix presents the estimated results based on a simple mixed logit choice model without random parameters. In line with the results presented in Table 3, respondents, on average, dislike paying more for electricity, as evidenced by the negative and significant coefficients for *additional electricity expenditure*, regardless of their outage experience.

[9]Each respondent's additional electricity expenditure is calculated by multiplying the predicted annual consumption of electricity (ACE) (in kWh) by the cost per kWh required for the policy described in Table 2. The predicted ACE is estimated using the 2015 Residential Energy Consumption Survey (RECS) data from the U.S. Energy Information

coefficients on the expenditure and outage attributes in the baseline model in Table 3 indicate that respondents do not prefer increases in electricity expenditure and prefer full service to outages of any duration.[10] Unsurprisingly, these estimates suggest that respondents prefer lower spending on electricity and shorter outages. Notably, however, respondents are willing to pay more to see policies implemented to protect the grid from severe weather in the future. The significant positive coefficients for the policy attributes indicate that respondents prefer better policies implemented to protect the Texas electric grid over doing nothing (the status quo), even if the cost and outage attributes remain unchanged.

Figure 2 presents the relative importance of three attributes, calculated as the difference between the largest and smallest coefficients for each attribute in the estimated mixed logit model (see Table A2), divided by the sum of the ranges of the three attributes. Consistent with other studies in the literature, the duration of the outage proved to be the attribute with the highest relative importance in the profiles, followed by cost and the proposed policy interventions.

Administration (EIA). We first run a regression model of the ACE with the following demographic factors: household income, age, employment status, education, number of household members aged 17 or younger, and homeowner-renter status based on the EIA data. We then predict annual electricity consumption with the same set of demographic factors in our sample. Figure A2 in the Appendix reports the distribution of the reported ACE from the EIA data and the predicted distribution in our sample. The Kolmogorov-Smirnov equality-of-distributions test shows that the largest difference between the two distributions is 0.0316, with the approximate asymptotic p-value of 0.424. Both distributions are *not* significantly different from each other, meaning that the predicted distribution of electricity expenditure is similar to the actual distribution. Finally, we generate a variable called *additional electricity expenditure* by multiplying ACE by the corresponding cost attributes in the conjoint experiment (see Table 2). The cost attribute is specified as the log of predicted annual electricity expenditure to account for the strong right skew and heteroscedasticity typical of household energy costs. The log transformation stabilizes the scale of the price coefficient and implies diminishing marginal disutility of cost, consistent with standard demand modeling. This specification produces a precisely estimated and consistently signed cost coefficient (Table 3), resulting in stable and economically meaningful MWTP estimates and aligning with established practice in stated-preference studies of electricity services.

[10] The variable outage duration is specified in natural logarithmic form. The outage length in the conjoint analysis has four attribute levels: full service (no interruptions), rolling blackouts or intermittent service on and off for up to 2 hours, rolling blackouts or intermittent service on and off from 2 to 12 hours, and a power outage for more than 12 hours. Here, the outage variable is defined as ln (outage duration + 1), using the upper bound of the attribute level. For the first two attribute levels, we use 2 hours and 12 hours, respectively. Additionally, we restrict the maximum length of the outage to 48 hours for the attribute level of more than 12 hours.

Table 3: Mixed Logit Estimations on the Willingness to Pay - Baseline Model

Variable	Coefficient	Std. Err.
Change in electricity expenditure (in log)	-0.4385***	0.075
Derived standard deviations	0.5764	0.135
Hours of rolling blackouts/ intermittent service	-1.2975***	0.173
Derived standard deviations	1.6989	0.280
Policy response/ investment		
Merge the Texas electrical grid with one of the two national grids	1.3907***	0.153
Require the winterization/ weatherization of the electricity system	2.1423***	0.185
Maintain a minimum reserve capacity	1.5061***	0.161
Increase the renewable energy supply	1.6823***	0.167
Log simulated-likelihood	-3351.3183	
	12,000	

Notes: * 10% significance level; ** 5% significance level; and *** 1% significance level, two-tailed tests.

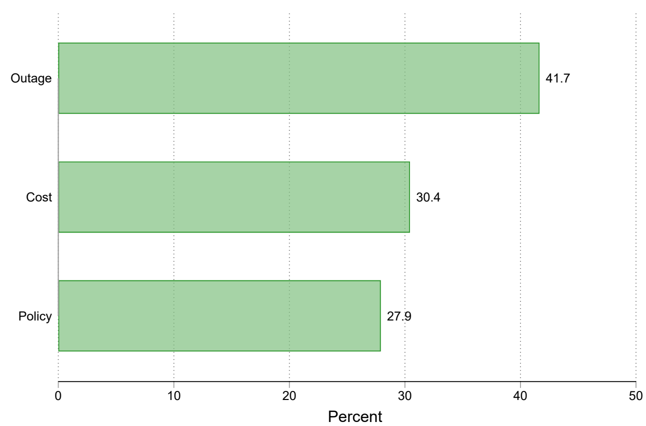

Figure 2: Relative Importance between Outages, Cost and Policy (Baseline model)

One advantage of conjoint analysis is that it allows quantification of respondents' willingness to pay for different proposed policies using estimated coefficients from mixed logit regressions. According to Equation (7), the marginal willingness to pay (MWTP) for attribute k can be presented as follows:

$$MWTP_k = \frac{\partial U/\partial x_k}{-\partial U/\partial p} = \frac{\beta_k}{-\beta_p}, \tag{10}$$

where p is the price attribute, which in this case is the change in the amount that customers pay for electricity per year (in log). Equation (10) suggests that the MWTP for a change in a specific attribute k can be interpreted as the marginal rate of substitution (MRS) between the additional electricity payments (i.e., p) and the amount expressed by the specific attribute (i.e., x_k), holding the utility level constant.

Figure 3(a) plots the estimated MWTP coefficients.[11] Negative signs for the coefficients in the first row of the figures indicate that respondents are willing to pay to *reduce* outage duration. For

[11]The estimated MWTP coefficients are presented in Table A3 in the Appendix.

the four policy proposals, the significant MWTP coefficients imply that individuals are willing to pay more on their annual electricity bills to see these proposals implemented. Figure 3(b) plots the marginal WTP for each of the four policy proposals in terms of price per kilowatts per hour (kWh).[12] For example, respondents are willing to pay about 3.47 cents more per kWh to see a policy implemented that requires the winterization of the electricity system, compared to 2.73 cents for a policy of increasing the renewable energy supply. Furthermore, respondents are willing to pay about 2.44 cents more per kWh to maintain minimum reserve capacity and about 2.25 cents more per kWh to merge grids. To prevent 12 hours of blackout, the WTP is approximately 3.86 cents per kWh.

It is worth noting that emotional responses to the recent traumatic event may have influenced respondents' willingness to pay. Because the survey was conducted shortly after a major power outage, it may have heightened respondents' urgency or concern, introducing emotional biases that could inflate or deflate WTP values, reflecting a short-term reaction rather than true long-term WTP.

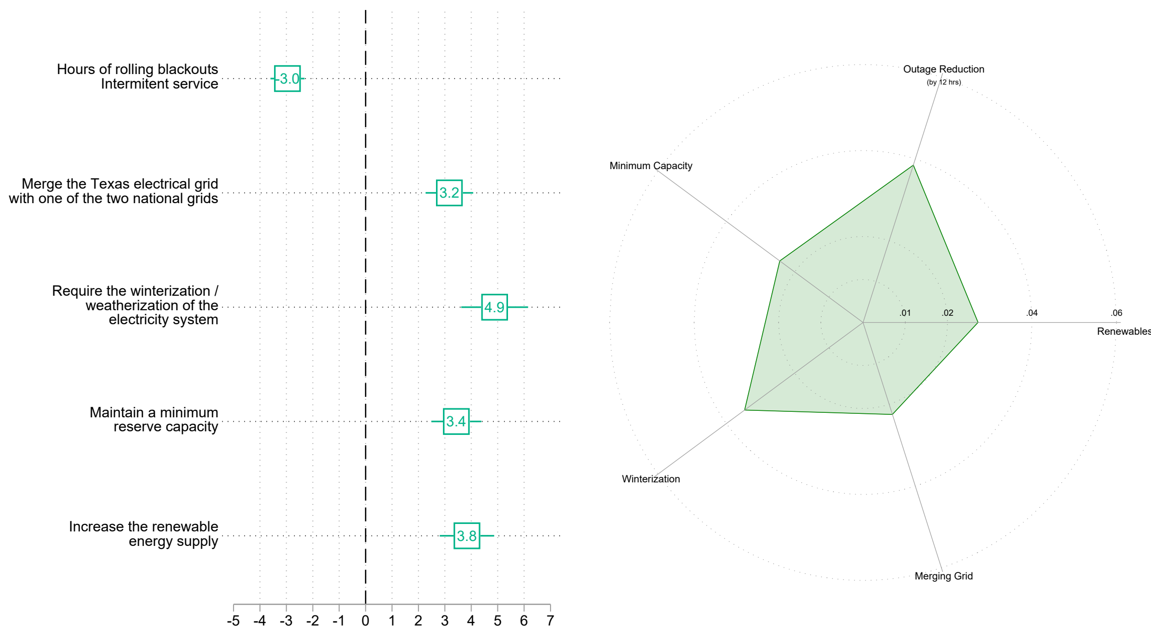

Figure 3: Estimated Marginal WTP for Policies

This analysis suggests that after Winter Storm Uri, the typical individual in our sample prefers lower costs and fewer outages, but is indeed willing to pay for policy interventions aimed at making

[12] Recall the marginal WTP (equation (10)) is presented as follows: $MWTP_k = [\partial U/\partial x_k] / [-\partial U/\partial p] = \beta_k (-\beta_p)^{-1}$, where p is defined as the additional electricity expenditure (in log) (see Footnote 9 for discussing the procedure of estimating the additional electricity expenditure in detail.) The estimated MWTP coefficients are presented in Table A3 in the Appendix.

As p is defined as $\ln P$, where P represents the additional electricity expenditure, the monetary value of WTP for a specific proposed policy k *in a year* is computed as $\partial P/\partial x_k = \beta_k (-\beta_p)^{-1} P$. We then compute the monetary value of the WTP for a specific proposed policy k *in a year* as $\partial P/\partial x_k = \beta_k (-\beta_p)^{-1} P$, where $p = \ln P$. To compute the additional payment for a specific policy *per kWh* instead of the total amount per year, the annual additional payment is divided by the average annual consumption of electricity ($\overline{ACE}$), that is, $\beta_k (-\beta_p)^{-1} P/\overline{ACE}$, where the amount of $P =$ \$106.69 and $\overline{ACE} = 14979.44$ kWh represent the average additional electricity expenditure according to the conjoint experiment and the annual average consumption of electricity, respectively. For example, on average, respondents are willing to pay \$0.0347 per kWh (i.e., $MWTP_{weatherization} \times \$106.69/14979.44 = 4.88 \times \$106.69/14979.44$) more to perform the weatherization of the electricity system, compared to \$0.0273 more for increasing the renewable energy supply.

the grid more resilient and reducing power outages. However, varying outage experiences during storm are likely to have affected an individual's WTP for the public good of reliable electricity. The next section assesses the role of subjective experience as presented in Section 2.2.

4.1 The effect of outage experience

Based on the theoretical model in Section 2.2, an individual i's WTP is influenced by their subjective assessment of the public good provider's ability to deliver the public good, which depends on their *past relative experience*, denoted by $\hat{\gamma}_i$, expressed as, $\Gamma(\hat{\gamma}_i)$, where $d\Gamma/d\hat{\gamma}_i < 0$. If individual i has previously encountered a *more unfavorable states* with the public good relative to the community (i.e., $\hat{\gamma}_i > 0$), then, Γ *decreases*, leading to a *lower WTP* for the public good, as shown in equations (6) and (7). Given the unique structure of the dataset, where the number of hours without power is a continuous variable, with some individuals not experiencing any power outages and other experiencing multiple days without power, the empirical analysis uses three discrete levels: those who experienced longer power outages (above the average of 46.24 hours), those who experienced shorter power outages (below the average), and those who did not experience power outages. The theoretical parameter $\hat{\gamma}_i$ can represent personal experiences with the length of power outages during the winter storm. If people are less likely to support the policy proposals (i.e., lower WTP) after experiencing more severe than average outages (longer-than-average outages), then $\Gamma(\hat{\gamma}_i)$ *decreases* for $\hat{\gamma}_i > 0$. Conversely, households are more likely to support the proposals if they were less affected by the power outages (i.e., shorter-than-average outages, or $\hat{\gamma}_i < 0$), or did not experience any outages at all.

As shown in Figure 1, the distribution of power outages does not exhibit a specific spatial pattern or clustering in particular regions. The impact of Winter Storm Uri on Texas' electric grid, leading to outages varying by region and time, appears almost random, which is leveraged as a natural experiment.

4.1.1 Identification strategy - balance tests

To validate the identification strategy, we perform several balance tests on 16 household characteristics to ensure that, all else being equal, the length of power outages is the primary factor affecting subjects' experiences. These characteristics fall into the following categories: (1) demographic (*female*, *white*, *Black*, *Hispanic*); (2) socioeconomic (*income*, *college education*, *home ownership*, *marital status*, and *having children under 18*); (3) political (*Democrat*, *Republican*, *liberal*, and *conservative*); and (4) behavioral (*risk aversion* and *electricity consumption*).

Figure 4(a) shows whether there is a systematic association between the demographic, socioeconomic, political, and behavioral traits of the respondents and their experiences with power outages during the winter storm. The figure displays p-values for the null hypothesis that the means of the 16 covariates are equal for both groups of households – those that experienced power outages and those that did not. The dashed vertical line denotes a statistically significant p-value smaller than 0.05. None of the p-values for the mean equality tests for these 16 covariates is below the 5% significance level, suggesting that the assignment to a group is considered random. This means that the distribution of the 16 factors for the households that experienced power outages is not significantly different from those for households that did not.

Similarly, Figure 4(b) presents the p-values among the covariates of different groups: red dots for comparisons between respondents who did not experience outages and those who experienced shorter outages, blue dots for comparisons between those who did not experience outages and those who experienced longer than average outages, and yellow dots for comparisons between the shorter and longer outages groups.[13] Consistent with Figure 4(a), none of the covariates is statistically different between the groups without interruption and the longest interruption or between the groups without interruption and the longest interruption.[14]

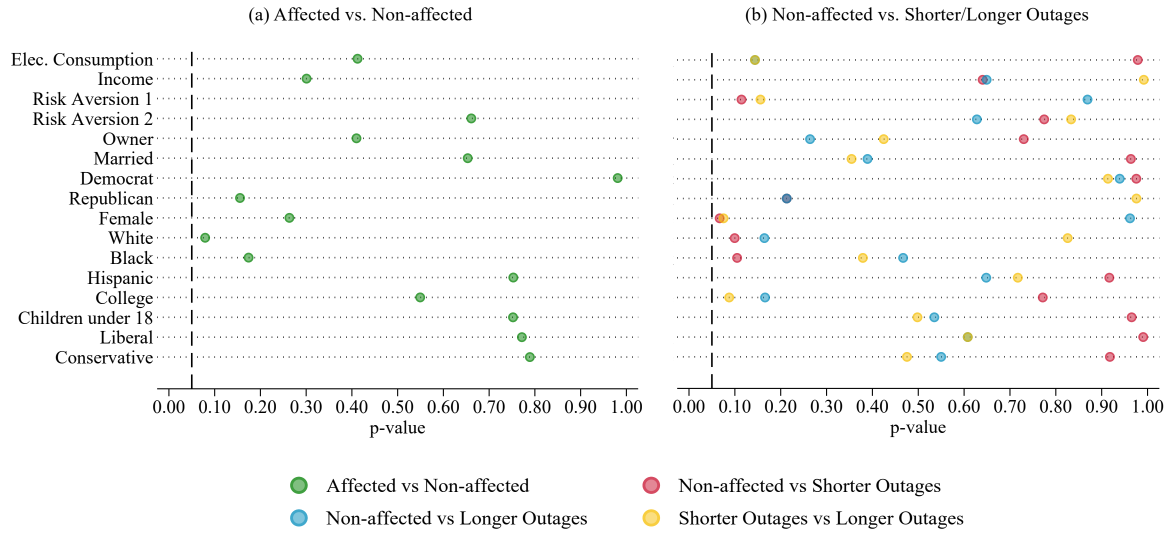

Figure 4: Balance Checks for Demographic Variables Across Household Types

4.1.2 MWTP by past experience of power outages

Table 4 shows the results of the regression analysis for the three different groups: households that had no outages (first column), households with shorter-than-average outages (second column), and households experiencing longer-than-average outages (third column). The analysis indicates a consistent pattern of preferences across all groups. Respondents, in general, prefer lower electricity costs and shorter power outages, which is in line with the findings of the baseline model in Table 3. This widespread dislike for higher costs and longer disruptions of the electricity supply holds regardless of individuals' outage experiences during Winter Storm Uri. Additionally, the positive and significant coefficients for policy attributes across all subsamples indicate a broad WTP more for policies designed to improve the resilience of the Texas electric grid against severe weather, as long as the associated costs and potential outages do not increase.

However, likelihood ratio (LR) tests to compare the estimates for the different groups reveal significant differences in policy preferences and WTP. Specifically, the estimates for households without power outages are significantly different from estimates for households with shorter-than-average outages at the 1% level. The LR test also shows a significant difference between households without outages and those with longer-than-average outages. These results suggest that while the general preference for lower costs and shorter outages is consistent, the magnitude of WTP for grid protection

[13] Table A1 in the Appendix shows in detail the distribution of the covariates analyzed in this section by group.

[14] The survey did not include detailed housing attributes (e.g., insulation, heating source, building age) that could affect both outage experiences and preferences for reliability. As an indirect check, we used electricity usage and household income in Texas as proxies, drawing on an additional data source from the *UH–TSU Texas Trends Survey 2025*, conducted by the University of Houston and Texas Southern University. In that survey, perceived home energy efficiency and home age are systematically correlated to income and electricity consumption, indicating that these proxies capture meaningful variation in housing conditions. Given that income and electricity usage are balanced across outage-duration groups, it is less likely that unobserved housing characteristics differ substantially across groups. The results are not reported due to brevity, but they are available upon request. We are grateful to the anonymous reviewer for this helpful comment. This limitation, however, is important for future survey work and a likely fruitful avenue of future research.

policies varies significantly depending on the household's prior experience with outages. The estimated WTP for three of the policies is higher for respondents who experienced shorter-than-average power outages compared to the other two groups. The only exception is the policy of increasing renewable energy supply, for which the WTP is highest among individuals who did not experience any outages. For the policy of maintaining a minimum reserve capacity, the WTP of those who experienced shorter-than-average outages is almost three times as large in comparison to those who experienced longer-than-average outages.

Figures 5 and 6 show how people's experiences with power outages during Winter Storm Uri have influenced their support for the different policies and their marginal WTP (in cents per kWh). The results presented in Figure 5 are calculated based on the estimated coefficients of MWTP for different policies, as estimated in Table 4.[15] These calculations follow a similar method outlined in equation (10) in Section 4.

Table 4: Mixed Logit Estimations on Willingness to Pay Across Three Types of Households

	Households without power outage		Households with outages shorter than average		Households with outages longer than average	
Variable	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Change in electricity expenditure (in log)	-0.3873**	0.109	-0.2985***	0.082	-0.8974***	0.292
Derived standard deviations	0.4094	0.193	0.4260	0.173	1.3064	0.505
Hours of rolling blackouts/ intermittent service	-1.5506***	0.361	-0.9108***	0.177	-1.5090***	0.331
Derived standard deviations	2.0156	0.559	1.1739	0.309	1.8162	0.475
Policy response/ investment						
Merge the Texas electrical grid with one of the two national grids	1.0291***	0.261	1.1546***	0.205	2.2741***	0.408
Require the winterization/ weatherization of the electricity system	2.1733***	0.345	1.8556***	0.252	2.6129***	0.419
Maintain a minimum reserve capacity	1.7222***	0.322	1.4149***	0.223	1.5058***	0.332
Increase the renewable energy supply	2.2414***	0.353	1.1322***	0.206	2.0478***	0.391
Log simulated-likelihood	-1046.5429		-1232.3041		-1043.0159	
Number of observations	3,888		4,264		3,848	
Likelihood ratio test for the equality of two models			24.35 (p-value = 0.0000)		31.41 (p-value = 0.0000)	

Notes: * 10% significance level; ** 5% significance level; and *** 1% significance level, two-tailed tests.
Households without power outage if baseline model for the LR tests.

[15] See Table A4 for the tests of coefficient equality across three types of households.

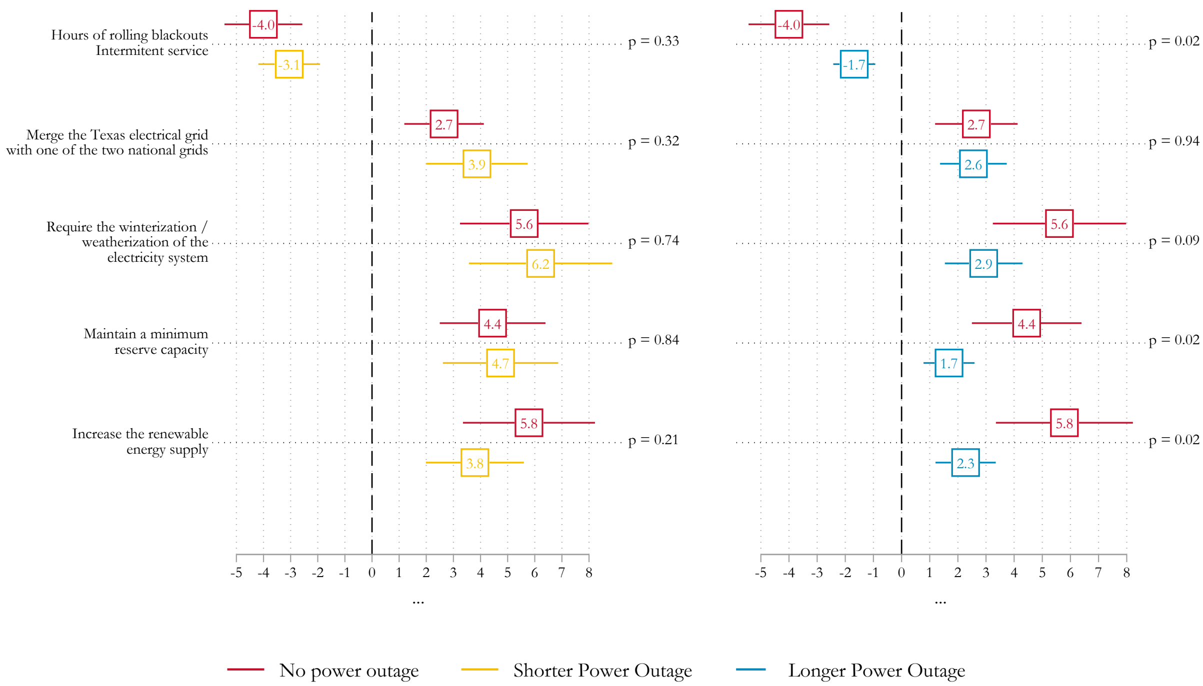

Figure 5: Estimated MWTP by Outage Length

The left panel of Figure 5 compares the MWTP coefficients between households that did not experience any power outages during Winter Storm Uri (in red) and those that experienced shorter-than-average outages (in orange). The results show that the coefficients are not statistically different between the two groups. This suggests that both groups have a similar WTP for policies aimed at improving grid reliability, regardless of whether they experienced any power outages or only shorter-than-average outages. For example, policies related to rolling blackouts and merging the Texas electrical grid with a national grid show negligible differences in WTP, which indicates that the experience of shorter outages is similar to the willingness to invest in these policies.

The right panel of Figure 5 compares households that *did not* experience any power outages (in red) and those with *longer-than-average* outages (in blue), showing significant differences in the MWTP coefficients for certain policies. For example, MWTP for policies that involve rolling blackouts exhibited a notable difference, with households that endured longer outages significantly less willing to pay for rolling blackouts. The result suggests that more severe outage experience decreased support for policies involving intermittent services, possibly due to greater dissatisfaction with the reliability of such measures. Similarly, the MWTP for the policy that requires winterization and weatherization of the electricity system is significantly lower among households that experienced longer outages compared to those without outages, which may reflect reduced confidence in the effectiveness of such policies among those who suffered more during the storm. However, the WTP for the merging of the Texas grid with a national grid does not show a significant difference between the two groups (p-value = 0.94), indicating a shared level of support for this broader infrastructure solution, regardless of outage experience.

The WTP to maintain a minimum reserve capacity also differs significantly based on past outage experiences. Households that have experienced longer outages are less willing to pay for this policy than those without outages. This difference emphasizes the impact of extended power loss on the perceived value of ensuring minimum reserve capacity, possibly due to skepticism about its effectiveness in preventing future outages. These findings highlight the importance of considering past outage experiences when evaluating public support for energy policies, as these experiences significantly influence the perceived value and effectiveness of potential interventions.

Similarly to Figure 3(b) in Section 4, Figure 6 presents a visual comparison of the MWTP for 12 hours of rolling blackouts or intermittent services and four key policy proposals across the three subsample groups.[16] Figure 6 complements the findings in Figure 5 and provides a more detailed view of how different outage experiences influence the WTP for various energy policies.[17] Households that did not experience power outages consistently demonstrate the highest WTP in all policies. Such households are willing to pay 5.228 cents more per kWh for 12 hours of rolling blackouts and express strong support for policy interventions, with the WTP amount ranging from 1.892 cents per kWh for merging the Texas grid with a national grid to 4.121 cents per kWh for increasing renewable energy supply. The relatively high WTP of the no outage group reflects a proactive attitude towards preventing future outages and investing in preventive measures.

Among those that experienced power outages, households that experience shorter-than-average power outages have slightly lower WTP values, ranging from 3.985 cents per kWh for rolling blackouts, and 2.701 to 4.427 cents per kWh for policy proposals. The highest WTP is for requiring winterization/weatherization of the electricity system (4.427 cents per kWh), indicating a strong preference for measures that directly address the causes of their outage experience. By contrast, households that experienced longer-than-average power outages have the lowest WTP across all categories. They are only willing to pay 2.196 cents per kWh for rolling blackouts, and their WTP for policy proposals ranges from 1.201 to 2.079 cents per kWh. As outlined in Section 2.1, this lower WTP can be interpreted as likely resulting from negative prior experiences and, consequently, from reduced confidence in the effectiveness of the proposed policies. Following their worse-than-average experience, these individuals are more cautious, showing skepticism about the potential benefits of the policies and showing reluctance to allocate additional resources to a system that failed them during the storm.

[16] See footnote 12 for the discussion on the MWTP calculation.

[17] Table A7 in the Appendix presents the complete estimation results underlying Figures 5 and 6, including all estimated coefficients and WTP values with their corresponding standard errors and confidence intervals, as well as test results across the different model specifications.

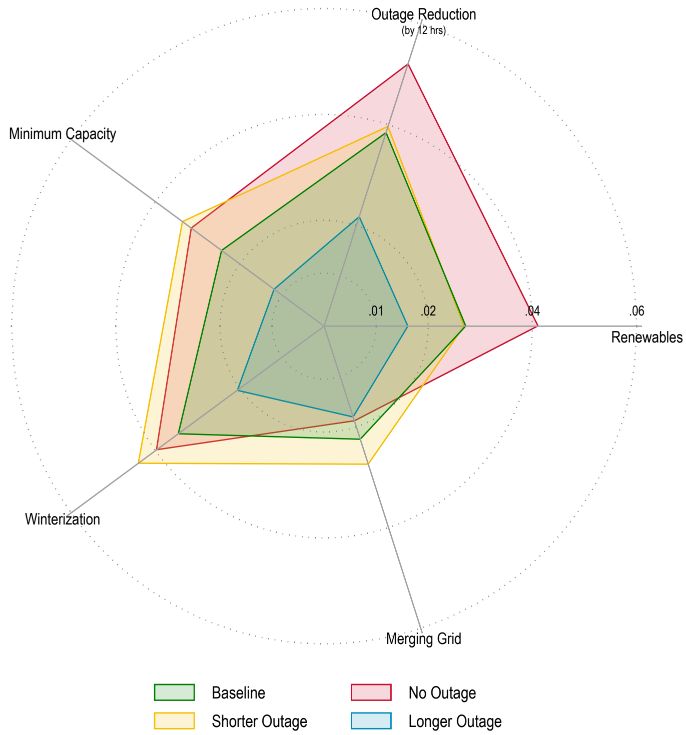

Figure 6: MWTP across policy investment (in dollars per kWh)

We also perform a battery of robustness checks to ensure that our results are not driven by specific locations or electricity utilities. The WTP is first estimated for different groups of households by removing one region from the sample one at a time. We consider the top three counties with the largest GDP: Harris County, Dallas County, and Travis County.[18] Panel A in Table A5 in the Appendix shows that the results of the estimated WTP in the sample without households living in Harris are generally similar to our baseline results. Households that did not experience power outages and those with shorter-than-average outages are willing to pay more for all policy options than households that experienced longer-than-average outages. These results are consistent across other subsample estimations, in which households in Dallas (panel B) and those in Travis (panel C) are removed from the sample.

Finally, we explore any possible heterogeneity of the WTP for respondents subscribing to services from different transmission and distribution utilities (TDUs), which may not provide identical quality of services. In Texas, Oncor is the largest TDU, supplying electricity to over 10 million residential and commercial consumers. Its service covers over 400 towns and cities, including Dallas, Fort Worth, Odessa, Killeen, Tyler, Wichita Falls, and Waco. The second largest electric utility in Texas is CenterPoint Energy. It delivers electricity to the Greater Houston area and surrounding locations. We perform a similar analysis as above by removing Oncor or CenterPoint Energy from the sample. The estimated results are presented in panels A and B of Table A6 in the Appendix. The results remain robust and similar to previous results. In panel C, we also remove the municipal TDUs from the sample and find similar results, namely, that households with outages longer than average are less willing to pay more to reduce the duration of future blackouts or for policy responses.

[18]The county with the highest GDP in Texas is Harris County ($359.65 million), followed by Dallas County ($239,7 million), and Travis County ($115.79 million). See BEA (2021).

4.1.3 Outage experience and valuation of the public good

Section 2.1 presented a theoretical framework aimed at explaining the relationship between outage experience and individuals' WTP for improvements to the electric system. The framework outlined in Sections 2.1 and 2.2 is rooted in the public good features of having access to reliable electricity. In the previous section, results showed systematic differences in WTP for policies aimed at making the Texas grid more reliable and resilient to extreme weather events, natural disasters, and other potential shocks to the supply of electricity to Texas households.

The severe impact of the storm on the Texas grid highlighted the system's vulnerabilities to all Texans, leading to increased demand for policy interventions. But all Texans did not experience the same outage length, with some experiencing more than 40 hours without power (relatively undesirable experience) and others experiencing shorter blackouts or none at all. Those who experienced no or shorter blackouts during Winter Storm Uri are more likely to have a positive perception of the electric system's reliability the public authority. By contrast, those who experienced long outages are more likely to lose faith in the public authority's ability to provide reliable electricity and be therefore less willing to pay for policies aimed at improving the system. Results from Section 4.1 are consistent: those who have experienced longer outages were less willing to pay more for the menu of policy changes presented in the conjoint experiment.

To further probe this mechanism, we analyze a series of responses to questions about who is responsible for the electric system's failure during the winter storm and who should pay for the investments needed to secure access to electricity during severe weather events. Consistent with the model's expectations, those who experienced longer-than-average outages during Winter Storm Uri are more likely to blame electricity producers, the government, and lack of oversight as the culprits for the failures of the system than respondents who experienced shorter outages or no outages at all.[19]

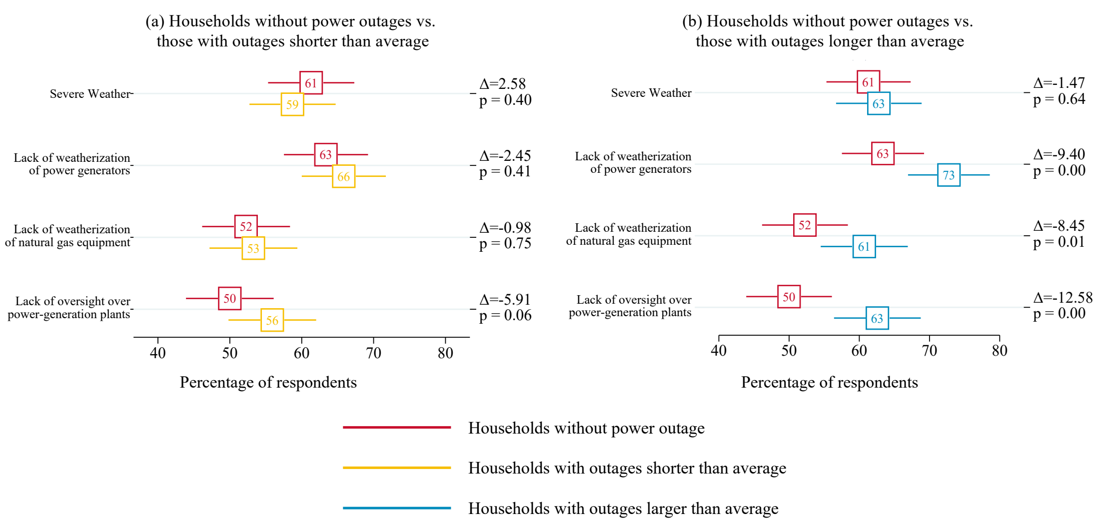

Figure 7: Perceived responsibility of power outages

Figure 7 shows the percentage of respondents who attribute blame for the power widespread and long outages to *Severe Weather*, the *Lack of Weatherization of Power Generators*, the *Lack of*

[19]The question in the survey read: *"From what you've read or heard, which of the following do you believe are responsible for the electricity grid failure during the winter storm this past February? Select all that apply"*. The answer options were: *Severe weather; the independence of Texas' electric grid from the nation's two other grids; lack of weatherization or winterization of power generators; lack of weatherization or winterization of natural gas industry equipment; reliance on renewable energy;* and *lack of oversight over power-generation plants.*

Weatherization of Natural Gas Equipment, and the *Lack of Oversight over Power-Generation plants*. Figure 7(a) presents the comparison between the group that did not experience any outage and the group that experienced an outage shorter than the average. There is no statistical difference between these two groups. In contrast, Figure 7(b) shows significant differences between the group without outages and the group that experienced an outage longer than average. Respondents who experienced longer outages are more likely to blame companies (*lack of weatherization of power generators* and *lack of weatherization of natural gas equipment*) and the government (*lack of oversight over power-generation plants*) than those who did not experience any power outages during the storm.

Respondents across Texas who experienced longer outages would also prefer others to pay for the extra costs from the proposed policies to the electric grid, particularly energy producers.[20] Individuals who experienced longer outages are more likely to think that the energy producers should pay to implement the policies. While 51.6% of the respondents in the group that experienced longer than average outages responded that the energy producers should pay for the policy changes, just 45% of respondents in the group experiencing shorter outages agreed with that statement (p-value = 0.0377).

5 Conclusion and policy implications

Winter Storm Uri revealed both the technical vulnerabilities of the Texas electricity grid and the institutional challenges associated with providing reliable electricity, a service that has the characteristics of a public good. Because reliability benefits all users simultaneously and cannot easily be withheld from non-payers, individuals face incentives to free-ride and underinvest relative to the socially optimal level of reliability. The results show that these classic public-good dynamics are amplified by households' lived experiences during the storm, which shape how they perceive the benefits of resilience investments and the credibility of the agencies responsible for delivering them. In turn, these beliefs, informed by relative past outage experience, impact households' willingness to pay for reliable access to electricity.

The analyses demonstrate that most respondents value improvements in grid reliability, but their willingness to pay for them varies significantly by outage experience. Households that experienced longer outages are consistently less willing to pay for resilience-enhancing policies, even though they stand to benefit most. This paradox is explained by reduced confidence in the electricity system due to a relatively worse outage experience: households most affected by the storm blame utilities and public authorities for the blackouts and seem less convinced that new investments will prevent future failures. In contrast, households that experienced no outage or only short interruptions are more willing to contribute financially to resilience measures, reflecting greater aversion to future blackouts and potentially higher confidence in the system's ability to deliver improvements. These findings suggest that effective public-good provision in electricity markets requires not only investment in infrastructure, but also attention to how households form expectations about system performance and government effectiveness in enforcing delivery standards.

Experience-based heterogeneity has important implications for cost-recovery design. Uniform rate increases may face particular resistance among households that experienced severe outages. Policymakers may need to consider phased cost adjustments, targeted bill credits, or income- and experience-sensitive rate structures that reflect differences in households' willingness and ability to

[20]The question about who should pay for the policy, the exact text was: *In your opinion, how do you think policies proposed to protect the Texas electric grid from effects of severe weather should be paid for?* The answer options were: *Paid for by sales taxes; paid for by property taxes; paid for by consumers through their electricity bill; paid for by energy producers;* and *do not enact the policies to protect the Texas electric grid from severe weather.*

contribute.

Rebuilding perceptions of institutional capacity emerges as another critical policy priority. The results presented in the paper show that households with long outages are more likely to attribute responsibility for the system failure to utilities and regulatory authorities (Figure 7) and that this mistrust is associated with lower willingness to pay for future improvements (Table 3, Figures 5 and 6). Policies aimed at strengthening grid resilience, therefore, need to be paired with governance reforms that enhance credibility and transparency. These may include clearer public reporting on weatherization compliance, performance-based regulation linking utility revenues to reliability outcomes, independent verification of system readiness before extreme weather seasons, and strengthened oversight of both electricity and natural-gas infrastructure. By making institutional performance more observable and enforceable, such measures help reduce the perceived risk that household contributions will be wasted, thereby encouraging participation in the collective provision of reliable electricity.

The findings also highlight the importance of communication and engagement strategies that recognize the diversity of household experiences. Communities affected by long outages may require explicit acknowledgment of past failures and clear evidence of corrective action before they will support additional investments. In contrast, households that experienced fewer disruptions may respond more readily to messages emphasizing efficiency gains and long-term cost savings. Incorporating these differentiated perspectives into the design and roll-out of resilience policies can help build the broad coalitions needed for reform.

Finally, while the analysis shows that lived outage experiences influence willingness to pay for reliability policies, several limitations are worth noting and help motivate future research. First, the sample is limited to Texas residents. Because all respondents were exposed to the broader context of Winter Storm Uri, a difference-in-differences analysis comparing affected and unaffected regions is not possible; using multi-state or national data would strengthen causal inference and external validity. Second, the survey measures WTP shortly after the storm, when the event's relevance is heightened. Follow-up studies could examine how these patterns evolve as households update their beliefs and preferences in response to subsequent grid performance and policy responses in the aftermath of an extreme weather event. More broadly, WTP research often relies on cross-sectional snapshots, but recent work emphasizes the value of tracking preferences over longer horizons (e.g., He and Zhang, 2021). Future studies could therefore adopt panel designs that reinterview the same individuals over time, allowing researchers to test whether WTP remains stable or changes in response to new information, lived experience, policy interventions, or even just the passage of time.

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6 Appendix

Tables

Table A1: Descriptive Statistics by Treatment Group (Balance Check)

	Full Sample			No Outage		
	No.	Mean	S.D.	No.	Mean	S.D.
Owner	1500	0.61	0.49	486	0.63	0.48
E.C.	1500	14.97	8.49	486	15.23	8.51
Married	1500	0.52	0.49	486	0.54	0.50
Income	1340	77.11	77.88	436	75.52	68.95
Democrat	1500	0.37	0.48	486	0.37	0.48
Republican	1500	0.22	0.41	486	0.21	0.40
Female	1500	0.56	0.49	486	0.55	0.50
White	1500	0.46	0.49	486	0.50	0.50
Black	1500	0.09	0.29	486	0.08	0.28
Hispanic	1500	0.37	0.48	486	0.37	0.48
College	1500	0.36	0.48	486	0.35	0.48
Children	1500	0.27	0.44	486	0.28	0.45
Liberal	1500	0.31	0.46	486	0.32	0.47
Conservative	1500	0.30	0.45	486	0.31	0.46
Risk Aversion 1	1,141	0.27	0.45	363	0.25	0.44
Risk Aversion 2	1,499	0.24	0.43	486	0.23	0.42

	Shorter outages			Longer outages		
	No.	Mean	S.D.	No.	Mean	S.D.
Owner	533	0.62	0.49	481	0.59	0.49
E.C.	533	15.22	8.58	481	14.44	8.38
Married	533	0.54	0.50	481	0.51	0.50
Income	472	77.90	82.91	432	77.84	80.80
Democrat	533	0.37	0.48	481	0.37	0.48
Republican	533	0.24	0.43	481	0.24	0.43
Female	533	0.60	0.49	481	0.55	0.50
White	533	0.45	0.50	481	0.46	0.50
Black	533	0.11	0.32	481	0.10	0.29
Hispanic	533	0.37	0.48	481	0.38	0.49
College	533	0.35	0.48	481	0.40	0.49
Children	533	0.29	0.45	481	0.27	0.44
Liberal	533	0.32	0.47	481	0.31	0.46
Conservative	533	0.31	0.46	481	0.29	0.45
Risk Aversion 1	407	0.30	0.46	371	0.26	0.44
Risk Aversion 2	533	0.24	0.43	480	0.25	0.43

Notes: E.C. stands for electricity consumption (in 1,000 kWh). Income is measured in $1,000.

Table A2: Policy Preferences on Protecting the Texas Electrical Grid from Severe Weather

	Baseline	
Variable	Coefficient	Std. Err.
Cost		
1 cent more per kWh	-0.2363***	0.067
2 cents more per kWh	-0.4511***	0.069
4 cents more per kWh	-0.9139***	0.071
6 cents more per kWh	-1.3240***	0.078
Outage duration		
Rolling blackouts/ intermittent service:		
On and off for up to 2 hours	-0.7659***	0.062
On and off for up to 12 hours	-1.3373***	0.067
For more than 12 hours	-1.8117***	0.079
Policy response/ investment		
Merge the Texas electrical grid with one of the two national grids	0.7527***	0.077
Require the winterization/ weatherization of the electricity system	1.2141***	0.075
Maintain a minimum reserve capacity	0.7799***	0.069
Increase the renewable energy supply	0.9268***	0.076
Log simulated-likelihood	-3302.2572	
Number of Observations	12,000	

Notes: * 10% significance level; ** 5% significance level; and *** 1% significance level, two-tailed tests.

Table A3: Marginal Willingness to Pay - Baseline and Subsamples

	Baseline	Households without Power Outage	Households with Shorter than Average Power Outage	Households with Longer than Average Power Outage
Hours of rolling blackouts/ intermittent service	-2.9590***	-4.0030***	-3.0512***	-1.6814***
	(0.328)	(0.732)	(0.580)	(0.380)
Merge the Texas electrical grid with one of the two national grids	3.1715***	2.6569***	3.8678***	2.5529***
	(0.459)	(0.748)	(0.953)	(0.604)
Require the winterization/ weatherization of the electricity system	4.8853***	5.6106***	6.2161***	2.9183***
	(0.646)	(1.2070	(1.348)	(0.704)
Maintain a minimum reserve capacity	3.4346***	4.4461***	4.7396***	1.6857***
	(0.483)	(0.994)	(1.084)	(0.462)
Increase the renewable energy supply	3.8364***	5.7863***	3.7928***	2.2762***
	(0.526)	(01.241)	(0.921)	(0.546)
Number of observations	12,000	3,888	4,264	3,848

Notes: * 10% significance level; ** 5% significance level; and *** 1% significance level, two-tailed tests.

Table A4: Equality Tests for Marginal Willingness to Pay Across Three Types of Households

	NO Outages		LONG Outages		Coefficient Equality	
	Coef	Std Error	Coef	Std Error	Chi Squared	p-value
Hours of rolling blackouts intermittent service	-4.0030***	[0.732]	-1.6814***	[0.380]	5.65**	0.02
Merge the Texas electrical grid with one of the two national grids	2.6569***	[0.748]	2.5529***	[0.604]	0.01	0.94
Require the winterization / weatherization of the electricity system	5.6106***	[1.207]	2.9183***	[0.704]	2.8*	0.09
Maintain a minimum reserve capacity	4.4461***	[0.994]	1.6857***	[0.462]	5.29**	0.02
Increase the renewable energy supply	5.7863***	[1.241]	2.2762***	[0.546]	5.6**	0.02

	SHORT Outages		LONG Outages		Coefficient Equality	
	Coef	Std Error	Coef	Std Error	Chi Squared	p-value
Hours of rolling blackouts intermittent service	-3.0512***	[0.580]	-1.6814***	[0.380]	3.66*	0.0556
Merge the Texas electrical grid with one of the two national grids	3.8678***	[0.953]	2.5529***	[0.604]	1.25	0.2633
Require the winterization / weatherization of the electricity system	6.2161***	[1.348]	2.9183***	[0.704]	4.56**	0.0328
Maintain a minimum reserve capacity	4.7396***	[1.084]	1.6857***	[0.462]	6.62**	0.0101
Increase the renewable energy supply	3.7928***	[0.921]	2.2762***	[0.546]	1.89	0.1697

	NO Outages		SHORT Outages		Coefficient Equality	
	Coef	Std Error	Coef	Std Error	Chi Squared	p-value
Hours of rolling blackouts intermittent service	-4.0030***	[0.732]	-3.0512***	[0.580]	0.96	0.33
Merge the Texas electrical grid with one of the two national grids	2.6569***	[0.748]	3.8678***	[0.953]	0.99	0.32
Require the winterization / weatherization of the electricity system	5.6106***	[1.207]	6.2161***	[1.348]	0.11	0.74
Maintain a minimum reserve capacity	4.4461***	[0.994]	4.7396***	[1.084]	0.04	0.84
Increase the renewable energy supply	5.7863***	[1.241]	3.7928***	[0.921]	1.6	0.21

Table A5: Robustness Check on Marginal Willingness to Pay - Subregion Regressions

	Baseline	Households without power outage	Households shorter than average power outages	Households with longer than average power outages
A. Removing Harris from the sample				
Hours of rolling blackouts/ intermittent service	-3.1325***	-3.9129***	-3.1479***	-2.0979***
	(0.359)	(0.709)	(0.642)	(0.721)
Policy response/ investment				
Merge the Texas electrical grid with one of the two national grids	3.2255***	2.4592***	3.9258***	3.1526***
	(0.494)	(0.715)	(1.030)	(1.079)
Require the winterization/ weatherization of the electricity system	5.3262***	5.2634***	7.1011***	3.7354***
	(0.721)	(1.150)	(1.593)	(1.328)
Maintain a minimum reserve capacity	3.7637***	4.402202	4.9385***	2.1208***
	(0.548)	(0.988)	(1.204)	(0.844)
Increase the renewable energy supply	4.2195***	5.567897	3.8653***	3.0351***
	(0.592)	(1.203)	(1.005)	(1.057)
Number of observations	10,024	3,768	3,440	2,816
B. Removing Dallas from the sample				
Hours of rolling blackouts/ intermittent service	-2.8881***	-3.6754***	-2.9278***	-1.8261***
	(0.323)	(0.693)	(0.572)	(0.422)
Policy response/ investment				
Merge the Texas electrical grid with one of the two national grids	3.2669***	2.5223***	4.0070***	2.8415***
	(0.470)	(0.714)	(1.008)	(0.659)
Require the winterization/weatherization of the electricity system	5.0353***	5.2811***	6.3353***	3.2176***
	(0.652)	(1.187)	(1.376)	(0.762)
Maintain a minimum reserve capacity	3.5348***	3.9108***	4.9011***	1.9906***
	(0.491)	(0.935)	(1.119)	(0.522)
Increase the renewable energy supply	3.8120***	4.9543***	3.8724***	2.5079***
	(0.523)	(1.183)	(0.954)	(0.590)
Number of observations	11,064	3,544	3,944	3,576
C. Removing Travis from the sample				
Hours of rolling blackouts/intermittent service	-3.0137***	-4.2176***	-3.2283***	-1.4729***
	(0.348)	(0.852)	(0.618)	(0.424)
Policy response/investment				
Merge the Texas electrical grid with one of the two national grids	2.9808***	2.2674***	4.0387***	2.1777***
	(0.465)	(0.736)	(1.005)	(0.622)
Require the winterization/weatherization of the electricity system	4.7490***	5.1713***	6.7272***	2.4954***
	(0.668)	(1.234)	(1.443)	(0.726)
Maintain a minimum reserve capacity	3.4420***	4.3492***	5.1831***	1.4055***
	(0.507)	(1.053)	(1.165)	(0.477)
Increase the renewable energy supply	3.6981***	5.4831***	4.0874***	1.8885***
	(0.538)	(1.291)	(1.001)	(0.545)
Number of observations	11,184	3,656	4,008	3,520

Notes: * 10% significance level; ** 5% significance level; and *** 1% significance level, two-tailed tests. Standard errors are in parentheses.

Table A6: Robustness Check on Marginal Willingness to Pay - Subsamples of Electric Utilities

	Baseline	Households without power outage	Households with outages shorter than average	Households with outages longer than average
A. Removing Oncor from the sample				
Hours of rolling blackouts/ intermittent service	-3.0364***	-5.9695***	-3.1701***	-1.8018***
	(0.391)	(1.576)	(0.674)	(0.447)
Policy response/ investment				
Merge the Texas electrical grid with one of the two national grids	3.3368***	3.5363***	5.1329***	2.4528***
	(0.583)	(1.260)	(1.432)	(0.570)
Require the winterization/weatherization of the electricity system	4.9695***	8.1948***	7.2509***	2.5246***
	(0.777)	(2.094)	(1.771)	(0.615)
Maintain a minimum reserve capacity	3.7055***	6.4665***	6.0368***	1.7535***
	(0.621)	(1.869)	(1.530)	(0.459)
Increase the renewable energy supply	3.7489***	7.0267***	4.6524***	2.0532***
	(0.630)	(1.980)	(1.281)	(0.508)
Number of observations	7,832	2,168	2,872	2,792
B. Removing Centerpoint from the sample				
Hours of rolling blackouts/ intermittent service	-3.2086***	-4.1417***	-3.0726***	-2.0668***
	(0.377)	(0.771)	(0.664)	(0.657)
Policy response/investment				
Merge the Texas electrical grid with one of the two national grids	3.2507***	2.3710***	3.6622***	3.4434***
	(0.517)	(0.727)	(1.022)	(1.095)
Require the winterization/weatherization of the electricity system	5.3192***	5.1449***	6.7236***	3.8973***
	(0.759)	(1.197)	(1.619)	(1.293)
Maintain a minimum reserve capacity	3.7893***	4.2317***	4.7385***	2.3273***
	(0.575)	(0.994)	(1.242)	(0.853)
Increase the renewable energy supply	4.3353***	5.4420***	3.6277***	3.3506***
	(0.629)	(1.251)	(1.001)	(1.085)
Number of observations	9,424	3,648	3,128	2,648
C. Removing Muncipal from the sample				
Hours of rolling blackouts/ intermittent service	-2.7833***	-3.3729***	-3.2366***	-1.3341***
	(0.361)	(0.665)	(0.642)	(0.318)
Policy response/ investment				
Merge the Texas electrical grid with one of the two national grids	2.7194***	1.8916***	3.8818***	1.8314***
	(0.469)	(0.663)	(0.986)	(0.476)
Require the winterization/ weatherization of the electricity system	4.3094***	4.3165***	5.9156***	2.3342***
	(0.689)	(1.107)	(1.365)	(0.601)
Maintain a minimum reserve capacity	3.0389***	3.5474***	4.4120***	1.3254***
	(0.510)	(0.919)	(1.074)	(0.403)
Increase the renewable energy supply	3.4777***	4.8233***	3.8736***	1.7056***
	(0.570)	(1.203)	(1.011)	(0.451)
Number of observations	9,936	3,264	3,488	3,184

Notes: ∗ 10% significance level; ∗∗ 5% significance level; and ∗∗∗ 1% significance level, two-tailed tests. Standard errors are in parentheses.

Figures

University Logo

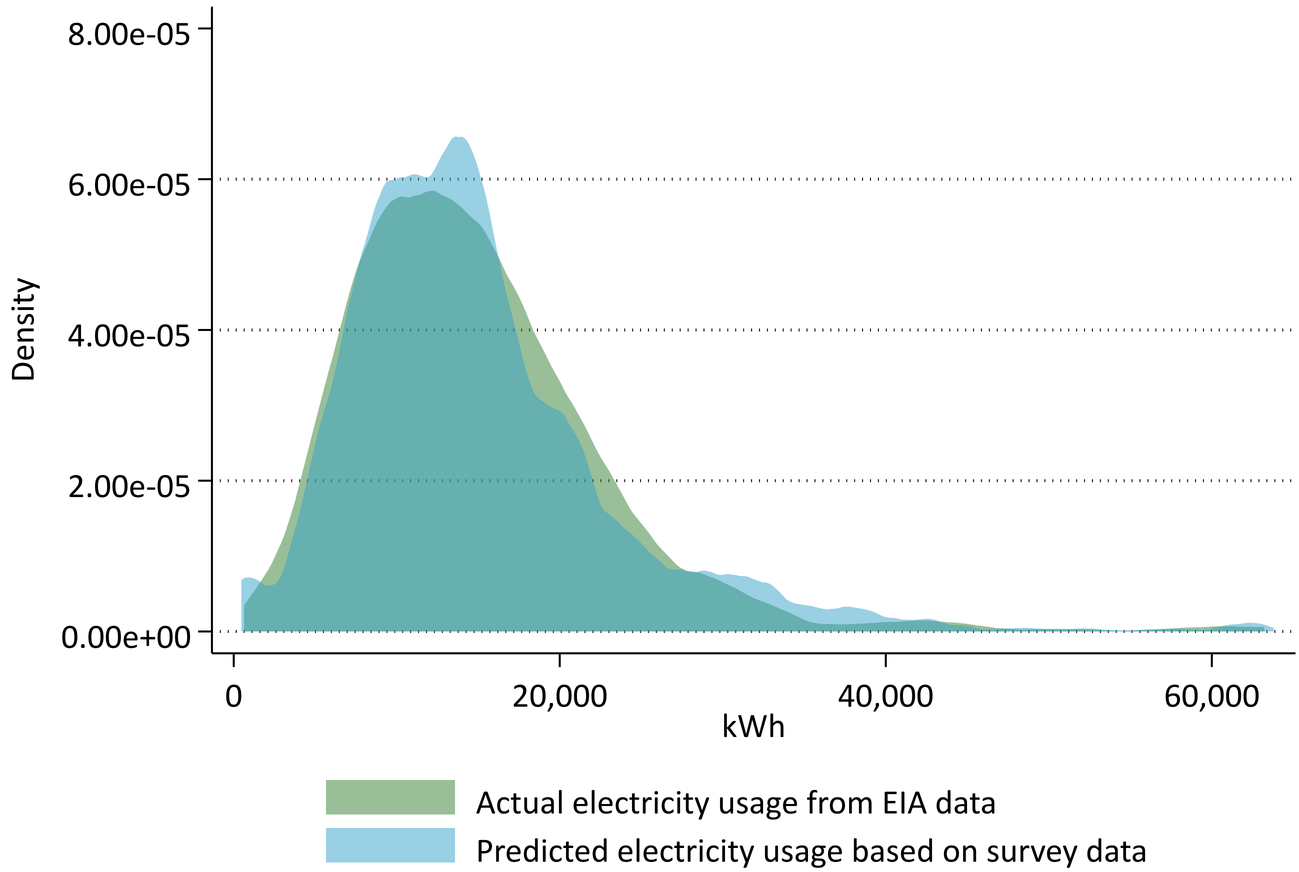
A number of policies have been proposed to protect the state of Texas from the effects of severe weather affecting its energy supply and delivery. Each proposal will need to be paid for in order to guarantee power outages are kept to the stated levels. In 2019, Texans spent an average of $103 per month on electricity (at 8.6 cents per kWh) and experienced power outages for about 4 hours per year. In the following screens you will be presented profiles of two hypothetical alternatives for protecting the Texas electrical grid from the effects of severe weather and their expected costs. Which of the two alternatives, A or B, would you be more likely to choose? Please consider each pair independently.

Attribute	Policy A	Policy B
Policy	Require the winterization / weatherization of the electricity system	Merge the Texas electrical grid with ono of the two national grids
Cost	2 cents more per kWh - 23% Increase	6 cents more per kWh - 70% increase
Outage Hours	Rolling blackouts/ intermittent service (on and off for up to 2 hours)	Rolling blackouts/ intermittent service (on and off for up to 12 hours)

○ Policy A

○ Policy B

Figure A1: An Example of the Conjoint Experiment



Notes: Largest difference between distributions = 0.0316. Approximate asymptotic p-value = 0.424.

Figure A2: Distribution matching

Table A7

	WTP coefficient			WTP (cents per kWh)		
	Coef.	95% LB	95% UB	Coef.	95% LB	95% UB
(a) Baseline model (All households)						
Hours of rolling blackouts/ intermittent service	-2.9590***	-3.6033	-2.3147	3.8646***	3.0232	4.7061
	[0.328]			[0.429]		
Policy response/ investment						
Merge the Texas electrical grid with	3.1715***	2.2701	4.0729	2.2588***	1.6169	2.9009
one of the two national grids	[0.459]			[0.327]		
Require the winterization/ weatherization	4.8853***	3.6189	6.1517	3.4795***	2.5775	4.3815
of the electricity system	[0.646]			[0.460]		
Maintain a minimum reserve capacity	3.4346***	2.4870	4.3822	2.4462***	1.7713	3.1212
	[0.483]			[0.344]		
Increase the renewable energy supply	3.8364***	2.8054	4.8674	2.7324***	1.9981	3.4668
	[0.526]			[0.374]		
(b) Households without power outage						
Hours of rolling blackouts/ intermittent service	-4.0030***	-5.4378	-2.5683	5.2281***	3.3544	7.1021
	[0.732]			[0.956]		
Policy response/ investment						
Merge the Texas electrical grid with	2.6569***	1.1906	4.1231	1.8923***	0.8480	2.9366
one of the two national grids	[0.748]			[0.532]		
Require the winterization/ weatherization	5.6106***	3.2431	7.9782	3.9961***	2.3099	5.6824
of the electricity system	[1.207]			[0.860]		
Maintain a minimum reserve capacity	4.4461***	2.4978	6.3944	3.1667***	1.7790	4.5543
	[0.994]			[0.707]		
Increase the renewable energy supply	5.7863***	3.3525	8.2201	4.1212***	2.3878	5.8547
	[1.241]			[0.884]		
(c) Households with shorter-than-average power outage						
Hours of rolling blackouts/ intermittent service	-3.0512***	-4.189	-1.9134	3.9850***	2.4991	5.4711
	[0.580]			[0.758]		
Policy response/ investment						
Merge the Texas electrical grid with	3.8678***	1.9990	5.7366	2.7548***	1.4237	4.0858
one of the two national grids	[0.953]			[0.679]		
Require the winterization/ weatherization	6.2161***	3.5735	8.8587	4.4273***	2.5452	6.3095
of the electricity system	[1.348]			[0.960]		
Maintain a minimum reserve capacity	4.7396***	2.6135	6.8657	3.3757***	1.8614	4.8900
	[1.084]			[0.772]		
Increase the renewable energy supply	3.7928***	1.985769	5.5998	2.7013***	1.4143	3.9884
	[0.921]			[0.656]		
(d) Households with longer-than-average power outage						
Hours of rolling blackouts/ intermittent service	-1.6814***	-2.4277	-0.9351	2.1960***	1.2213	3.1707
	[0.380]			[0.497]		
Policy response/ investment						
Merge the Texas electrical grid with	2.5529***	1.3676	3.7383	1.8182***	0.9740	2.6626
one of the two national grids	[0.604]			[0.430]		
Require the winterization/ weatherization	2.9183***	1.5382	4.2984	2.0785***	1.0956	3.0615
of the electricity system	[0.704]			[0.501]		
Maintain a minimum reserve capacity	1.6857***	0.7801	2.5912	1.2006***	0.5556	1.8456
	[0.462]			[0.329]		
Increase the renewable energy supply	2.2762***	1.2058	3.3466	1.6212***	0.8588	2.3836
	[0.546]			[0.388]		

(e) Coefficient equality tests across samples	(b) No outage vs (c) Short outage		(b) No outage vs (d) Long outage		(c) Short outage vs (d) Long outage	
	χ^2	p-value	χ^2	p-value	χ^2	p-value
Hours of rolling blackouts/ intermittent service	0.96	0.3274	5.65	0.0175	3.66	0.0556
Merge the Texas electrical grid with one of the two national grids	0.99	0.3188	0.01	0.9363	1.25	0.2633
Require the winterization/ weatherization of the electricity system	0.11	0.7400	2.80	0.0941	4.56	0.0328
Maintain a minimum reserve capacity	0.04	0.8417	5.29	0.0214	6.62	0.0101
Increase the renewable energy supply	1.60	0.2065	5.60	0.0179	1.89	0.1697