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

Gail J. Buttorff, Yuhsin Annie Hsu, Yewande Olapade, María P. Perez Arguelles, Pablo M. Pinto, Savannah L. Sipole, Agustín Vallejo and M. C. Sunny Wong[†]

October 29, 2024

Abstract

Winter Storm Uri led to power outages in many Texas households in February 2021 and exposed crucial deficits in the state's electricity grid. We use Winter Storm Uri as a case study to answer two related questions. First, does experiencing a natural disaster impacting electricity supply affect willingness to pay (WTP) for policy interventions aimed at improving the reliability of the electricity grid? Second, did the duration of the power outage experienced make individuals more or less willing to pay to improve the reliability of the electricity supply? Given its public good properties, reliable electricity supply in times of natural disasters will tend to be undersupplied absent public policy interventions. We present a simple model of an individual's expenditure (or willingness to pay) function for varying levels of a public good. Using a choice experiment embedded in a survey fielded after Winter Storm Uri, we evaluate respondents' preferences for potential policy interventions aimed at increasing the reliability of the Texas electric grid. We estimate the expenditure function, namely the price respondents would pay for such interventions to improve the level or the quality of the public good. We find that, naturally, individuals prefer lower costs and fewer outages. More importantly, we are also able to account for variation in past outage experience - which we characterize as the number of hours without power - and its impact on WTP by exploiting the 'as-if' random assignment of outage duration during the storm. We find that respondents who experienced longer-than-average outages revealed a WTP increase of 2 cents per kWh for winterizing the grid. Notably, this increase is significantly lower than the 4 to 4.4 cents more offered by those who had shorter or no outages, respectively. Additionally, individuals experiencing longer outages are more likely to blame government authorities and electricity producers for the grid failure during the Winter storm.

[†]Hobby School of Public Affairs. University of Houston.

1 Introduction

The reliability of an electricity system depends on the ability of electricity suppliers to meet demand, which is not a problem under normal circumstances. Winter Storm Uri in February 2021, however, exposed the vulnerability of the Texas grid to natural disasters and extreme weather events. Between February 14-20, 2021, Texas experienced an unprecedented collapse of its electrical generation and distribution system, causing more than 10 million Texans to lose power for multiple days amidst freezing and below-freezing temperatures. The cold weather froze natural gas pipelines, which were not weatherized to endure exceptionally low temperatures, reducing the supply of fuel to a large proportion of electricity producers. The cold weather also forced some power plants out of the system when demand was expected to peak as consumers braced for the extreme temperatures. At its peak, the storm left 4.5 million homes and businesses without power, killed at least 151 people, and cost at least $195 billion in material losses. Given that extreme weather events are only expected to increase in frequency in Texas and elsewhere, such events will continue to threaten the reliable supply of energy, resulting in disruptions and losses of human life and physical capital.

Addressing problems with the electricity grid to secure a more reliable energy supply demands massive investments and regulatory changes that will ultimately raise the cost of electricity. 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). In this paper, we examine individuals' willingness to pay (WTP) for policy interventions and investments aimed at enhancing the reliability of the electricity supply, a public good.

To investigate the impact of natural disasters and extreme weather on the valuation of a resilient electricity supply, we develop a theoretical framework connecting valuation of public goods, specifically electricity services, to WTP. We also develop a choice experiment embedded in an online survey to understand public preferences regarding policy interventions to enhance the reliability of electricity services in the face of severe weather events, and to examine respondents' willingness to financially support such interventions. 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 (i.e., Winter Storm Uri). This approach allows us to better evaluate how experiences with natural disasters and long outages influence individuals' willingness to pay for reliable electricity supply, as respondents do not have to "imagine" hypothetical unplanned outages. Our baseline findings show that people prioritize lower electricity costs and reduced power outages as expected. Respondents are also willing to pay additional costs for policies to safeguard the electricity grid from severe weather events, indicating a strong preference among the public for a more resilient system.

Yet, while all respondents in Texas experienced the extreme weather event which caused widespread outages of long duration, they were not all impacted identically. Households experienced outages of different lengths, and some not at all, a fact we leverage as a natural experiment to explore how past outage experience shapes WTP. We argue that experiencing prolonged blackouts negatively affects individuals' assessment of the ability of government and power suppliers to reliably deliver electricity. This negative assessment, in turn, is associated with lower willingness to pay for investments in resiliency. Experiencing shorter blackouts, by contrast, increases individuals' valuation of the public good and willingness to pay for policies aimed at making the electric grid more resilient to natural disasters and mitigating expected losses. 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. Our results show that households with longer-than-average power outages were willing to pay significantly *less* for reliable energy, compared to those who had shorter-than-average outages or no outages at all. Furthermore, those who experienced longer outages were *more likely* to hold the government and electricity producers responsible for the Texas power grid failure. These findings provide a basis for reconciling conflicting results in the existing literature concerning the influence of prior experience on the willingness to pay for reliable electricity and public goods in general (e.g., Cohen et al. (2018); Baik et al. (2020); Taale and Kyeremeh (2016); Amador, González and Ramos-Real (2013)).

The rest of our paper proceeds as follows. Section 2 briefly summarizes the literature on the factors influencing WTP for reliable electricity. Section 3 presents a simple theoretical model for determining the willingness to pay for public goods. Section 4 discusses the empirical strategy and model specification, and Section 5 presents the baseline results of the analysis. In Section 6, we use Winter Storm Uri as a natural experiment to estimate how the WTP of policies can be impacted by an individual's past experience with power outages. Section 7 discusses the findings and, finally, Section 8 offers our concluding remarks.

2 Related Literature on 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 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 (Goett, Hudson and Train, 2000). The WTP of electricity customers to avoid power outages, especially sudden or unplanned ones, varies with their age, family size, season, location, type of housing, and day and time of the week (Carlsson and Martinsson, 2008; Abdullah and Mariel, 2010; Taale and Kyeremeh, 2016; Kim, Kim and Yoo, 2019; Hensher, Shore and Train, 2014; Ozbafli and Jenkins, 2016; Cohen et al., 2018).

Previous studies on WTP for reliable electricity service have documented that demographic characteristics account for heterogeneity in WTP, likely due to how these factors relate to dependence and demand for electricity. Outages of different lengths can also have adverse welfare effects depending on an individual's demographic profile, the season, time of the week, and housing type. For example, WTP to avoid power outages is expected to be higher on weekends or weeknights than on weekdays (Carlsson and Martinsson, 2008). People are likely to be home during the former and thus more negatively affected by a power outage than if it happened during a weekday when they would likely be at work or school. Similarly, Cohen et al. (2018) find that which season induces a higher WTP depends on local temperature, particularly whether the country or region has hotter summers or colder winters.

Other demographic factors are considered to capture the ability of respondents to pay more and, therefore influence WTP. Taale and Kyeremeh (2016), for example, show that in Ghana, household size was negatively associated with WTP. The authors suggest that larger households are likely to have tighter budget constraints, not leaving much room for spending beyond basic needs and thus lowering their WTP. By contrast, Abdullah and Mariel (2010) in their study of WTP for electricity in Kisumu, Kenya find that larger households were more willing to pay for reliable service, which the authors attribute to larger demand and reliance across household members.

Factors related to reliance on and demand for electricity also account for some heterogeneity in WTP for reliable electricity, with higher electricity usage associated with greater disutility from power outages. 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. Taale and Kyeremeh (2016) suggest that education positively influenced WTP because more educated individuals are likely to rely more on electricity and own more electric appliances, resulting in greater welfare loss when the electricity goes out.

Beyond demographic factors, 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, arguing this lower WTP stems from lower confidence in government among older participants in their study area. Taale and Kyeremeh (2016) find that receiving prior notices of power outages is associated positively with WTP, suggesting that enhanced communication increased trust in the electricity service providers, thus influencing respondents' WTP.

Previous experience with power outages is also linked to individuals' WTP for reliable electricity, though conclusions vary regarding whether and how past experience(s) impacts WTP. 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 that this is likely due to "the readiness factor" making such individuals better equipped to endure future power outages (p. 39). Thus, those who have experienced long-duration power outages may be willing to pay less because they are better prepared to endure sustained power outages. Similarly, Ozbafli and Jenkins (2016) argue that older respondents were not as negatively affected by power outages as younger respondents because older respondents had more "experience coping with such inconveniences" compared to younger respondents (p. 448).

On the other hand, other research shows that 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-duration power outages again. 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 supply. 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. Furthermore, 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 the previous outage(s).

3 Determining WTP for Public Goods

The Texas electricity system was designed to promote competition among producers and limited government intervention. Producers are only paid when supplying electricity to the system, and there are no requirements to keep backup capacity. To avoid federal regulation of the Texas electricity grid, the Texas Interconnection of the Electric Reliability Council of Texas (ERCOT) is not linked to the other major national grids. The reliability of the system, therefore, depends on the ability of electricity providers to meet demand, which under normal circumstances is not a problem. However, the system can be vulnerable to natural disasters and extreme weather events, as reflected in the massive impact of Winter Storm Uri. The problem is not only limited 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.

Addressing problems in the Texas electricity grid, including a reliable electricity supply, requires massive investments and regulatory changes that will affect the cost of electricity. Moreover, the reliability of the electric grid can be characterized as a public good that the current system does not necessarily supply at the optimal level. Access to a reliable electricity supply is valuable for individuals. However, it is unlikely that people will internalize the value of the reliability of the system. Just like in the case of other public goods, as is well documented in the literature, neither individuals nor private suppliers of the public good face incentives to contribute to its provision, resulting in under-investment and under-supply (Pigou, 1947; Brainard and Dolbear, 1967; Williams, 1966; and Stiglitz and Rosengard, 2015).

To describe the underlying problem, this section presents a simple model 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, we introduce a potential intervention aimed at increasing the level or the quality of the public good. In theory, due to the typical properties of public goods, individuals have no incentive to reveal their willingness to pay as they can free-ride on the contributions by other actors with a higher valuation for the good. We then add to the basic model by incorporating individuals' past experience, in this case with outages, which shape individuals' expectations of the public authority's ability to provide the proposed level of the public good. Importantly, this theoretical framework helps reconcile results in the empirical literature, which suggest both positive or negative associations between outage experience and willingness to pay for reliable access to electricity.

3.1 A Basic Setup

We present a modified theoretical framework originally suggested by Oh and Hong (2012), showing the differential effect of outage experiences on an individual's WTP for reliable electricity supply. Consider the utility function of individual i over two types of goods, X and Y, as follows:

$$U_i = U\left(X_i, Y\right),$$

where $X_i = [x_{i1}, ..., x_{iJ}]$ is a vector of J private goods for individual i, and Y is a public good. The utility function U has regular properties, where $U_z = \partial U/\partial z > 0$ and $U_{zz} = \partial^2 U/\partial z^2 < 0$, for $z \in \{X, Y\}$, and $\partial^2 U/\partial X \partial Y = \partial^2 U/\partial Y \partial X > 0$. 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.[1]

Let P be a vector of prices for private goods X, and I_i be the level of disposable income of the individual i. The individual chooses the optimal level of X to maximize her utility function given the levels of price P, income I_i, and public good Y.[2] As a result, the indirect utility function can be written as:

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

We can derive the expenditure function from the indirect utility function (1). The expenditure $E(\cdot)$ is represented as the minimum amount that individual i must spend on *private goods* in order to achieve

[1] We will use public good provider, public authority, and government interchangeably to describe an entity providing public goods in society.

[2] Without loss of generality, we assume that the initial level of public good Y^0 has been paid by the public authority to focus on willingness to pay for changes in the provision of the public good.

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, such that $Y^1 > Y^0$. We define the change in the level of the public good as $y = Y^1 - Y^0 > 0$. Assuming that the additional level of public good will be paid by individuals and that society prefers more of the public good, we can derive the willingness to pay for the extra level of the public good for individual i:

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

where $y_i^e = \left(Y_i^1\right)^e - Y_0$, U_i^0 represents the initial utility level, and $\left(Y_i^1\right)^e$ the expected level of the public good for individual i after the policy implementation, which is *not* necessarily identical across individuals in society. Equation (3) suggests that individual i is willing to spend less on private goods if she expects to obtain more (better) public good $\left(Y_i^1\right)^e$, given the same level of utility. Hence, the difference between the expenditure on private goods with the original level of public good $E\left(P, Y^0, U_i^0\right)$ and the expenditure with a higher expected level of public good $E\left(P, \left(Y_i^1\right)^e, U_i^0\right)$ is interpreted as the willingness to pay for the additional level of public good for the individual i, *ceteris paribus*.

From Equation (3), if individual i's expected level of public good $\left(Y_i^1\right)^e$ equals the level that the public authority proposes (i.e., Y^1), then $WTP\left(y_i^e\right) = WTP\left(y\right)$. In other words, society is willing to contribute an amount to the public authority for providing a certain level of public good based on their valuation of the public authority's ability to supply that good. However, an individual would be less willing to pay if she expects that the public authority will not be able to deliver the proposed level or quality of the public good.

To develop the relationship between individuals' valuation of public good providers and their willingness to pay for public goods, we first linearize the private-good expenditure function of $E_i\left(P, \left(Y_i^1\right)^e, U_i^0\right)$ around the initial level of the public good Y^0 based on the first-order Taylor approximation:

$$E\left(P, \left(Y_i^1\right)^e, U_i^0\right) \approx E\left(P, Y^0, U_i^0\right) + E_Y\left(P, Y^0, U_i^0\right) \cdot \left(\left(Y_i^1\right)^e - Y^0\right), \tag{4}$$

where $E_Y\left(\cdot\right) = \partial E\left(\cdot\right) / \partial Y < 0$. Substituting (4) into (3), the linearized function of willingness to pay for the public good can be presented as:

$$WTP\left(y_i^e\right) = -E_Y\left(P, Y^0, U_i^0\right) \cdot y_i^e > 0. \tag{5}$$

Equation (5) shows that individual i's willingness to pay for the public good depends on the negative value of the marginal expenditure on public good $\left(-E_Y\right)$ multiplied by the expected change in the level of public good $\left(y_i^e\right)$ for individual i.

3.2 The Role of Subjective Experience

To capture the effect of individuals' past experience with outages, we assume, following Oh and Hong (2012), that 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, we have:

$$y_i^e = \int_0^y y^* f\left(\hat{\gamma}_i, y^*\right) dy^* = \Gamma\left(\hat{\gamma}_i\right) y, \tag{6}$$

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. We assume that $\hat{\gamma}_i$ represents the relative undesirable experiences of the public goods, 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 policy implementation will meet the individual's expected standard as they had better-than-average experience(s) in the past. Finally, we obtain the following linear willingness to pay function for individual i by substituting (6) into (5):

$$WTP\left(y_i^e\right) = -E_Y\left(P, Y^0, U_i^0\right) \Gamma\left(\hat{\gamma}_i\right) y. \tag{7}$$

According to Equation (7), we see that $\partial WTP\left(y_i^e\right)/\partial\hat{\gamma}_i < 0$ for $\hat{\gamma}_i > 0$. In other words, 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). In other words, Equation (7) suggests that an individual's willingness to pay 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.

4 Empirical Strategy

To assess individuals' willingness to pay for reliable electricity, we fielded an online survey 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, as well as their willingness to pay for the required policy interventions to make the grid more resilient to the effects of severe weather events. Table 1 presents the descriptive statistics of the relevant demographic characteristics.

Figure 1 presents a map of survey respondents' average hours without power by ZIP codes in Texas. The hour distribution does not appear to follow a spatial pattern or cluster in specific regions. While the most impacted counties in terms of the average number of customers without power were Throckmorton (93%), Brazoria (92%), and Wharton (90%), power outages occurred statewide. In addition, power outages varied in length, hour by hour from February 10 to February 19, with February 16 the day when the highest number of customers were affected.

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

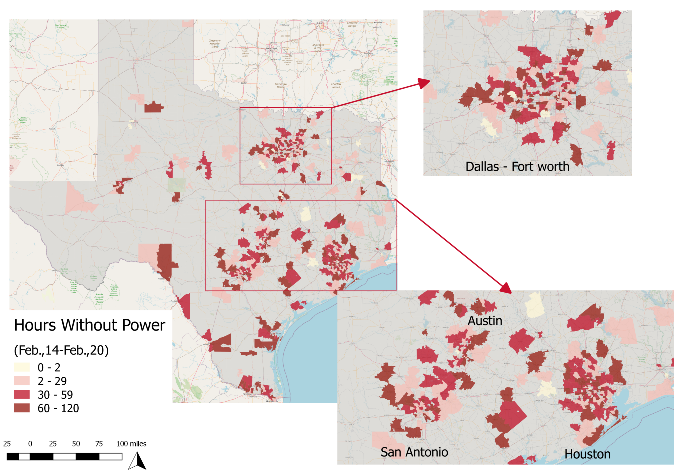


Figure 1: Geographical Distribution of Electricity Outages

4.1 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 supplier (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 values of the resource or service (Hanley et al., 1998).

Table 2 shows attributes and corresponding levels for the conjoint analysis. 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). Each profile featured three attributes: *cost* (additional expenditure), *outage duration*, and *policy*, with randomly assigned attribute levels for each choice. Following previous studies (e.g. Abdullah and Mariel, 2010; Carlsson and Martinsson, 2008; Morrison and Nalder, 2009; Ozbafli and Jenkins, 2016), we characterized reliability as the duration of the outage. For the duration of the outage, there were 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.*

For policy attributes, we presented respondents with five different options, which included the *status quo* - doing nothing or no new investment. The four policy proposals that respondents were presented were based on policies to protect the Texas interconnection from the effects of future severe weather that were widely discussed in the media and policy circles in the aftermath of Winter Storm Uri. 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, we chose cost attribute levels based on the average cost of electricity in the state of Texas in 2019. 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.

4.2 Mixed Logit Model

To analyze the data, we follow 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.[3] In each conjoint experiment trial, respondent i makes a 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:

$$U_{ijt} = x_{ijt}\beta_i + \epsilon_{ijt}, \tag{8}$$

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). We apply a mixed logit model, where the coefficient vector β_i in equation (8), called random coefficients, are different across respondents due to unobservable factors, such as tastes and preferences.[4]

The random parameters β_i in the utility function (8) 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 β_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:

$$P_{ijt|\beta_i} = \exp(x_{ijt}\beta_i) \,/\, \sum_{k=1}^{J} \exp(x_{ikt}\beta_i). \tag{9}$$

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 $f(\beta, \theta)$:

$$P_{ijt} = \int P_{ijt|\beta_i} f(\beta, \theta)\, d\beta. \tag{10}$$

Equation (10) 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 (10) is approximated by maximum simulated likelihood where β_i are randomly drawn from the specified distribution.

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

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

5 Willingness to Pay - Baseline Results

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.[5] Note that 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).[6] The significant negative 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.[7] 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 reveal that respondents prefer to have better policies implemented to protect the Texas electric grid over doing nothing (the status quo), if the cost and outage attributes remain unchanged.

Figure 2 presents the relative importance of three attributes, which is calculated by taking the difference between the largest and smallest coefficients for each attribute of 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, we find that 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.

---

[5] In Table A2 in the Appendix we present the estimated results based on a simple mixed logit choice model without random parameter. 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.

[6] 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 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).

[7] 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 up to 12 hours, and 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.

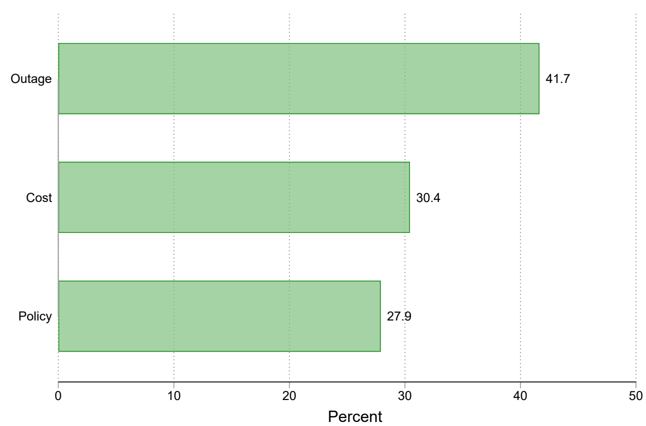


Figure 2: Relative Importance between Outages, Cost and Policy (Baseline model)

One of the advantages of conjoint analysis is that we can quantify how much respondents are willing to pay for different proposed policies based on the estimated coefficients in the mixed logit regressions. According to Equation (8), the marginal willingness to pay (MWTP) for attribute k can be presented as follows:

$$MWTP_k = \frac{\partial U/\partial x_k}{-\partial U/\partial p} = \frac{\beta_k}{-\beta_p}, \tag{11}$$

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 (11) 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.[8] Negative signs for the coefficients in the

[8]The estimated MWTP coefficients are presented in Table A3 in the Applendix.

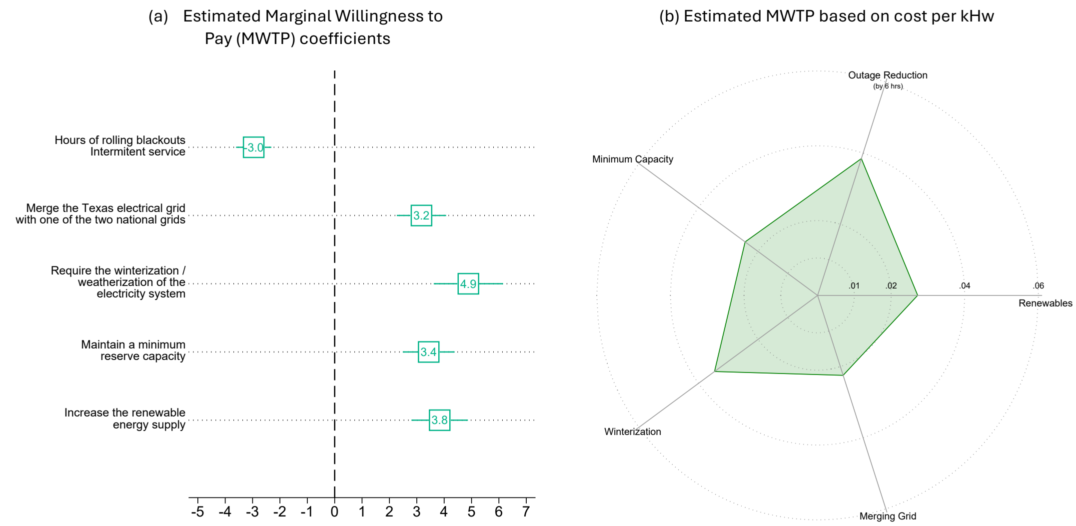


Figure 3: Estimated Marginal Willingness to Pay for Policies

first row of the figures indicate that respondents are willing to pay to *reduce* outage duration. For 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 willingness to pay for each of the four policy proposals in terms of price per kilowatts per hour (kWh).[9] 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 willingness to pay is approximately 3.86 cents per kWh.

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 the grid more resilient and reducing power outages. However, we also argue that varying experiences during the natural disaster are likely to have affected an individual's willingness to pay for the public good of reliable electricity. In the next section, we turn to assessing the role of subjective experience as presented in Section 3.2 and specifically how individuals' differential experiences with power outages affect their WTP for regulatory changes to the Texas electricity grid to lower outages and mitigate the impact of severe weather events on the supply of electricity.

[9] Recall the marginal willingness to pay (equation (11)) 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 6 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, we can compute the monetary value of willingness to pay for a specific proposed policy k *in a year* as $\partial P/\partial x_k = \beta_k(-\beta_p)^{-1} P$. We then compute the monetary value of the willingness to pay 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, we divide the annual additional payment 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.

6 Winter Storm Uri as a Natural Experiment

According to Equation (7) in Section 3.2, given a better-than-average past experience, an individual will trust the public authority to provide a level of the public good that meets the individual's expected standard. By contrast, an individual who had a worse-than-average experience will have a lower valuation of the public authority and thus lower WTP. Here, an individual's past experience is represented by outage length during Winter Storm Uri. 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, we investigate three discrete levels for the empirical analysis: 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.

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 the Uri storm on Texas' electric grid, leading to outages varying by region and time, appears almost random, which we leverage as a natural experiment.

6.1 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. We can see that none of the p-values for the mean equality tests for these 16 covariates is lower than a 5% significance level. suggesting that the assignment to either 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. 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.[10]

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

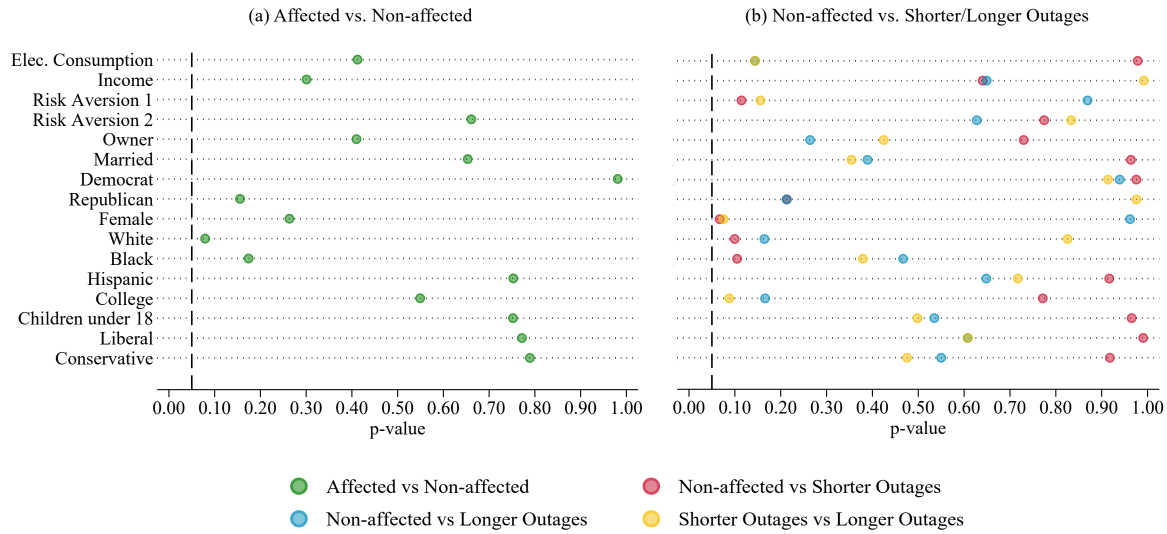


Figure 4: Balance Checks for Demographic Variables Across Household Types

6.2 Marginal Willingness to Pay 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 willingness to pay 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, conducting likelihood ratio (LR) tests to compare the estimates for the different groups, we find 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 willingness to pay for grid protection 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 willingness to pay (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.[11] These calculations follow a similar method outlined in equation (11) in Section 5.

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

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.

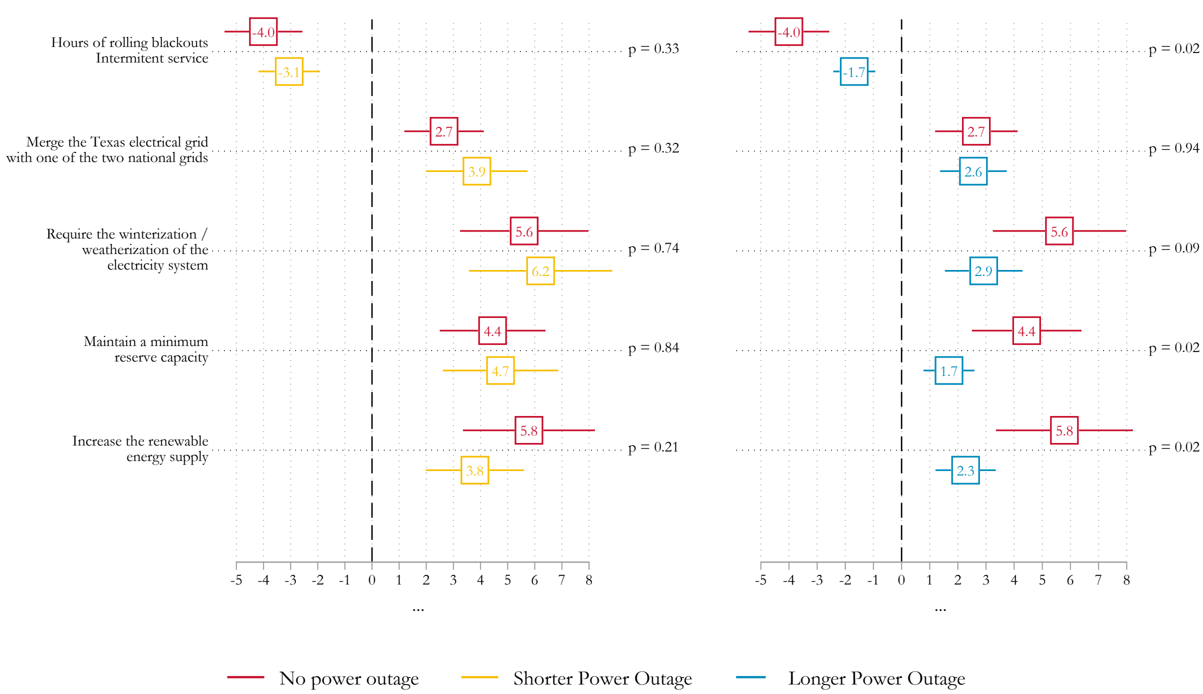


Figure 5: Estimated Marginal Willingness to Pay by Outage Length

In the left panel of Figure 5, we compare 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). We find that the coefficients are not statistically different between the two groups. This suggests that both groups have a similar willingness to pay 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. This 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). We observed 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 this policy. This suggests that more severe outages 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 trust in the effectiveness of such policies among those who suffered more during the storm. However, the willingness to pay 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 willingness to pay 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 5, we have presented 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.[12] 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. We find that households that did not experience power outages consistently demonstrate the highest WTP in all policies. They are willing to pay 5.228 cents more per kWh for 12 hours of rolling blackouts and express strong support for policy interventions, with 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 3, we can understand this lower WTP as likely resulting from reduced trust in the public authority and thus in the effectiveness of the proposed policies. Following their worse-than-average experience, they are more hesitant, showing skepticism about the potential benefits of these policies and a reluctance to invest more in a system that failed them during the storm.

We also perform a battery of robustness checks to ensure that our results are not driven by specific locations or electricity utilities. We first estimate the WTP for different groups of households by

[12] See footnote 9 for the discussion on the MWTP calculation.

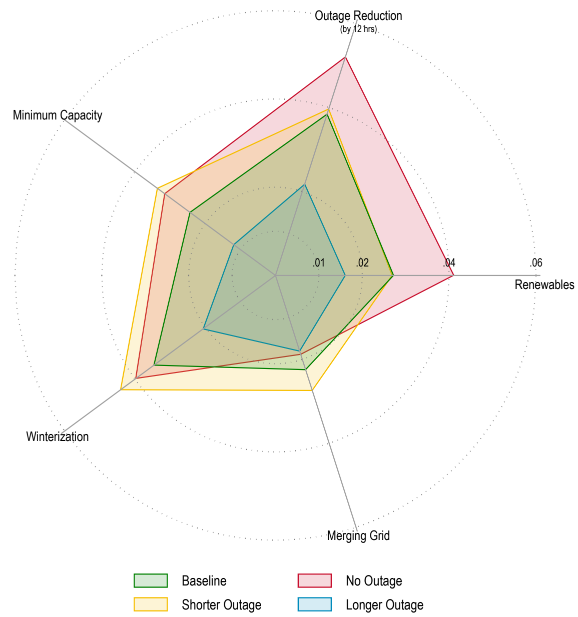


Figure 6: Marginal willingness to pay across policy investment (in dollars per kWh)

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.[13] 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. We find that households that did not experience power outages and those with shorter-than-average outages are willing to pay more for all different policy options than those experiencing longer-than-average power outages. These results are consistent in other subsample estimations where 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. We find that the results remain robust and similar to our 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.

7 Explaining Differences in WTP

In Section 3 we presented a theoretical framework aimed at explaining the relationship between outage experience and individuals' willingness to pay for improvements to the electric system. The

[13]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).

framework is rooted in the public good features of having access to reliable electricity. In the previous section, we found systematic differences in the willingness to pay 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. Those who have experienced longer outages were less willing to pay more for the menu of policy changes presented in the conjoint experiment.

The severe impact of the storm on the Texas grid is likely to highlight the system's vulnerabilities to all Texans, leading to increased demand for policy interventions. 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 and resiliency to shocks. On the other hand, those who experienced long outages are more likely to lose faith in the electricity grid's reliability and be less willing to support policies aimed at improving the system. Additionally, individuals' past experiences could affect their perceptions of the government and the provider's ability to ensure reliable access to electricity.

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 and natural disasters. We find that, consistent with our 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.[14]

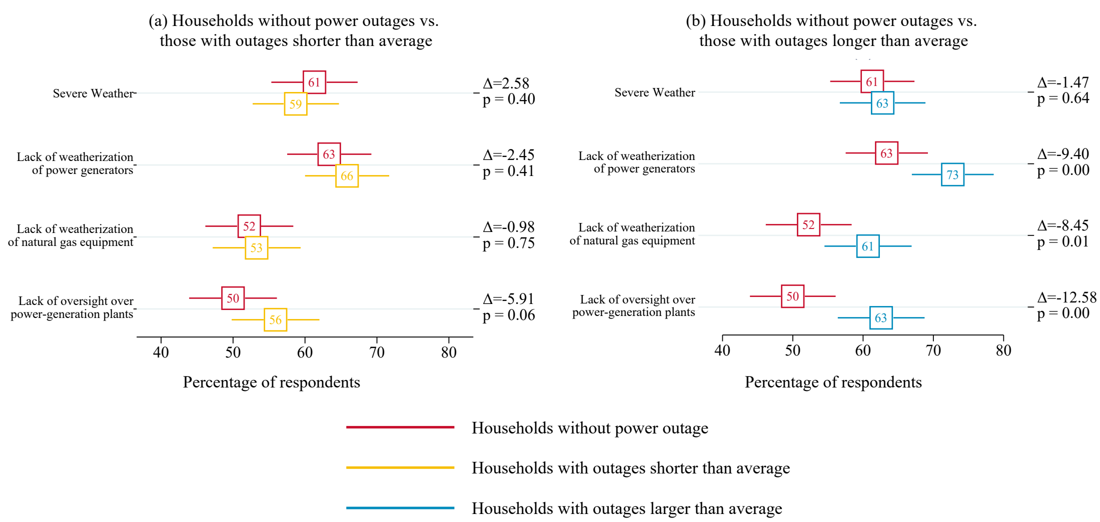


Figure 7: Perceived responsibility of power outages

Figure 7 shows the percentage of respondents who attribute blame for the power outage to *Severe Weather*, the *Lack of Weatherization of Power Generators*, the *Lack of 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. We can see that people who experienced longer

[14]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.*

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.

We also find that respondents across Texas who experienced longer outages would prefer others to pay for the extra costs from the proposed policies to the electric grid, particularly energy producers.[15] 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).

8 Conclusion

The disruptions caused by Winter Storm Uri in Texas provided a unique opportunity to study how individuals' experiences during a natural disaster shape their willingness to pay for more reliable electricity services. We conducted a choice experiment of policy interventions aimed at improving the reliability of electricity services embedded in a representative survey of Texas residents after 2021 Winter Storm Uri. Our baseline results show that people generally prefer lower electricity costs and shorter power outages. While this is not surprising, given that affordability and reliability are top concerns for consumers, respondents are also willing to bear additional costs to support policies that would enhance the grid's ability to withstand extreme weather events. This willingness to invest in grid improvements demonstrates the public's strong preference for a more resilient system capable of withstanding future disruptions and their willingness to share some of the costs of such investments.

Moreover, the 'as-if' random assignment of varying outage lengths across different households and regions allowed us to investigate how past experiences shape individuals' WTP. We find that households that experienced longer power outages during the storm are less willing to pay for grid protection policies compared to those who had shorter outages or no outages at all. We argue that prolonged outages eroded trust (lower valuation) in policymakers' and energy providers' ability to deliver on promises of a more resilient electricity system, thereby making such individuals less willing to support and fund additional investments. Conversely, those with shorter outages exhibited greater WTP, while those unaffected by the storm were most supportive of preventative measures, such as increasing renewable energy supply. Interestingly, those who did not experience any outages are the most willing to pay for policies, such as increasing renewable energy supply.

Our findings offer important policy implications for policymakers in Texas and other areas facing similar challenges with electricity reliability. First and foremost, the results underscore the importance of recognizing past outage experiences on public support for grid improvements. Policymakers should recognize that households who experienced longer outages are more reluctant to support further investments unless they can be convinced that these policies will prevent similar failures in the future. Recognizing that households who experienced longer outages are more likely to be skeptical of proposed solutions, policymakers may need to consider targeted policies and communication strategies to address their concerns, such as through prioritizing investments in areas that were most affected by the storm. In addition, to increase public support for grid investments, policymakers should focus on rebuilding trust through enhanced communication with the public about the specific

[15] 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.*

steps being taken to improve grid reliability and by demonstrating a commitment to addressing past shortcomings and holding energy providers accountable.

References

Abdullah, Sabah, and Petr Mariel. 2010. "Choice experiment study on the willingness to pay to improve electricity services." *Energy Policy*, 38(8): 4570–4581. (Cited on 2, 3, 8)

Adebo, G.M., and O.C. Ajewole. 2012. "Gender and the urban environment: Analysis of willingness to pay for waste management disposal in Ekiti-State, Nigeria." *American International Journal of Contemporary Research*, 2(5): 228–236. (Cited on 2)

Alozie, Nicholas O., and Catherine McNamara. 2010. "Gender differences in willingness to pay for urban public services." *Urban Affairs Review*, 45(3): 377–390. (Cited on 2)

Amador, Francisco Javier, Rosa Marina González, and Francisco Javier Ramos-Real. 2013. "Supplier choice and WTP for electricity attributes in an emerging market: The role of perceived past experience, environmental concern and energy saving behavior." *Energy Economics*, 40: 953–966. (Cited on 2, 3, 7)

Baik, Sunhee, Alexander L Davis, Jun Woo Park, Selin Sirinterlikci, and M Granger Morgan. 2020. "Estimating what US residential customers are willing to pay for resilience to large electricity outages of long duration." *Nature Energy*, 5(3): 250–258. (Cited on 2, 3)

Baumgärtner, Stefan, Moritz A Drupp, Jasper N Meya, Jan M Munz, and Martin F Quaas. 2017. "Income inequality and willingness to pay for environmental public goods." *Journal of Environmental Economics and Management*, 85: 35–61. (Cited on 2)

Bolduc, Moshe Ben-AkiWand Denis, and Denis Ben-AkiWand. 1996. "Multinomial probit with a logit kernel and a general parametric specification of the covariatice structure." *Massachusetts Institute of Technology: Cambridge Mass.* (Cited on 9)

Brainard, William C., and Jr. Dolbear, F. Trenery. 1967. "The possibility of oversupply of local public goods." *Journal of Political Economy*, 75: 86–92. (Cited on 1, 4)

Cai, Yongxin, Iraj Deilami, and Kenneth Train. 1998. "Customer retention in a competitive power market: Analysis of a 'double-bounded plus follow-ups' questionnaire." *The Energy Journal*, 56(2): 191–215. (Cited on 7)

Carlsson, Fredrik, and Peter Martinsson. 2008. "Does it matter when a power outage occurs?—A choice experiment study on the willingness to pay to avoid power outages." *Energy economics*, 30(3): 1232–1245. (Cited on 2, 8)

Cohen, Jed, Klaus Moeltner, Johannes Reichl, and Michael Schmidthaler. 2018. "Effect of global warming on willingness to pay for uninterrupted electricity supply in European nations." *Nature Energy*, 3(1): 37–45. (Cited on 2, 3)

Flores, Nicholas E., and Richard T. Carson. 1997. "The relationship between the income elasticities of demand and willingness to pay." *Journal of Environmental Economics and Management*, 33(3): 287–295. (Cited on 2)

Goett, Andrew A. 1998. "Estimating customer preference for new pricing products. Final Report (EPRI-TR–111483), Palo Alto." *Electric Power Research Institute*. (Cited on 7)

Goett, Andrew A., Kathleen Hudson, and Kenneth E. Train. 2000. "Customers' choice among retail energy suppliers: The willingness-to-pay for service attributes." *The Energy Journal*, 21(4). (Cited on 2)

Greene, W.H. 2011. "Econometric analysis ([7. sup. th] edition)." (Cited on 9)

Hanley, Nick, Douglas MacMillan, Robert E. Wright, Craig Bullock, Ian Simpson, Dave Parsisson, and Bob Crabtree. 1998. "Contingent Valuation Versus Choice Experiments: Estimating the Benefits of Environmentally Sensitive Areas in Scotland." *Journal of Agricultural Economics*, 49(1): 1–15. (Cited on 7)

Hensher, David A, Nina Shore, and Kenneth Train. 2014. "Willingness to pay for residential electricity supply quality and reliability." *Applied energy*, 115: 280–292. (Cited on 2)

Horowitz, John K, and Kenneth E McConnell. 2003. "Willingness to accept, willingness to pay and the income effect." *Journal of economic behavior & organization*, 51(4): 537–545. (Cited on 2)

Huang, Chung L. 1993. "Simultaneous-equation model for estimating consumer risk perceptions, attitudes, and willingness-to-pay for residue-free produce." *Journal of Consumer Affairs*, 27(2): 377–396. (Cited on 2)

Kim, Hyo-Jin, Sung-Min Kim, and Seung-Hoon Yoo. 2019. "Economic Value of Improving Natural Gas Supply Reliability for Residential Consumers in South Korea." *Sustainability*, 11(2): 515. (Cited on 2)

López-Mosquera, Natalia. 2016. "Gender differences, theory of planned behavior and willingness to pay." *Journal of Environmental Psychology*, 45: 165–175. (Cited on 2)

Louviere, Jordan J., David A. Hensher, and Joffre D. Swait. 2000. *Stated Choice Methods: Analysis and Applications.* Cambridge University Press. (Cited on 7)

McFadden, Daniel. 1973. "Conditional logit analysis of qualitative choice behavior." *Frontiers in Econometrics*, 105–142. (Cited on 9)

McFadden, Daniel, and Kenneth Train. 2000. "Mixed MNL models for discrete response." *Journal of Applied Econometrics*, 15(5): 447–470. (Cited on 9)

Mehndiratta, Shomik Raj. 1996. *Time-of-day effects in inter-city business travel.* University of California, Berkeley. (Cited on 9)

Morrison, Mark, and Craig Nalder. 2009. "Willingness to pay for improved quality of electricity supply across business type and location." *The Energy Journal*, 30(2): 117–133. (Cited on 8)

Oh, Hyungna, and Jong Ho Hong. 2012. "Citizens' trust in government and their willingness-to-pay." *Economics Letters*, 115(3): 345–347. (Cited on 4, 5)

Olli, Eero, Gunnar Grendstad, and Dag Wollebaek. 2001. "Correlates of environmental behaviors: Bringing back social context." *Environment and behavior*, 33(2): 181–208. (Cited on 2)

Ozbafli, Aygul, and Glenn P. Jenkins. 2016. "Estimating the willingness to pay for reliable electricity supply: A choice experiment study." *Energy Economics*, 56: 443–452. (Cited on 2, 3, 7, 8)

Pigou, Arthur C. 1947. *A Study in Public Finance.* Macmillan, London. (Cited on 1, 4)

Revelt, David, and Kenneth Train. 1998. "Mixed logit with repeated choices: Households' choices of appliance efficiency level." *Review of economics and statistics*, 80(4): 647–657. (Cited on 7, 9)

Stiglitz, Joseph E., and Jay K. Rosengard. 2015. *Economics of the Public Sector (the fourth edition).* W. W. Norton & Company. (Cited on 1, 4)

Taale, Francis, and Christian Kyeremeh. 2016. "Households' willingness to pay for reliable electricity services in Ghana." *Renewable and Sustainable Energy Reviews*, 62: 280–288. (Cited on 2, 3)

Tianyu, Jin, and Li Meng. 2020. "Does education increase pro-environmental willingness to pay? Evidence from Chinese household survey." *Journal of Cleaner Production*, 275: 122713. (Cited on 2)

Train, Kenneth E. 2009. *Discrete choice methods with simulation.* Cambridge University Press. (Cited on 9)

Williams, Alan. 1966. "The optimal provision of public goods in a system of local governments." *Journal of Political Economy*, 74: 18–33. (Cited on 1, 4)

Wolters, Erika Allen. 2014. "Attitude–behavior consistency in household water consumption." *The Social Science Journal*, 51(3): 455–463. (Cited on 2)

Xu, Zhihua, and Jingzhu Shan. 2018. "The effect of risk perception on willingness to pay for reductions in the health risks posed by particulate matter 2.5: A case study of Beijing, China." *Energy & Environment*, 29(8): 1319–1337. (Cited on 2)

Zorić, Jelena, and Nevenka Hrovatin. 2012. "Household willingness to pay for green electricity in Slovenia." *Energy policy*, 47: 180–187. (Cited on 2)

List of Tables

List of Figures

9 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

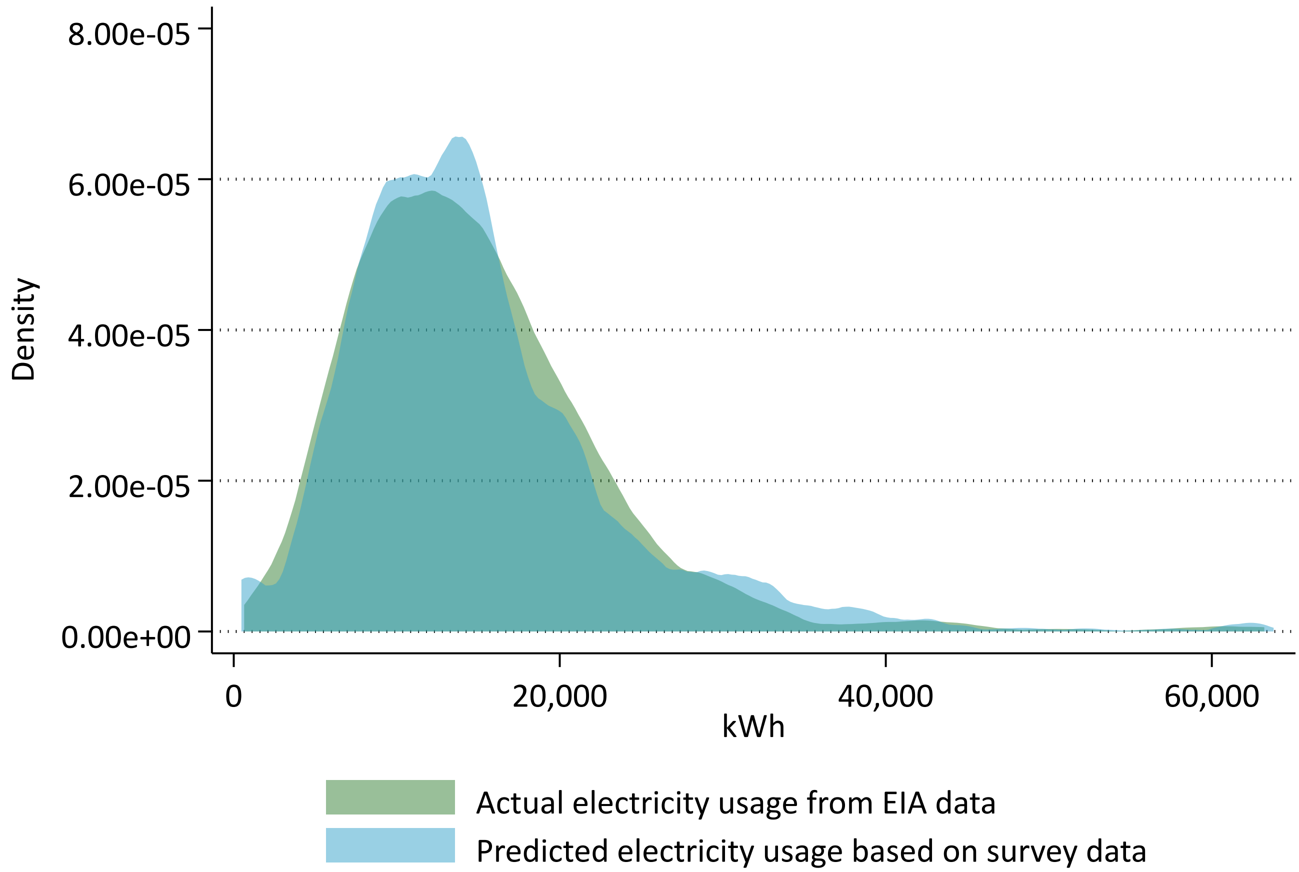
A number of policies have been proposed to protect the state of Texas from the effects of severe weather affecting its energy supply and delivery. Each proposal will need to be paid for in order to guarantee power outages are kept to the stated levels. In 2019, Texans spent an average of $103 per month 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)

O Policy A

O 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