Preferences for Alternative Water Supplies in the Pacific Northwest: A Choice Experiment

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Authorization to Submit

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Abstract

Understanding residential water preferences allows utility and municipal water managers to improve residents' welfare through informed pricing and investment decisions. This paper employs a choice experiment (CE) to elicit residents' stated preferences for water sources, storage methods, and conservation policies across the inland Pacific Northwest. Generally, results suggest that–conditional on needing an additional municipal water supply–individuals have a strong aversion to creek-water, and are relatively indifferent to reclaimed wastewater or additional diversions from large rivers. Residents also have a strong preference for additional local water storage, either in the form of aquifer injection or reservoirs. CE results also suggest strong heterogeneity in preferences correlated with gender, current water supplier (municipal or personal well), and where respondents grew up. In particular, males are significantly more price-driven than females, and well-owners have a strong preference for municipal water reclamation.

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Chapter 1

Introduction

Water utility managers across the United States are facing a confluence of obstacles, ranging from insufficient supplies, to flooding, to obsolete infrastructure (Marlow et al., 2013). The American Water Works Association (AWWA) anticipates the need for an additional $1.4 trillion in water infrastructure investments to maintain current levels of service (AWWA, 2012). Simultaneously, sea-level rise, climate change, and land sidence are increasing flood exposure for coastal cities across the United States (Hallegatte et al., 2013). Demographic trends also pose problems; shrinking cities like Detroit and Flint require the continued funding of large infrastructure, but have smaller and smaller customer bases to cover those costs. In other locations, population growth and changing climatic conditions are reducing water security for entire cities, although significant reductions in household water consumption have thus far been a successful solution to decreased supplies (Gaur & Mohanty, 2019; Gober, 2019)

In the face of these many difficulties, utility managers are often forced to do more with less. Most utilities are required by law to be non-profit or are quasi-government entities (Goldstein, 1986). As such, residential water suppliers rarely set prices directly; rates are instead set by local representatives (Goldstein, 1986) or negotiated with the state, where stantial rate increases are considered politically infeasible. These pricing limitations and inability to increase their customer base–utilities are geographically constrained to their service area–leave water managers with limited options to increase revenues for maintenance and future investments. Moreover, the quasi-public distinction of many water utilities complicates the issue further, since managers are often required to make decisions that go beyond the financial scope of utility operations. For example, water utilities often have greenhouse gas (GHG) reduction plans, despite limited regulatory requirements to do so (40 CFR Part 98; WRF 2013). Even limiting decisions to utility-specific considerations, managers often face competing objectives such as total cost recovery, conservation, provisions of ecosystem services, social equity, and providing services to customers with heterogeneous preferences and motivations (Montginoul, 2007; Maas, Goemans, Manning, et al., 2017). Despite these limitations, understanding customer preferences can provide additional opportunities to generate revenue and guide investment.

Municipal water customers have specific preferences for the attributes of their water supply system (e.g. quality, water source, etc.), suggesting consumer welfare depends on the municipal water attributes piped to and from their home. Thus, utility managers and policy makers make choices that affect the social welfare of their costumers and broader constituents, potentially with limited understanding of the public's water preferences. In part, this lack of information is due to the inherent market-structure underlying municipal water. In competitive markets, consumers' preferences can be observed through purchasing decisions. The value of particular attributes in any good can be directly observed based on customers' willingness to pay for a good with or without that attribute. Thus, researchers and policy makers can observe consumer choices in a market with many heterogeneous goods and derive values associated with attributes of each good. For example, foods labelled as USDA organic or locally grown reveal a price premium of 7-10% compared to their conventional counterpart (Loureiro et al., 2002). These observations can then be used to make future business decisions. The same process cannot be used to derive preferences for residential water, since no such markets exist.

Municipal water markets require expensive infrastructure and generally have significant institutional constraints that prevent new water suppliers from reasonably entering the market (Grigg, 2005). At the same time, adding additional customers to existing systems can be accomplished with relatively low variable costs, which are usually recuperated by the utility in the form of tap fees. The resulting natural monopolies limit individuals' choices when selecting their water or electricity supplier.[1] Thus, water within a service area is largely homogeneous and consumer behavior provides little insight into the underlying preferences of customers. In the absence of observable purchasing behavior, stated preference methods are often used to derive demand for particular goods and their underlying attributes, which allows utility managers to increase market efficiency, better control revenues, increase customer satisfaction, and make better-informed water investment decisions. The research presented herein was conducted for these purposes and to guide future investment decisions based on residents' preferences for additional water supplies in the inland Pacific Northwest (iPNW).

The Palouse Region of the iPNW is largely rural, with a population of just over 60 thousand. The Palouse is known for its dryland agricultural, picturesque vistas, and as home to both Washington State University and the University of Idaho, as well as several mid-sized towns. Population growth and limited aquifer recharge have depleted the local aquifers, with few alternatives for additional water supplies. As such, this study was conducted in conjunction with the Palouse Basin Aquifer Committee, and the towns of Pullman, WA and Moscow, ID to elicit residents' preferences for additional water sources, storage methods, and conservation strategies to guide future investment decisions. Thus, our work contributes to the literature by investigating consumer preferences for additional local water supplies in the iPNW via a choice experiment (CE). The analysis provides a rank order of proposed projects in the region and estimates the willingness to pay for specific water service attributes. These attributes include water source, conservation policies, and storage methods. Next,

[1]Notably, the decoupling of electricity generation from distribution has begun to provide observed data in consumer preferences with the goal of better aligning services to customers' energy needs (?, ?; Sangroya & Nayak, 2017; S. MacDonald & Eyre, 2018). In a 2016 review, the National Renewable Energy Lab (NREL) found an average price premium of 1.8 cents/kWh in markets where green electricity was available.

we investigate how these preferences are correlated with individuals' characteristics (age, gender, current water provider, etc.).

Knowledge of consumers' preferences for water service is limited to several aspects of supply, generally related to reliability, end-use quality, water use restrictions, and land-use changes (Brox et al., 2003; Hensher et al., 2005; D. H. MacDonald et al., 2010; Stone et al., 2018; Cooper et al., 2019). Although consumer preferences for specific storage method and water source have rarely been estimated, evidence suggests individuals are willing to pay for reliability and additional supplies even if the water is not being used (Powe et al., 2004; Tentes & Damigos, 2014). Moreover, there have be conflicting results on public acceptance of water reuse to supplement supplies (Garcia-Cuerva et al., 2016). However, water-customers are generally amenable to small-scale water recycling for outdoor use and other gray water systems compared to building additional large-scale dams (Blamey et al., 1999). While some work exists in this area, preferences for water characteristics are often temporally and geographically heterogeneous (Brouwer et al., 2010; Martin-Ortega et al., 2012), which limits the applicability of past research to new problems. This paper adds to the limited literature by investigating consumer preferences for additional water supplies by source-type (groundwater, large river, creek, or wastewater reclamation), storage method (no storage, aquifer injection, or a reservoir), and municipal conservation policies (rebates vs. restrictions) in a previously unstudied region of the United States (the iPNW).

Chapter 2

Methods

Because municipal water markets lack the observable purchasing transactions required to identify preferences for specific attributes (a free market with heterogeneous goods), stated preference methods are necessary to estimate consumersâ demand for particular characteristics of their water supply. This study uses a Choice Experiment (CE), where individuals choose their preferred option from two hypothetical additional water supply alternatives. These choices are used to estimate the utility and willingness to pay for each attribute of the hypothetical water supply options. CE's are often the preferred method for demand estimation and cost-benefit analysis when markets are imperfect or non-existent (Holmes et al., 2017).

CE's have an strong track-record in non-market economics and have been used to study environmental quality (Hanley et al., 2001), health care preferences (de Bekker-Grob et al., 2012), and recreation opportunities (Hanley et al., 2002). CE's are preferred to other stated preference methods when addressing decisions with complex trade offs (Hanley et al., 2001). While the CE methods used herein are well-established, the attributes and respondent information collected allows for novel analysis of factors driving heterogeneity in preferences and specific willingness to pay estimates for an unstudied region.

CE's owe much of their popularity to a consistent theoretical base rooted in Random Utility Theory (McFadden et al., 1973; Louviere et al., 2010), and because they are well-suited for multidimensional analysis, where trade-offs between choices are salient (Hanley et al., 2001). In CE's, individuals are assumed to choose the option that provides the highest utility, where an individualâs utility for a particular option can be written as a function of the attributes comprising that choice and the individuals' characteristics (Equation 1).

$$U_{ij} = V_{ij}(\beta, X_{ij}) + \varepsilon_{ij} \tag{1}$$

Where U_{ij} represents the utility of individual i selecting choice j, X_{ij} is a vector of the characteristics that make up alternative j. β is a vector coefficients to be estimated. ε_{ij} is a random error term. The choice characteristics, V_{ij} (where individual i chooses j), is a function of the alternative attributes X_{ij}. Individual i chooses alternative 1 ($j = 1$) from J number of alternatives, if and only if, their utility of choosing i (U_{i1}) is higher than or equal to the utility they would get from choosing any other option among J alternatives. (Lancsar & Louviere, 2008; Hauber et al., 2016) Thus, the probability of individual i choosing 1 can be written as:

$$P_{i1} = P(U_{i1} > U_{ij}) \tag{2a}$$

$$= P(V_{i1} + \varepsilon_{i1} > V_{ij} + \varepsilon_{ij}) \tag{2b}$$

$$= P(V_{i1} - V_{ij} > \varepsilon_{ij} - \varepsilon_{i1}) \forall j \neq 1 \tag{2c}$$

To estimate the coefficients of interest, different assumptions can be made about the random term ε_{ij}, which necessitate particular CE model choices. The conditional Logit, a commonly used model, assumes ε_{ij} has an extreme value distribution and homogeneous preferences between individuals, which may be a significant limitation in analyses across diverse populations. The mixed logit model has gained in popularity because it addresses this issue by allowing the estimated coefficients, β, to vary by individual (Hauber et al., 2016), where coefficients are assumed to follow a density function $f(\beta \mid \theta)$ (Equation 3a). Thus, mixed logit models estimate a different coefficient vector β for each individual. In practice (and by experimental design), individuals may make several decisions, mixed models also allow individuals' choices to be grouped such that the probability of their available choices are calculated together (Equation 3b), where S is the probability of the individualâs choices(Train, 2009):

$$P_{i1} = \int \frac{e^{V(\beta,X_i)}}{\sum_j e^{V(\beta,X_i)}} f(\beta \mid \theta) \tag{3a}$$

$$S = \prod_{t=1}^{T} \prod_{j=1}^{J} \int [\frac{e^{V(\beta,X_i)}}{\sum_j e^{V(\beta,X_i)}}]^{Y_{jt}} f(\beta \mid \theta) d\beta \tag{3b}$$

The mixed logit presented in Equation 3 relaxes certain assumption but imposes others; it implies that: (1) each individual has a homogeneous preference across their choice set, (2) choices are independent of alternatives omitted from each choice set, and (3) current choices are unaffected by previous choices (Tentes & Damigos, 2014). Given the context of our analysis, each of these assumptions appears reasonable.

Equation 3 is estimated directly, and the estimated coefficients are then used to calculate the approximate willingness to pay (WTP) (Equation 4), where WTP_n is the price individuals are willing to pay for each attribute of the water supply system (Hole, 2007):

$$WTP_n = \frac{\beta_n}{\beta_{cost}} \tag{4}$$

2.1 The Study Region

The choice experiment was conducted in the Palouse region of the United States' inland Pacific Northwest (iPNW). Respondents were largely from two counties, Whitman County in Washington state, and Latah County in Idaho state (Figure 1), where surveys were conducted in-person via tablet. These two counties share two aquifers that have been declining since the 1800s (PBAC, 2017) with significant uncertainty around their connectivity and recharge (Douglas et al., 2007). The phenomenon of over-extracting a common pool resource is well-documented and can be be exacerbated under uncertainty (Madani & Dinar, 2012; Maas, Goemans, Mannng, et al., 2017). However, the context of our study is unique insofar as a cooperative, multi-jurisdictional, local committee was created via inter-agency (Idaho Department of Water Resources and Washington Department of Ecology) to monitor and address the situation locally.

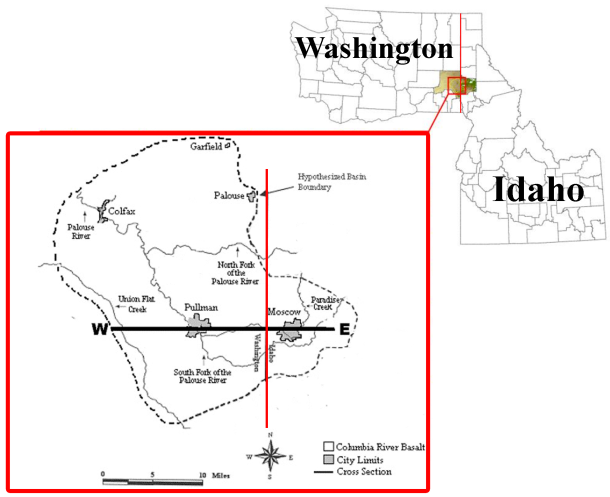

Figure 2.1: Study Region (Douglas et al., 2007; Beall et al., 2011)

In 1967, Washington and Idaho created a unique interstate local committee, the Palouse Basin Aquifer Committee (PBAC), to find a long-term, sustainable solution to the declining aquifer (PBAC, 2018). PBAC is made up of representatives from major water users in the region (although smaller towns in the area also withdraw from the aquifer), which include the University of Idaho, Washington State University, and local elected representatives and practitioners from the cities of Pullman and Moscow.

The committee implemented a groundwater management plan in 1992, to maintain a sustainable aquifer and begin identifying alternative water sources. While management under the committeeâs supervision has been successful in decreasing the rate of aquifer decline, from 1.5ft/year to 0.9ft/year (PBAC, 2017), through a combination of conservation and technical pumping solutions, a steady-state has not been obtained. This continued decline and annual population growth between 1-2%

have increased pressure to find suitable water source alternatives. With the current population growth rate and consumption trends, consumersâ demand is expected to increase by more than 20% by 2065 (PBAC, 2017).

To address this impending shortage, PBAC commissioned a report to identify technically and legally feasible sources for alternative supplies. Several solutions were identified as alternative water sources, including small creeks, large rivers, and increased reuse/reclamation (table 1). Each proposed solution varies not only by the source of water, but also in cost, annual energy requirements, conservation requirements, and environmental impact (PBAC, 2017). Thus, the goal of our research is to quantify the preferences of residents for diverse water supply attributes in order to aid decision-makers in choosing the welfare-maximizing project.

Table 2.1: Alternative Water Projects

Project	Water source	Storage	Total cost ($M)	Costs ($\frac{\$}{Month.Household}$)
1	Large river	No storage	$74.00	$102.78
2	Small river	Aquifer injection	$57.40	$79.72
3	Small river	Surface storage	$81.40	$113.06
4	Wastewater and Small river	Aquifer injection	$70.00	$97.22

2.2 Survey Design

The survey was constructed using Qualtrics software and included three sections: 1) demographic information, 2) the choice experiment, and 3) water use perception. The data collected in these sections are used to test and measure preference heterogeneity across demographics, quantify preferences for water supply attributes, and gauge individuals' awareness of their own water use, respectively.

Section 1 elicits personal characteristics that may influence preferences, such as age, childhood location, housing status, and current water supplier (a full list of demographic questions is included in Supplemental Material). Basic demographic characteristics (age, income, and gender) are typically correlated with particular water supply and environmental preferences (Tucker et al., 2014; Zuo et al., 2015; Breffle et al., 2015; Karytsas et al., 2019; Rice et al., 2020). Age and location of childhood–defined as the US region where respondents self-identified as having grown–are collected to account for preference differences across generations and life experiences with water. Housing status is used to differentiate between individuals who rent and own their homes, which has implications for one's willingness to attain a long-term sustainable solution, since water supplies may be capitalized in home and land values (Torell et al., 1990). Similarly, water supplier information is collected to study the effects of owning a personal well on individuals' willingness to pay for alternative supplies, since individuals with personal wells may be able to free-rider, benefiting from increased aquifer levels, while municipalities (and government agencies) largely cover the cost of the proposed project. The collected demographic information is also used to verify that our sample is representative of the region.

The second section presents the choice experiment, which asked individuals to pick a preferred option between two alternatives. Each individual was asked to make this choice seven times, across randomly generated options (Option A or Option B) comprised of predetermined levels for each of four attributes: 1) increase to monthly bill, 2) water source, 3) conservation method, and 4) water storage method. Monthly bill was used to elicit monetary values because it provides a salient price signal and method of payment. In each choice experiment, attributes were selected based on existing literature, feasible projects, and in collaboration with local government representatives and PBAC. Specific levels included in each attribute are presented in Table 2, while Figure 2 illustrates a sample screen on which participants make their choice.

Table 2.2: Attributes Levels

Increase to bill	Water Source	Conservation Method	Storage method
$0	Large river	Appliance rebates	Reservoir
$5	Ground water	Watering restrictions	Aquifer Injection
$10	Small river	Grass removal rebates	No Additional Storage
$20	Treated wastewater	Grass area restrictions	
$30			

	Water Supply Option 1	Water Supply Option 2
Increase to your monthly water bill	$30	$10
Freshwater source	Treated Wastewater Reuse	Treated Wastewater Reuse
Municipal Water Conservation Method for Households	Create Rebates or Payments to customers that Upgrade Inefficient Appliances	Create Rebates or Payments to customers who remove grass
Water storage method	No Additional Storage	No Additional Storage
	○	○

Figure 2.2: Survey Example

Surveys were conducted primarily in-person, via tablet, at both public and private establishments, such as grocery stores, county fairs, farmer's markets, a bowling alley, and shopping centers. 99 surveys, or 24%, of the surveys were administered via a Qualtrics panel to include all individuals older than 18 living in the zipcodes associated with the Palouse. A breakdown of respondents by location is presented in Figure 3. Responses were collected between June-October 2019. The date and times for survey canvasing were randomly generated from the available working hours of each establishment, in an attempt to create a representative sample, although disproportionately high participation occurred at county fairs and farmers markets.

Chapter 3

Results

3.1 Sample Characteristics

Our sample includes 412 respondents, where each individual chose option A or B seven times for a total of 2884 discrete choices. The majority of in-person-responses were collected at county fairs, farmers markets and grocery stores (Figure 3).

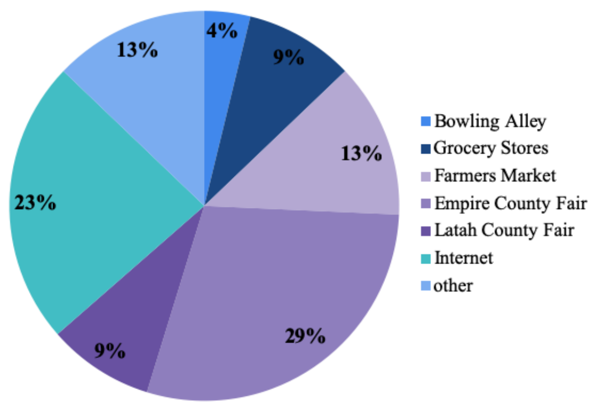

Figure 3.1: Location Response Pie Chart

Table 3 summarizes the demographics information of our sample, which generally aligns with the population, although older age groups and males are over-represented.[1] The large percentage of respondents who grew up outside the Northwest is likely due to the presence of large universities in the area. 23% of respondents owned a personal well, 68% reported municipal supplies, and 9% were uncertain.

[1]US Census information estimates 8% of the population to be between ages 18-24 and 12% of the population to be 65+. Similarly, females are over-represented by 7% while males are underrepresented by the same amount.

Table 3.1: Survey Demographics

Age	% of Sample	% of Pop. (Census)	Gender	% of Sample
18-24	13%	21%	Male	37%
25-34	16%	14%	Female	57%
35-44	16%	21%	Other	6%
45-54	19%	21%		
55-65	16%	10%		
65+	20%	12%		

Growing up location	% of Sample	Water Provider	% of Sample
Northwest	55%	Municipal water	68%
Southwest	10%	Personal Well	23%
Northeast	9%	Uncertain	9%
Southeast	6%		
Midwest	13%		
Outside the US	7%		

3.2 Survey Responses

Most respondents, 78%, had at least some knowledge of the declining aquifer and the need for additional water supplies. Less than 14% of individuals believed they consume more water than their neighbors, while the remaining respondents believed they used about same amount (43.6%) or less (42.6%). Respondents also strongly agreed that municipal leaders should invest in implementing a solution for the expected future shortages now (84.6% agreed with that statement). Additionally, respondents think it is important for any new water project to consider wildlife habitat and low annual energy requirements. When asked about other co-benefits (flood mitigation, educational opportunities, and recreational opportunities), respondents still had positive importance ratings, but these attributes scored slightly below energy and habitat considerations. Likert scale results from this series of questions are reported in Figure 4.

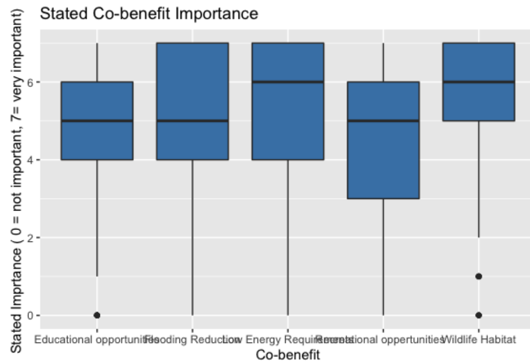

Figure 3.2: Co-benefits Importance

3.3 Choice Experiment

Regression results from Equation 3 are presented in Supplemental Material while results transformed into WTP space are presented below. Thus, estimates presented in Table 4 should be interpreted as the average respondent's willingness to pay for a specific water supply attribute compared to the baseline (omitted levels). Baseline levels were selected consistent with current conditions and include: groundwater as the water source, grass rebates for conservation method, and no additional storage for storage method.

Overall, residents appear indifferent between additional groundwater supplies and large river withdrawals, but they are strongly opposed to small river or creek diversion, where small creek supplies reduce willingness to pay by $6.79 per month. Notably, when the model is conditioned on respondents with personal wells (as opposed to publicly supplied water), there is a strong price premium on using reclaimed wastewater to meet additional supply needs ($15.12).

Preferences for conservation method are inline with expectations, where rebates enjoy an increased willingness to pay, while restrictions mark a significant decrease. Residents are indifferent between cash-for-grass programs and appliance rebate programs, and are considerably less supportive of grass area restrictions (WTP: $-12.69) compared to daily or timed use restrictions (WTP: $-5.77).

As suggested from the closed-form questions, residents are keen to increase the sustainability and reliability of regional water supplies. Results suggest respondents would be willing to pay an additional $14 per month to have new storage capacity in the basin, although they appear largely indifferent to the type of storage.

To examine heterogeneity in water preferences, the sample is divided into subgroups based on the respondent characteristics. The sample was first split based on home status: renters and homeowners. Surprisingly, the willingness to pay for different attributes was similar across these groups, even though homeowners have the ability to capitalize the benefits of additional amenities in their home values.[2]. When the sample is divided by gender, we find that both groups are price responsive (negative coefficient on price), but females are willing to pay significantly more to avoid grass and watering restrictions (p=.001), and have stronger preferences for aquifer injection as an additional storage option (p=.045). The sample was also split by age (>45 or <45, where older respondents have higher willingness to pay for most attributes. While incomes were not collected, this finding may be a result of the comparative wealth of respondents in each age category. Lastly, the sample was split by personal-well ownership. Individuals with personal wells would require significant compensation to restrict grass area or watering ($27.39 and $16.74 respectively). These same respondents have a significant preference for municipalities to reuse wastewater for an additional supply option ($15.12) compared to municipal water users (p=.002). Respondents were also divided by the region of the country in

[2]Confidence intervals for WTP estimates were calculated via individual-clustered bootstrapping

Table 3.2: WTP by Demographic Group

	Full Sample	Males	Females	Age<45	Age >45	Utilities	Well	Own	Rent
Large River	1.09	1.86	0.23	-2.27	5.21	0.56	7.2	2.06	2.7
Small River/Creek	-6.79**	-9.75*	-5.46	-3.66	-11.65***	-9.16**	10.63	-7.80**	-5.02
Wastewater	-1.30	-1.35	-1.01	-1.26	0.29	-1.74	15.12**	-3.22	0.57
Groundwater	-	-	-	-	-	-	-	-	-
Appliance Rebate	1.73	3.24	0.85	1.07	3.39	3.33	1.04	3.73	0.41
Grass Restriction	-12.69***	-6.48	-15.86***	-10.95***	-16.02***	-12.98***	-27.39**	-12.66***	-13.73***
Watering Restriction	-5.77**	-2.17	-9.03***	-4.43	-7.59*	-6.67**	-16.74**	-7.37**	-3.95
Grass Rebate	-	-	-	-	-	-	-	-	-
Aquifer Injection	12.79***	8.03*	15.60***	9.78***	16.67***	14.55***	11.79*	9.77***	15.92***
Reservoir	14.25***	9.39**	18.23***	10.31***	20.50***	15.15***	16.28**	16.19***	12.77***
No Storage	-	-	-	-	-	-	-	-	-
Observations	5768	2156	3262	2800	2954	4102	448	3402	2044

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

which they grew up (Table 5), since water laws and issues vary. Generally, respondents from the Southwest appear to have significantly different preferences for water across both source and storage method. This geographic heterogeneity is not surprising, since water scarcity and storage is a larger concern in the arid Southwest and diversions from large rivers to reservoirs are commonly used for municipal supplies.

Table 3.3: WTP by Growing Up Locations

	Northwest	Southwest	Northeast	Midwest
Large river	-1.52	13.21***	-1.90	-0.11
Small River/Creek	-7.32**	6.89	-16.56**	-16.30*
Wastewater	-4.19	13.62**	-7.33	14.43
Groundwater	-	-	-	-
Appliance Rebate	-4.12	-7.40	-2.36	-1.82
Grass Restriction	-13.25***	-9.13*	-19.37*	-13.79
Watering Restriction	-4.87*	-9.86*	-10.32	-8.47
Grass Rebate	-	-	-	-
Aquifer Injection	15.38***	0.40	14.54*	23.43**
Reservoir	14.65***	6.09	15.91**	25.32**
No Storage	-	-	-	-
Observations	3,864	588	518	756

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Chapter 4

Discussion and Conclusion

Understanding customer preferences for water supply attributes and co-benefits is critical in guiding policy and investment for municipal water utilities, which are tasked with balancing the competing objectives of conservation, social welfare, and cost-recovery. Our results suggest a strong public aversion to using small rivers or creeks for additional supplies. While we do not identify the underlying motivations behind these preferences, we posit that diverting water from small rivers may be undesirable due to perceptions around water quality, effects on habitat, or supply uncertainty (Crabill et al., 1999; Jaynes et al., 1999; Cambardella et al., 1999).

Consistent with other work, our results suggest a strong aversion to grass and watering restrictions (Hensher et al., 2006) and a relatively large willingness to pay (>$10 per month) for storage infrastructure (del Saz-Salazar et al., 2016). Contrary to previous findings (Ormerod & Scott, 2013), our results also suggest respondents are indifferent between large river diversions and reclaimed water, with the exception of well-owners, who strongly prefer reclaimed water. The survey did not differentiate the end-use of reclaimed water, but other work suggests customers' support may decrease if reclaimed water were to be used as potable water (Blamey et al., 1999).

Our results also highlight heterogeneous preferences among residents for additional supply and conservation strategies, such that policy-makers should carefully balance the will of their constituents. Notably, men appear less price responsive and largely indifferent among water supply and conservation efforts. To the extent that men remain indifferent across choices, this result may be explained through a combination or risk tolerance differences, status quo bias, and the well-documented phenomenon of women prioritizing environmental considerations (Torgler et al., 2008;

López-Mosquera, 2016; Schubert et al., 1999).

While these results are useful in guiding regional decisions, there are a number of limitations worth acknowledging. First, while the location and times were quasi-randomly selected, total responses obtained at each location varied widely and were voluntary, raising concerns over sampling bias. This led to disproportionate responses from attendees of both county fairs and farmers market compared to the other locations. Additionally, the heterogeneity of preferences identified herein suggests researchers should be wary of using our results in benefit-transfer methods. The external validity of geographically-specific choice experiments–particularly in water preference–is an area of some debate. Lastly, there are concerns over potential effects of status quo designations in CE's, since utility from status quo is experienced by the respondent, but utility associated with other alternatives is hypothetical (Scarpa et al., 2007).

Despite these limitations, we are able to estimate customer preferences where price signals rarely exist, but are crucial to inform efficient, large capital investments. This need is exacerbated by increased financial, regulatory, and physical constraints faced by many residential water suppliers (Duan et al., 2019; Mercer, 2017). Consistent with previous work, we find residential preferences for water supply go beyond cost minimization such that residents may actually prefer options that cost more, if those options include attributes of importance (Haider & Rasid, 2002). For example, aggregating our results, for the current 60,000 customer in the combined Moscow-Pullman area, suggests an additional annual willingness to pay of nearly $10.3 million a year to create a reservoir in the area. Depending on how long the costs are spread over time (table 6), cost recovery for the considered projects in the region is possible between 6 to 10 years without reducing consumer welfare. Moreover, adding co-benefits and non-critical amenities to these investments may help utilities increase revenue while increasing customer satisfaction. Results from the closed form survey, suggest a strong desire to include considerations like wildlife habitat, recreation, and energy requirements in these investments. Indeed, this mentality is being adopted in programs like "Total Water Solutions" (AWWA) or "One Water" approaches, which have gained traction in recent years as a way to simultaneously fund infrastructure and improve livability for residents (Grigg et al., 2018).

Table 4.1: Alternative Projects Costs Over Time Periods

Project	Water source	Storage	Monthly Costs per user over a year	Over 5 years	Over 7 yers	Over 10 years
1	Large river	No storage	$102.78	$20.56	$14.68	$10.28
2	Small river	Aquifer injection	$79.72	$15.94	$11.39	$7.97
3	Small river	Surface storage	$113.06	$22.61	$16.15	$11.31
4	Wastewater and Small River	Aquifer injection	$97.22	$19.44	$13.89	$9.72

4.1 Appendix

Appendix A: Demographic Questions

- My age is:

  1. 18-25
  2. 26-35
  3. 36-45
  4. 46-55
  5. 56-65
  6. >65

- Town where you currently live: beginitemize

- Age

  1. Moscow
  2. Pullman
  3. Palouse
  4. I live in the Palouse region, but not in any town's limits
  5. I don't live in the Palouse Region

- Where did you grow up? (check all that apply)

  1. The Palouse Region
  2. The Pacific Northwest (but not in the Palouse Region)
  3. The Southwest
  4. The Northeast

5. The Southeast
6. The Midwest
7. Outside of the US

- Do you rent or own your current home?
  1. Rent
  2. Own
  3. Other

- Your current water supplier (select all that apply):
  1. Moscow Water Department
  2. Pullman Water Department
  3. Personal well for drinking
  4. Personal well for irrigation
  5. I don't know
  6. Other municipal provider

Appendix B: Mixed-Logit Results

Table B.1: Mixed-Logit Results by Region

Variables	Northwest	Southwest	Northeast	Southeast	MidWest
Price	-0.0437***	-0.0657***	-0.0906***	-0.212**	-0.0359*
	-0.00716	-0.0218	-0.0324	-0.0935	-0.0194
Large River	-0.0665	0.868***	-0.172	0.574	-0.00381
	-0.133	-0.326	-0.586	-0.866	-0.325
Small River/Creek	-0.320**	0.453	-1.500**	0.0438	-0.585*
	-0.133	-0.361	-0.736	-1.048	-0.349
Waste Water	-0.183	0.895**	-0.664	0.45	0.518
	-0.173	-0.373	-0.74	-0.918	-0.541
Appliance Rebates	0.18	-0.486	-0.214	-0.737	-0.0654
	-0.144	-0.371	-0.641	-1.137	-0.367
Grass Rebates	-0.579***	-0.600*	-1.755*	-1.493	-0.495
	-0.151	-0.355	-1.015	-0.979	-0.351
Watering Restrictions	-0.213*	-0.648*	-0.935	0.703	-0.304
	-0.128	-0.334	-0.701	-0.958	-0.362
Aquifer Injection	0.672***	0.0264	1.317*	-0.357	0.841**
	-0.142	-0.365	-0.8	-0.848	-0.365
Reservoir	0.640***	0.4	1.441**	0.2	0.909**
	-0.117	-0.299	-0.696	-0.729	-0.378
Observations	3,864	588	518	378	756

Standard errors in parentheses
*** p0.01, ** p0.05, * p0.1

Table B.2: Mixed-Logit Results by Group

Variables	All	Male	Female	Younger	Older	Utilities	Well
Price	-0.0402***	-0.0361***	-0.0423***	-0.0454***	-0.0357***	-0.0369***	-0.131***
	-0.00525	-0.0102	-0.00683	-0.0077	-0.00716	-0.00618	-0.0469
Large River	0.044	0.0671	0.0291	-0.103	0.186	0.0206	0.943
	-0.1	-0.176	-0.148	-0.148	-0.148	-0.125	-1.096
Small River/Creek	-0.273**	-0.352*	-0.23	-0.166	-0.416***	-0.338**	1.393
	-0.106	-0.199	-0.141	-0.154	-0.148	-0.135	-0.953
Waste Water	-0.0524	-0.0488	-0.00323	-0.0574	0.0102	-0.0642	1.981**
	-0.14	-0.247	-0.194	-0.189	-0.208	-0.18	-0.994
Appliance Rebates	0.0695	0.117	0.0884	0.0488	0.121	0.123	0.136
	-0.106	-0.209	-0.149	-0.153	-0.16	-0.138	-0.834
Grass Rebates	-0.510***	-0.234	-0.673***	-0.497***	-0.572***	-0.479***	-3.588**
	-0.116	-0.192	-0.164	-0.169	-0.165	-0.141	-1.41
Watering Restrictions	-0.232**	-0.0785	-0.339**	-0.201	-0.271*	-0.246**	-2.193**
	-0.101	-0.182	-0.14	-0.146	-0.147	-0.125	-1.072
Aquifer Injection	0.514***	0.290*	0.697***	0.444***	0.595***	0.537***	1.545*
	-0.107	-0.172	-0.152	-0.162	-0.152	-0.131	-0.905
Reservoir	0.573***	0.339**	0.860***	0.468***	0.732***	0.559***	2.133**
	-0.0913	-0.167	-0.131	-0.136	-0.136	-0.117	-0.852
Observations	5,768	2,156	3,262	2,800	2,954	4,102	448

Standard errors in parentheses
*** p0.01, ** p0.05, * p0.1

Table B.3: Mixed-Logit Results by Home Ownership

Variables	Own	Rent
Price	-0.0354***	-0.0617***
	-0.00632	-0.0117
Large River	0.073	0.169
	-0.128	-0.222
Small River/Creek	-0.276**	-0.31
	-0.137	-0.208
Waste Water	-0.114	0.0353
	-0.187	-0.255
Appliance Rebates	0.132	0.0255
	-0.134	-0.211
Grass Rebates	-0.448***	-0.847***
	-0.14	-0.25
Watering Restrictions	-0.261**	-0.244
	-0.126	-0.216
Aquifer Injection	0.346***	0.982***
	-0.132	-0.247
Reservoir	0.573***	0.788***
	-0.116	-0.209
Observations	3,402	2,044

Standard errors in parentheses
*** p0.01, ** p0.05, * p0.1

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