Forecasting the Public's Acceptability of Municipal Water Regulation and Price Rationing for Communities on the Ogallala Aquifer

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Abstract

Among many, increasing the price of municipal water is considered to be the most effective mechanism for enhancing municipal water conservation, whether during times of drought or not. However, increasing the price of something that is considered to be, literally, a life-giving resource is politically taboo. This study follows two others that evaluate survey data with Likert scale responses, in determining whether or not constituents would outright reject the idea of using price to ration municipal water. But it goes several steps further--it controls for both community and respondent level variables, calculates and evaluates in-sample response probabilities, and most importantly, attempts to forecast the attitudes of constituents in communities that are *not* in our survey sample. In the end, our model produces both in-sample and out-of-sample response probabilities that are reasonable, and relatively stable across communities; it therefore provides communities and researchers with a means to gauge public support for pricing initiatives.

Introduction

This study follows two others that focus on whether community residents in the High Plains region of the United States, will outright reject increasing the price of municipal water to enhance conservation of their area's water supply. The common belief among community officials is that they will. Outlined in greater detail below, in general, many officials believe that residents would not support higher prices for a resource they view as essential to basic health and hygiene.

The initial seed study by Pumphrey et al. (2008) that fostered the idea of this current project, explores whether this view is correct. It conducts a survey of residents in Lubbock, TX, deemed the "urban" community, and five surrounding "rural" communities, to determine whether a policy of water demand regulation, price rationing of water consumption, or a hybrid of the two policies, would be most acceptable by the constituents in this area. What they found was that a hybrid of the two policies would be acceptable. They also found that residents of rural communities would tend to prefer less regulation than those in the urban area.

A second study broadens the Pumphrey et al. survey to include twenty nine communities across the eight states overlying the entire Ogallala aquifer area of the High Plains [Edwards, et al., 2012]. [1] These states are Colorado, Nebraska, Texas, Wyoming, Kansas, New Mexico, and Oklahoma--Nebraska, Texas, and Kansas, hold most of the aquifer's geographical area. However, it does not assume a rural/urban dichotomy, and it analyzes the data in a very simplistic, descriptive statistics fashion. The purpose was to allow a mostly non-technical regional audience (e.g., community officials) a greater understanding of the attitudes toward pricing and regulatory measures.[2] They found that in general, while regulation of water was the preferred mechanism for municipal water conservation policy both during periods of drought (the short run) and to enhance the longevity of the water supply for the foreseeable future (the long run), there was a "near unanimous indifference" toward using a price rationing approach to water conservation in a short run scenario.

The current study builds on Edwards et al., primarily by extending the analysis of the data into *out-of-sample* predictions across Likert scale responses from strongly agree to strongly disagree on a range of survey questions. It also controls for respondent and community level characteristics when estimating response probabilities, thereby generating more useful and more accurate in-sample predictions. The extension of the simple model into this type of ordered logistic analysis will not only enhance substantive inference drawn from the estimators, but allow researchers and officials alike the ability to predict how their community would respond to our survey questions given their state and community-level demographics. As surveys are quite expensive to conduct, we hope that this will give these players the ability to focus more on the marketing aspects of policy options, and not have to concern themselves as much with data collection and modeling.

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But, exactly why is the study of regulatory versus price rationing in the context of municipal water conservation important? And why is the Ogallala Aquifer region of the High Plains an important place to conduct such an experiment?

Municipal Water Regulation versus Price Rationing

As with any good, the options for allocating water resources to end-users are many, including tying water rights to land ownership, negotiation, queuing, lottery, and command-and-control. However, in the absence of extenuating circumstances, pricing, not regulation, is likely to be the best option. On a very basic level, the argument for increasing price to reduce the consumption (and wasting) of municipal water is a matter of efficiency, and therefore, effectiveness of the prescribed policy. Typically applied, regulation would involve the reduction and/or elimination of ones ability to water their lawn, gardens, etc. It may even limit ones ability to wash their cars, or a requirement to fix leaking faucets. Violations of these policies usually result in reprimands and/or pecuniary fines being levied against the offender.

Regulation, however, is quite inefficient and expensive. Part of the inefficiency resides in the fact that not all individuals are affected; for instance, only car owners are affected by car washing restrictions, and only homeowners with lawns would be affected by lawn watering restrictions. In other words, under these policies, you can use as much water as you want at the current price as long as you do not have a lawn or own a car. Secondly, circumvention of the policy is quite easy. Anecdotal evidence is provided by one of the authors of this paper while he was living in Lubbock, TX. During that time, a resident was only allowed to water their yards between 6 pm and 6 am. Because a large portion of homes have privacy fences, many individuals would water their back yards well before 6 pm. In other words, as long as someone can not be seen committing the violation, there is an increased probability it will occur. There are also many conflicting signals given to citizens with regulatory policy. For instance, it may not be okay to water your yard before 6 pm, but would it be acceptable if someone's automated yard sprinkler watered their lawn during a rainstorm even if it was during the prescribed time?

Considering the expense of regulatory policy, the local government must monitor the actions of the citizens of the community when regulation is in place. Law enforcement officials now become proxies of the municipality's water department (or vice versa). Any fines that are issued would necessarily involve the court system either through payment of the fine to the clerk of court, or if the fine is contested, by the district's judge or magistrate. However, increasing prices to reduce consumption substantially reduces this burden.

As long as the water source is metered, which includes the vast majority of water used by municipal residents, circumvention becomes difficult as the meter would actually have to be bypassed by the resident, possibly requiring substantial changes in landscaping and plumbing (think of what it would take to reroute water lines to bypass the typical household water meter). Pricing does allow someone to water their lawns and/or vehicles anytime they choose, but they will pay a higher price for it, likely causing many not to partake in that task. And lastly, since a leaking faucet would necessarily cost a resident more to tolerate, it would be in the residents' financial interest to stop the leak. But what should the price of water be to encourage conservation?

In theory, the efficient price of water should be the long run marginal cost of supply. This long run marginal cost should reflect all of the costs, including prorated capital costs, the cost of treatment and distribution, and the opportunity costs of using the water. It is these opportunity costs that are the most difficult to calculate, because one must calculate an expected cost of using water now instead of later, as well as an estimate of the benefits of leaving water in the ground, river, or reservoir (e.g. for the environmental benefits). Even though such calculations are hypothetically possible, expecting every municipal provider of water to conduct such an analysis accurately is clearly unreasonable, and approximations must be made. In fact, it is well known that urban water prices are set well below the long run marginal cost in many cases (e.g. Sibly, 2006) and even well below the cost of provision in many cases (e.g. Timmins, 2003).

However, these difficulties cannot be used as an excuse to overlook the benefits of using price to allocate water. In the absence of a pricing mechanism some governmental or other allocation body must make a decision about what action to regulate, and how much water such regulation would save. Hence, even if one were to argue that finding the 'optimal' price is quite difficult if not impossible, the pricing mechanism still may be the most efficient way to achieve the desired outcome (see e.g. Olmstead and Stavins, 2009).

Recognizing that the supply of water is partially exogenous and prone to shocks, pricing is also exceptionally useful as a signal during times of drought. During periods of drought the opportunity cost of using water sharply increases, as the probability of "running out" increases. The most commonly used methods of encouraging conservation during periods of drought are “moral suasion or direct regulation” (Gibbons 1986 page 21). Persuading people to use less because it is the "right thing to do" is unlikely to be effective. In fact, Edwards et al. (2012) found that a statistically significant majority of constituents in 21 of 29 communities surveyed agreed with the statement that "mandatory restrictions would be ignored by many" in their community.

And finally, the Western U.S., a separate but equally water-stressed region as the High Plains, has been transformed through urban growth, tourism, and industry, and now reallocation of water rights is becoming increasingly important. The transactions costs involved in these reallocations are significant, and could have been avoided under a pricing mechanism (Colby, 1990). Indeed, water law in this region is extremely complex, not only restricting transfers but also how water may be used by rights holders (e.g. Kanazawa, 2003). Determining efficient pricing levels for different uses of water rather than restricting use would arguably be far easier to implement and be more effective than allocation to appease the arguments of self-interested rights holders.

So why isn't price rationing more common? Timmins (2003) suggests that price-setting regulators are often reluctant to use price because of equity over efficiency considerations. And anecdotal evidence gathered by this team of researchers found that community officials are hesitant to use a price rationing approach simply because (they think) there will be a public backlash that could cost them their place in the community at the next election. On the other hand, these price setters may be more comfortable with alternative pricing structures such as increasing block pricing or variable unit pricing. Under an increasing block pricing structure there is a lower price per unit for the first *n* units of "necessary" water usage, and a higher price thereafter for “optional” or “excess” home usage. In a variable unit pricing scheme if a user consumes less than say, 500 units of water in a month then they pay low price p_1 per unit, but if they use more than 500 units of water in a month, then all units will be charged at price p_2 (see Loehman, 2008).

In addition to its increased palatability for policymakers concerned with equity, increasing block pricing may have two additional benefits. Olmstead et al. (2007) find evidence (though not conclusive) that using increasing block pricing may actually make consumer demand more elastic in their price response for water. They also suggest that the use of increasing block pricing is likely to subject more households to a more efficient, higher marginal price for water, since under uniform marginal price paradigms this price is often set too low. Having said that, data collected by this team of researchers for a separate national study, indicate that only 109 out of 467 quasi-randomly selected communities across the U.S. have an increasing block price structure. Hence, even this sort of price rationing approach is rare. In this study, we only explore price increases in general, and do not attempt to gauge the public's support for various pricing structures.

High Plains Corn, Ethanol Production, and the Ogallala Aquifer[3]

Answering the question of exactly why the Ogallala aquifer area of the High Plains region of the country is an appropriate place to conduct such an experiment begins with the federal government.

The Energy Policy Act (2005) authorized the creation of the Renewable Fuels Standard (RFS), mandating increased amounts of renewable fuels to be produced and blended with the nation’s fuel supply starting in 2006. The Policy Act was amended in 2007 to include a larger

[3] The general outline of this section was taken from Edwards et al., 2012.

portion of renewable fuels to be in the form of what the RFS calls “advanced biofuels,” or feedstock from biomass, cellulosic, etc. (American Coalition for Ethanol, 2012). As a result of both acts, biofuel production (ethanol and advanced biofuels) in the U.S. has increased over 700% since 2000 (RFA, 2011). Accordingly, biorefineries in the same time period have increased production by 100% in Kansas, 250% in Nebraska, and almost 1100% in Texas (Nebraska Energy Office, 2012).

Of the eight states in this study, Kansas and Nebraska have the largest amount of acreage planted in corn, with planted acreage in Nebraska about double that of Kansas (9.8 million acres in Nebraska, 4.9 million acres in Kansas in 2011) (NASS, 2011). The largest *increases* in corn planted acres have been in Kansas, Colorado and Wyoming, with 34%, 36%, and 31% growth respectively (NASS, 2011). Kansas State Research and Extension estimates that it would take 2,150 gallons of water from irrigation to produce one bushel of corn in northwest Kansas under normal conditions (O’Brien, 2008). The U.S. Department of Agriculture (USDA, 2004) and O’Brien (2008) estimate that a typical ethanol plant will convert one bushel of corn into approximately 2.7 gallons of ethanol, which means that it takes roughly 800 gallons of irrigation water to produce one gallon of ethanol (USDA, 2004). Given the collective production capacity in the eight state study area in 2011, that translates into 2.3 trillion gallons of water that is needed *in addition* to what is already being withdrawn from the Ogallala for other purposes.

Not only is water required to grow the feedstock, but water is also needed in the direct production of ethanol. On average, a biorefinery consumes approximately 4 gallons of water for each gallon of ethanol produced (Pate, 2007, O’Brien, 2008). A typical ethanol facility that produces 100 million gallons per year (mgy) would use about 400 million gallons of water in the production of ethanol annually. This translates into an additional 11.7 billion gallons of water.

In a large percentage of areas overlying the Ogallala aquifer, withdrawals of groundwater have far exceeded natural recharge. Estimated annual recharge ranges from a mere 0.02 inch per year in the southern portion to 6 inches annually in the northern region of the aquifer. In most areas, the groundwater is considered nonrenewable, meaning groundwater is being withdrawn at a rate much faster than recharge. Groundwater levels have dropped as much as 100 to 200 feet in parts of Texas, Oklahoma, and Kansas, and by 2007 the water table dropped as much as 234 feet in some areas of Texas (Luckey, 1981; Gutentag, 1984; McGuire, 2009).

In short, given the fairly recent ethanol mandates, we can expect a substantial increase in water withdrawal rates from the aquifer for both irrigation and the direct production of ethanol. Since the resource is for the most part, finite, we can expect that there will be increased pressure on the 2.3 million residents, most of who live in municipalities, to find alternative sources of water. But until then, conservation practices are key to increasing the longevity of the resource. And even though 95% of the aquifer is used for irrigation, implying that the farmers and ethanol producers must play a large role in the overall conservation efforts, it certainly behooves communities in the area to establish their own efficient conservation practices.

Survey Data and the Ordered Logistic Model

The survey used to generate data for this study was conducted by the Earl Survey Research Laboratory at Texas Tech University from fall of 2009 to the fall of 2010 using a random digit dialing system (RDDS). This traditional sampling method uses computer based dialing to generate listed and unlisted phone numbers in the study region. By using the RDDS, one is able to include individuals who recently moved into the survey region and avoid the sample selection bias typically found in mail surveys (Carson, 2000).

There are 2983 partially and fully completed surveys of people who use municipal water living in 29 communities across the Ogallala area. To determine which communities would be surveyed, the region was divided into equidistant grids (see Figure 1) of approximately 170,500 square meters each. This resulted in 30 grids at least partially overlying the aquifer itself. Within each grid, the largest community by population was chosen to be surveyed. Because the region is so sparsely populated to begin with, this method resulted in a selection of not only quite large communities, such as Lubbock, TX, with over 200,000 people, but quite small communities numbering only in the hundreds. Having said this, there were problems with two of the communities that were chosen. At the time the survey was conducted, Grenville, NM, in grid number 19, had only 26 inhabitants. And even though the community of Crosbyton, TX, in grid number 28 had well over 1,000 individuals, we were only able to complete 27 surveys of that community before it became apparent that resources for data collection were being substantially strained. Therefore, it was decided to drop Crosbyton entirely, and add Yuma, CO, in grid number 11, to replace Grenville, NM. Adding Yuma made sense in that it has a sufficiently large population, it rests on the western portion of the aquifer, and resides in Colorado. We already had several New Mexico communities on the survey list, but none from Colorado--Yuma gave us a community from this state.

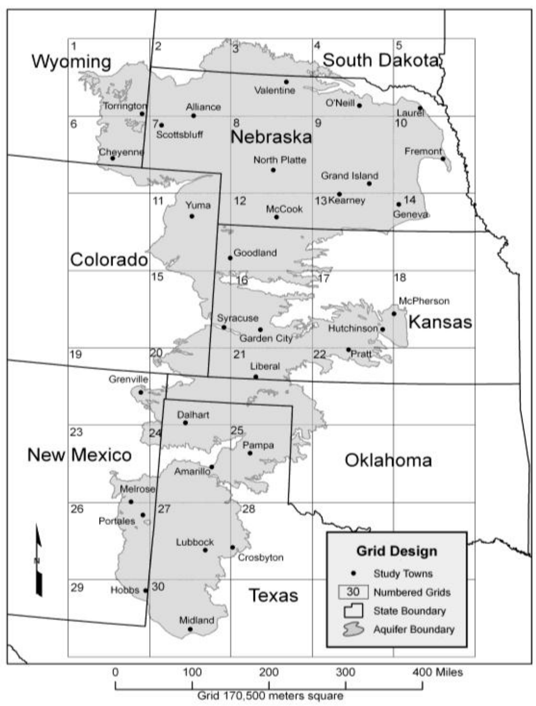

Figure 1: The Ogallala Aquifer and Survey Grids[4]

One possible drawback of the collection method is that instead of randomly collecting observations across all communities, the surveys were randomly conducted within each community. In other words, 29 communities were chosen, and approximately 100 randomly

[4] See Edwards et al., 2012.

chosen respondents within each community were given the survey (provided they used municipal water). We chose this collection method because it ensures that the sample is spread out across the entire Ogallala. We felt it necessary to avoid a possibly large clustering of observations in one area relative to another. Only asymptotically would we be sure of an equal distribution of observations. Given that the Ogallala covers such a large area with dramatically different aquifer recharge and rainfall rates, we felt it important to have approximately the same number of observations in each respective region. The community level random sample is therefore representative of each community's population with regards to gender, unemployment and the number of individuals per household, if not of the Ogallala as a whole due the statistical ramifications of the selection method.

Participants answered questions on a contingent valuation survey with 4-point Likert scale responses. Previous studies on water conservation and consumption have successfully utilized this scale (see Gregory and Leo, 2003; Hurd, 2006; Polyzou et al., 2011) which is designed to give a discrete measure of the intensity of respondent's feelings or opinions towards the survey questions (Pumphrey, et al., 2008). Each participant was given the response choices ‘strongly agree’ (SA), ‘agree’ (A), ‘disagree’ (D) and ‘strongly disagree’ (SD), ranging from 1 to 4, respectively, as well as the options ‘don’t know’ and refuse to answer. To provide a more intuitive ordering of the data, the survey responses are reordered so that higher values correspond with more positive outcomes i.e. ‘strongly disagree’ to ‘strongly agree’ now corresponds with 1 to 4, respectively.

To conduct this analysis, we take the usable responses (those with responses other than “don’t know” and “refuse to answer”) to the questions described in the following section and regress on a host of determinants--some taken from survey responses of other questions asked, as well as community and state-level statistics. These auxiliary data are extremely helpful in teasing out the differences among communities and states and may help decision makers easily identify where their community or district falls within the analysis.

An important characteristic of the dependent variable data is that the responses are ordered, and therefore requires an appropriate estimation technique. This makes both multinomial and ordinary regression analysis inappropriate, because these models treat the difference between SD and SA the same as the difference between SA and A. We use an ordered logitistic regression (OLM) framework to conduct the econometric analysis. In its most basic form with an elementary conditioning set, one could calculate the probabilities directly from the survey responses; however, the OLM is still preferred since a smoothness assumption is imposed allowing differences in the regressors to be integrated in each category (StataCorp, 2007a).

Like the binary version, our discussion of the ordered model begins with a brief discussion of the latent variable model. In theory, the latent variable represents the continuous range of the respondent's attitude toward the question that is known to the respondent, but unobservable by the researcher (Train, 2009; Greene and Hensher, 2010). It is a linear function of the measurable factors that affect individual choices and their unobservable idiosyncratic errors. Consider a survey question y with $j = 1\ldots J$ response options that are equivalent to the Likert scale responses described previously. The latent variable expression for an individual is therefore:

$$(1)\quad y^*_{ics} = \boldsymbol{\alpha}^{\mathrm{T}}\mathbf{x}_{ics} + \boldsymbol{\gamma}^{\mathrm{T}}\mathbf{z}_{cs} + \boldsymbol{\delta}^{\mathrm{T}}\mathbf{d}_{s} + u_{ics},$$

where vector $\boldsymbol{\alpha}^{\mathrm{T}}\mathbf{x}_{ics}$ is the function of the co-regressors taken from the survey, $\mathbf{x}_{ics}$, and unknown parameters, $\boldsymbol{\alpha}$, $\boldsymbol{\gamma}^{\mathrm{T}}\mathbf{z}_{cs}$ represents the function of the observed community-aggregated variables, $\mathbf{z}_{cs}$, and the associated parameters of interest $\boldsymbol{\gamma}$, $\boldsymbol{\delta}^{\mathrm{T}}\mathbf{d}_{s}$ is the function of the observed state-aggregated statistics, $\mathbf{d}_{s}$, and $\boldsymbol{\delta}$ is the vector of unknown parameters. The subscript $i = 1\ldots I$ indexes the individuals in the sample, $c = 1...C$ the communities in the sample, and $s = 1...S$ the states in the sample. The superscript T indicates that the vector is transposed and u_{ics} is the random unknown portion of y^*_{ics}. The distribution of u_{ics} determines the probability of the j responses.

For simplicity, denote

$$(2)\quad \boldsymbol{\beta}^{\mathrm{T}} = (\boldsymbol{\alpha}, \boldsymbol{\gamma}, \boldsymbol{\delta}) \text{ and } \mathbf{w}_{ics} = (\mathbf{x}_{ics}, \mathbf{z}_{cs}, \mathbf{d}_{s}).$$

Hence **w** is a k×1 vector of the observable variables that affects opinions and **β** is a k×1 vector of the corresponding parameters of interest. Model (1) can therefore be written as

$$(3)\quad y^*_{ics} = \boldsymbol{\beta}^{\mathrm{T}}\mathbf{w}_{ics} + u_{ics}.$$

The respondent's choice is based on some threshold or cut-point, τ_j, with j = 1…J-1, of the unobservable latent variable, y^*_{ics}. The J-1 cut-points are identifiable parameters that divide the latent variable into J distinct sections that are related to the observable Likert options (Greene and Hensher, 2010).These thresholds can be thought of as points on the latent variable with higher outcomes corresponding to higher cut-points and are the same for each individual in the sample. While we do not observe y^*_{ics}, we do observe each respondent's rating of agreement with (or opinion towards) the survey question. For the J- alternative model we observe

$$(4)\ y_{ics} = j \text{ if } \tau_{j-1} < y^*_{ics} \le \tau_j, \text{ where } \tau_0 = -\infty \text{ and } \tau_j = \infty.$$

More explicitly, as there are four outcomes ranging from SD to SA we observe

$$(4a)\qquad y_{ics} = 1(\mathrm{SD}) \text{ if } y^*_{ics} \le \tau_1,$$

$$(4b)\qquad y_{ics} = 2(\mathrm{D}) \text{ if } \tau_1 < y^*_{ics} \le \tau_2,$$

$$(4c)\qquad y_{ics} = 3(\mathrm{A}) \text{ if } \tau_2 < y^*_{ics} \le \tau_3,$$

$$(4d)\qquad y_{ics} = 4(\mathrm{SA}) \text{ if } y^*_{ics} > \tau_3.$$

The mathematical application of the maximum likelihood procedure used to estimate this model as well as the application of robust standard errors, which we perform in our estimation, is available upon request.

The discussion of the results focuses on the predicted probabilities with standard errors calculated using the delta method. The delta method is a convenient and widely used method of obtaining standard errors of nonlinear transformations of parameters such as predicted probabilities or marginal effects without costly re-sampling of the data (Cameron and Trivedi, 2005; Papke and Wooldridge, 2005). It is often used as a means to reduce bias (Parr, 1983). The delta method estimates have oftentimes been very similar to those estimates found using the bootstrap of jackknife methods (Parr, 1983). The maximum likelihood procedure applied to this model estimates the parameters, $\hat{\boldsymbol{\beta}}$ and $\hat{\boldsymbol{\tau}}$, as well as provides robust standard errors. Fortunately, many statistical packages provide the delta method standard errors associated with the predicted probabilities.

Unfortunately several of the independent variables are collinear. Collinearity creates large standard errors making it difficult to estimate the individual effect of the variables on the likelihood of making each choice; nevertheless, parameter estimates are asymptotically unbiased (Studenmund, 2006). Since the parameter estimates are unbiased, collinearity is usually only of concern when conducting hypothesis tests. Like all estimates, there may be cases whereby the finite sample coefficient estimates do deviate from their asymptotic values. Since these estimates are used to calculate the probabilities, both the predicted probabilities and their delta method standard errors may be affected by the large standard errors. Therefore, their may be a tradeoff between the value of including these variables to evaluate the effects of a 'full' conditioning set in conjunction with avoiding possible omitted variable bias, and faulty finite sample inference. We obviously side with the former especially since omitted variable bias tends to cause greater bias in estimates than collinearity.

While the description of the OLM modeling technique is useful for a more technical audience, it may be quite complicated for general practitioners. Using an OLS-type description of the *general* relationships that are tested, model (A) simply tells us that the response, *y*, of individual '*i*' that was surveyed and resides in community '*c*' and state '*s*', is regressed upon a set of respondent-level variables, *x*, that are taken directly from survey responses, and community-level variables, *z*, that are determined by non-survey data.

$$\text{(A)} \qquad y_{ics} = a_0 + a_1 x_{ics} + a_2 d_{ics} + a_3 z_{cs} + u_{ics} \ ,$$

where $d_{ics} = d_{1s} x_{ics}$. In other words, we allow the coefficient estimates of the respondent-level variables to differ by state, but by only one state at a time. That state will effectively be our 'state of interest' when drawing inference from our results. To separate differences in the effects that *x* has on y for all states at the same time would lead to a rather large conditioning set that would have problems converging to a stable solution. Effectively, then, for five of the six states for which we forecast policy, the estimate for a_1 constitute the effect the x's have on y for those five states only, while $a_1 + a_2$ constitute the effect that the x's have on y for the sixth state only. Having said this, as mentioned before, it is actually not the coefficient estimates we are interested in per se, but the predicted probabilities of each outcome that interest us most. To this end, we generate two sets of forecasts--state-level and out-of-sample community-level predicted probabilities.

To accomplish the former, we hold x_{ics} at its state-level mean for the state of interest while letting the survey responses vary for the other states, and z_{cs} is held at its state-level mean for all states. We then calculate the average predicted probability by state. Since d_{ics} represents only one state at a time, a separate regression was run for each state. What this procedure accomplishes is that for the state of interest, individuals in that state are assumed to respond, on average, like other individuals in their state; however, this assumption is not made for individuals in other states. The prediction made for the state of interest is specific for that state, while the remainder acts as their own separately unified entity.

To accomplish the latter, we perform exactly the same procedure, but we set z_{cs} equal to the out-of-sample community-level values for the state within which this community resides, and let the variable remain at the state-level means for the remaining states. Together with the fact that we restrict the x_{ics}' s to their state-level means for the state of interest, this assumes that (i) the individuals in the out-of-sample community, had they taken our survey, on average, would have answered the respondent-level questions in the same way that others in that state have responded, and (ii) it also allows for the out-of-sample community-level data to play a substantial role in determining the predicted probability estimates for each response category.

Respondent-Level Variables

The questions asked to identify particular characteristics of each respondent are (i) how many years the respondent has lived in the state, (ii) whether a respondent owns their home, (iii) whether they pay their own water bill, (iv) if they are employed in the agricultural industry or ethanol industry, (v) how many reside in the household, (vi) whether the respondent is unemployed, (vi) how long the respondent believes that the water in their state will last, (vii) how important water conservation should be to their local government, (viii) how important the agricultural sector is to their community, (ix) whether they make an effort to buy water efficient appliances, (x) whether farmers should pay for all of the water they use, (xi) whether farmers should pay for their water over a certain free allotment, and (xii) whether farmers should be fined for wasting water.

The control variables are included to help hold constant characteristics that may bias an individual's response toward one policy or another. For instance, how long someone has lived in a particular state, we hope, will indicate one's 'commitment' to water conservation in their area. We didn't include a question in the survey that directly broaches conservationism simply because no one would want to be 'branded' as being against conservation. We have learned from experience that direct questions such as these tend to result in substantially biased responses; hence, we employ this proxy of state resident tenure instead.

The home ownership and unemployment variables should help proxy for income and wealth. The inclusion of an income question that specifically placed individuals in particular income brackets resulted in a loss of nearly 50% of the observations, so we rely on these two variables to control for that effect. An income/wealth effect has obvious importance here simply because responses to policy, especially to pricing strategies, could be considerably influenced by one's ability to pay. At the one extreme, if a respondent is employed and owns a home, their response to pricing policy could be considerably different from an unemployed respondent living on a fixed government subsidy.

Whether a respondent pays their own water bill will help control for a respondent's vested pecuniary interest in water conservation within the household. We would expect a different reaction to a price rationing strategy from a household member that writes the check every month for their water consumption as opposed to someone in the household that doesn't. The same might be true for a respondent that lives in a household with many individuals. It is unlikely that an individual that resides in a household with many individuals would advocate for an increase in water prices, or regulatory restrictions for that matter, as a conservation strategy. To this end, we include a variable that asks the respondent for the number of individuals that live in their home.

Finally, in this part of the country, attitudes will certainly be formed based upon whether a respondent is employed in the agriculture or ethanol related industries, as well as their inherent opinion of the farming community as incomes and job opportunities are overwhelmingly tied to this industry; yet, it is commonly known that farmers use the vast majority of water in the Ogallala area for irrigation purposes and are the main cause of stress on the aquifer's water supply.

Community-Level Variables

As mentioned, these variables reflect characteristics that are aggregated at the community level. They are divided into three groups for the purpose of this study. These groups are (1) demographic variables, (2) precipitation variables, and (3) municipal water pricing structure variables. The demographic variables include community level statistics on population levels, changes in population, median income levels, percentage of population with a high school, bachelor's, and graduate degree, unemployment rates, and cost of living standardized around the value 100 which represents the U.S. average cost of living. All of the demographic data was collected from City-Data.com.

The precipitation category includes drought severity index variables and 30-year average annual rainfall totals. The rainfall data were collected from NOAA via The Weather Channel's website. In order to investigate the potential impact of drought on the responses of those surveyed, we measure drought intensity using the standard US Drought Monitor Intensity Index[5].

[5] This index is produced and maintained as a partnership between the US Drought Mitigation Center, the USDA, and NOAA. See http://droughtmonitor.unl.edu/.

According to this index an area can either be Normal, Abnormally Dry, in Moderate Drought, Severe Drought, Extreme Drought, or Exceptional Drought. Using the county that each city is predominantly located in, we assigned the numbers 1-5 to represent the drought intensity for each of the categories of Abnormally Dry-Exceptional Drought. Then, for three different time periods we calculated the “average drought intensity” over that period in the county, using weekly data. In order to measure the more recent drought history, we calculated the average drought intensity the month before the respondents in each municipality were surveyed, and also for the year before the respondents were surveyed. In order to get a long run drought history, the average drought intensity for 1-6 years before the survey took place (a 5 year period) was calculated.

The pricing variables measure the current pricing structure for that community--i.e., decreasing, increasing, or constant block pricing of municipal water and are collected directly from (a) the community's own website, or (b) from calling the water department of that community directly. These are simply dummy variables representing each price structure separately.

Dependent Variables

The dependent variable data are based upon a four point Likert scale as outlined earlier, and are generated from the following survey questions:

General Question

(1) I personally would use less water if I were charged more for it.

Short-run Questions

(2) Mandatory water restrictions enforced by your local government, such as limiting car washing, lawn watering, plant and garden watering and so on, are a good way to help save water during periods of drought.

(3) Increasing the price of water during periods of drought would be a good way to help save water during these periods.

Long-run Questions

(4) Mandatory water restrictions are a good way to help save water for the future even if there is no drought.

(5) Increasing the price of water when there is not a drought would be a good way to help save water for the future.

Compliance and Enforcement Questions

(6) Mandatory water restrictions such as those just mentioned would be ignored by many in your community.

(7) Mandatory water restrictions such as those just mentioned would be strictly enforced by your community's officials such as the police department, water department, and such.

Question (1) simply tries to tease out whether a respondent would be sensitive to a change in the price of their municipal water. We realize that there are ambiguities in this question with regard to how much the price would rise and the level of sensitivity that would occur given the price increase; but, as will become clear later, this question does an adequate job of detecting whether a community should pursue a pricing strategy or not.

The next two questions try to determine whether a respondent will agree or disagree with a regulatory and pricing policy prescription respectively. We call questions (2) and (3) short-run questions simply because we frame these questions within a period of drought. We do not indicate the length of the drought, some of which can last years, but we believe the general consensus among the average survey participant would be that droughts are typically temporary in nature. Having said this, the questions try to gain the acceptability/viability of said policy based upon the idea that these measures would be temporary in nature. Questions (4) and (5) extend the previous two questions into a longer time frame by simply making the respondent aware that these measures would not be triggered/determined by a drought in their area. To ensure that the respondent recognizes this to be the case, we ask both of these questions after the short run questions to add relativity to the question's premise.

Finally, questions (6) and (7) try to capture the respondent's attitude toward their fellow man's willingness to follow the law when regulation is established, and subsequently, their local law enforcement agency's ability to enforce said regulation. These questions are important proxies in determining how expensive and/or effective any regulation would be. A constituent that believes their neighbor would ignore such policy would indicate that considerable enforcement of it would be required, increasing costs; a constituent that believes their law enforcement agencies would not prosecute such infractions would indicate that the policy is ineffective.

Results

The actual coefficient results generated from model (A) are not the central focus of this paper. The purpose of this study is to determine the predicted probabilities at the state level for each of the Likert outcomes using the variables just listed, and for community-level out-of-sample policy forecasts. The coefficient estimates for all states are available upon request.

Evaluating question (1) of the state-level results in Table 1, we find that there is roughly a 60% chance that a constituent would reduce their consumption of water if they were charged more for it, indicating at least some sensitivity to changes in the price of water. The exception to this claim would be the state of Wyoming whereby there is only a 53% chance of agreeing with this question. The strongly agree probabilities reflect a measure of emphasis in this area, and with the exception of Wyoming, the strongly agree probabilities for the other five states are roughly 3.5 times the strongly disagree probabilities; in Wyoming, the difference is only about 1.5 times.

Moving on to the short run regulation questions, it quickly becomes obvious that this form of water conservation during periods of drought is widely and emphatically accepted. There is anywhere between an 80% and 90% chance of a constituent agreeing with this concept, with strongly agree probabilities from 18-35%. On the other hand, a short run price increase during a period of drought is a far less favorable policy, although not rejected outright.

Table 1: Predicted Response Probabilities at the State Level

State	Response	Law of Demand		S. R. Regulation		S. R. Price Increase		L. R. Regulation		L. R. Price Increase		Ignore Regulation		Enforce Regulation	
		Prob.	S. E.	Prob.	S. E.	Prob.	S. E.	Prob.	S. E.	Prob.	S. E.	Prob.	S. E.	Prob.	S. E.
CO	S A	0.104	0.018	0.188	0.031	0.059	0.011	0.067	0.013	0.034	0.007	0.089	0.016	0.092	0.015
	A	0.545	0.026	0.611	0.009	0.357	0.037	0.598	0.036	0.300	0.038	0.560	0.030	0.588	0.026
	D	0.325	0.038	0.157	0.025	0.470	0.028	0.304	0.042	0.573	0.029	0.323	0.040	0.276	0.032
	S D	0.024	0.005	0.041	0.009	0.112	0.020	0.030	0.007	0.091	0.017	0.025	0.005	0.041	0.008
KS	S A	0.075	0.006	0.245	0.014	0.067	0.006	0.062	0.005	0.036	0.004	0.091	0.007	0.082	0.007
	A	0.486	0.014	0.601	0.010	0.382	0.014	0.586	0.014	0.313	0.015	0.562	0.013	0.576	0.013
	D	0.402	0.016	0.122	0.008	0.450	0.011	0.317	0.014	0.563	0.013	0.320	0.015	0.294	0.014
	S D	0.035	0.004	0.030	0.003	0.100	0.008	0.033	0.004	0.086	0.007	0.025	0.003	0.045	0.004
NE	S A	0.085	0.006	0.234	0.011	0.067	0.005	0.054	0.004	0.032	0.003	0.083	0.006	0.085	0.006
	A	0.505	0.012	0.599	0.009	0.381	0.012	0.559	0.012	0.286	0.012	0.546	0.012	0.571	0.012
	D	0.377	0.013	0.132	0.008	0.448	0.011	0.346	0.013	0.582	0.011	0.341	0.013	0.296	0.012
	S D	0.032	0.003	0.034	0.003	0.098	0.006	0.039	0.004	0.098	0.006	0.028	0.003	0.047	0.004
NM	S A	0.084	0.010	0.251	0.022	0.070	0.008	0.078	0.008	0.039	0.005	0.132	0.014	0.074	0.008
	A	0.510	0.021	0.602	0.011	0.394	0.021	0.631	0.016	0.327	0.022	0.609	0.013	0.557	0.020
	D	0.373	0.026	0.117	0.012	0.440	0.019	0.264	0.019	0.553	0.019	0.240	0.021	0.316	0.021
	S D	0.031	0.004	0.028	0.004	0.094	0.010	0.025	0.003	0.080	0.009	0.016	0.002	0.051	0.006
TX	S A	0.090	0.008	0.251	0.016	0.064	0.006	0.071	0.007	0.032	0.004	0.121	0.010	0.067	0.006
	A	0.521	0.015	0.602	0.010	0.374	0.017	0.618	0.015	0.290	0.017	0.602	0.012	0.534	0.016
	D	0.358	0.018	0.117	0.009	0.457	0.015	0.282	0.017	0.580	0.014	0.257	0.016	0.339	0.017
	S D	0.029	0.003	0.028	0.003	0.103	0.009	0.027	0.003	0.096	0.009	0.018	0.002	0.058	0.006
WY	S A	0.067	0.009	0.352	0.027	0.072	0.010	0.095	0.012	0.031	0.004	0.039	0.006	0.146	0.019
	A	0.465	0.026	0.552	0.018	0.401	0.026	0.656	0.016	0.288	0.024	0.401	0.030	0.639	0.012
	D	0.427	0.029	0.077	0.009	0.434	0.025	0.227	0.023	0.583	0.018	0.502	0.029	0.189	0.022
	S D	0.040	0.006	0.017	0.002	0.090	0.012	0.019	0.003	0.096	0.011	0.057	0.009	0.024	0.004

CO=Colorado; KS=Kansas; NE=Nebraska; NM=New Mexico; TX=Texas; WY=Wyoming. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree. Prob.=Predicted Probability; S.E.=Standard Error. S.R.=Short Run; L.R.=Long Run. Standard errors were calculated using the Delta method.

The chance that a constituent will strongly agree with using price as a conservation mechanism during periods of drought range from 5.9% in Colorado to 7.2% in Wyoming; the agree outcomes range from 35.7% in Colorado to 40.1% in Wyoming. Overall, then, there is somewhere between a 41% and 48% chance that a constituent will at least agree with using price to reduce consumption during periods of drought. These numbers are substantially higher than for periods of no drought. Over the long run, price increases are only favored with a 31.9% chance in Wyoming to a high of 36.6% in New Mexico. Furthermore, the percentage that strongly agree with a long run price increase is only about one-half that of strongly favoring a short run increase. Interestingly, however, long run regulatory policy is actually quite favorable. There is anywhere from about a 65% to 75% chance that someone would at least agree with using regulatory policy on a more permanent basis, with strongly agree percentages ranging from about 5% to nearly 10%.

It becomes clear that the most favored policy is in fact, a regulatory policy--regardless of whether it is implemented during periods of drought or not. However, it is also true that a constituent in Kansas, Nebraska, New Mexico, and Wyoming would favor increasing prices during periods of drought by nearly 45% or greater, indicating that policy makers have some flexibility when determining conservation measures during these periods. Since our study did not include any pre-question marketing of the necessity of using prices as a conservation mechanism during droughts, it would likely be the case that a well-advertised campaign, educating the public on the efficiencies associated by using price as a conservation tool, the probabilities may lean more in the direction of price increases. Furthermore, the next two sets of results indicate that regulatory policy would be relatively expensive.

When asked whether a respondent believes that others in the community would effectively ignore regulatory restrictions to water use, in four of the five states, there is roughly a 65% to 75% chance that someone would at least agree that this would be the case. The strongly agree probabilities in these states range from 8.3% in Nebraska to an astounding 13.2% in New Mexico. The only state whereby the constituents believe their neighbors will actually respect the policy requirements is Wyoming. But this difference in outcomes may simply reflect the level of enforcement and reliability of the enforcers of such policy.

The highest level of agreement when asked whether community officials would enforce such policy is also in the state of Wyoming, with a combined agree/strongly agree outcome of 78.5%. Thus, the trust in fellow constituents may reflect the effectiveness of city officials to enforce regulatory policy, thus leading to the (perceived) inclination of constituents to abide by such policy; however, the previous results could also be independent of such perceptions as well. Perhaps the most ineffectual outcome from regulation would occur in the state of Texas, where there is a 72% chance that a respondent would at least agree that regulation would be circumvented, but only a little over 60% chance that officials would enforce said policy. In all, it would certainly be the case that regulatory policy would prove costly and inefficient relative to pricing. Therefore, a hybrid policy of pricing and regulatory measure would likely be more efficient, at least during periods of drought.

Table 2 provides greater insight to the particular prescription each state should consider pursuing. It does this by ranking each state by the first five questions with regard to their percentages of strongly agree and agree respectively.

Table 2: Relative Probability Rankings for States

Rank	Law of Demand		S. R. Regulation		S.R. Price Increase		L. R. Regulation		L.R. Price Increase	
	SA	A	SA	A	SA	A	SA	A	SA	A
Highest Percentage	CO	CO	WY	CO	WY	WY	WY	WY	NM	NM
.	TX	TX	NM	NM	NM	NM	NM	NM	KS	KS
.	NE	NM	TX	TX	KS	KS	TX	TX	CO	CO
.	NM	NE	KS	KS	NE	NE	CO	CO	NE	TX
.	KS	KS	NE	NE	TX	TX	KS	KS	TX	WY
Lowest Percentage	WY	WY	CO	WY	CO	CO	NE	NE	WY	NE

From this perspective, the rankings for the strongly agree and agree categories shown in Table 2 indicate that Coloradans would be most impacted by an increase in the price of their municipal water, while Wyomingites would be the least impacted. On the other hand, residents of Wyoming are the most emphatic about short run price increases to address conservation during periods of drought, while Coloradans are the least energetic.

Long run regulation seems to be most tolerated by Wyomingites, and least tolerated by Nebraskans; on the other hand, respondents in New Mexico would accept long run prices increases more than respondents from other states, while Wyomingites seems to be least enthusiastic. However, the most consistency lies in the center of the rankings lists.

For instance, New Mexicans rank second in the categories of short run regulation, long run regulation, and short run price increases, and tops the list in long run price increase. These placements seem to indicate overall support for *any* measure that promotes conservation of municipal water. Results such as this may lead one to believe that overall, New Mexicans are the most conservation minded with regard to water resources. An alternative, although similar, reasoning may be that they think the abuse of municipal water is to such a degree that it requires a substantial response from state and local governments. Respondents from Kansas seem to rank in the upper three with regard to using price as a rationing mechanism, while Texans rank in the upper three with regard to using regulation as a rationing tool (seemingly contrary to the trust they have in their neighbors). Nebraskans consistently rank in the bottom three regardless if the category involves pricing or regulation. Results such as this may lead one to believe that Nebraskans are the least conservation minded with regard to water resources. And while the state-level results are interesting, they of course aggregate the outcomes across communities, thereby only allowing for a state-level decision for water policy prescriptions. More interesting would be out-of-sample forecasts of policy prescriptions at a more disaggregated community level.

Out-of-Sample Community-Level Policy Forecasts

Of particular interest are the out-of-sample predictions of how constituents would respond to the survey questions. The predicted probability for each response is calculated by assuming that on average, the constituents residing in the out-of-sample community are demographically similar to those in the in-sample communities within the state, but we inject the out-of-sample community data into the model via the z_{cs} variable. For instance, when calculating the predicted probabilities for Burlington, CO, community-level data will be held at their realized values, and the respondent-level values will be held constant at the means of the in-sample respondent-level data for the Colorado community that was surveyed. All values for respondents that do not live in Colorado are allowed to vary.

Table 3 lists the predicted probabilities in a way that is similar to Table 1, but the left hand column lists the out-of-sample communities we chose to investigate. These are Burlington, CO, Dodge City, KS, Plainview, TX, Hastings, NE, Wheatland, WY, and Clayton, NM. We chose these particular communities mostly based upon three criteria--one community from each state, three with a relatively large population, and three with relatively small populations. The policy prescriptions we can infer from these predictions are interesting.

Burlington, Colorado

Increasing prices on municipal water in Burlington, would have a substantial effect as there is a 13% chance someone would strongly agree with question (1), with an additional 57% chance that this person would agree with this statement. Combined with the fact that there is more than a 45% chance one would agree with a short-run price increase, residents in this community may not revolt if a price rationing policy were implemented during these periods with an appropriate marketing strategy. (The standards errors of the predicted probabilities for the short-run increase are rather large, implying that it could be the case that the respective probability could exceed 50%; of course, the opposite could be true as well.) But a long run pricing policy is probably not feasible without causing a community backlash with only 37% agreeable response for this particular policy proposal. Both short and long run regulation would be highly supported by the community, but, there is a 67% chance that a respondent would have little faith that their neighbors would actually follow the regulation. On the other hand, there is a 68% probability that a respondent would have confidence in their community officials to enforce regulatory policy. *The policy prescription for Burlington would be one of a temporary price increase during periods of drought, combined with regulatory water restrictions. The community should investigate a policy of long term regulation as well.*

Table 3: Out-of-Sample Predicted Probabilities

State	Response	Law of Demand		S. R. Regulation		S. R. Price Increase		L. R. Regulation		L. R. Price Increase		Ignore Regulation		Enforce Reg.	
		Prob.	S. E.	Prob.	S. E.	Prob.	S. E.	Prob.	S. E.	Prob.	S. E.	Prob.	S. E.	Prob.	S. E.
Burlington,	S A	0.126	0.026	0.182	0.038	0.067	0.015	0.083	0.020	0.040	0.010	0.096	0.022	0.092	0.020
CO	A	0.569	0.026	0.611	0.010	0.384	0.045	0.634	0.038	0.332	0.048	0.571	0.034	0.588	0.033
	D	0.283	0.045	0.163	0.031	0.448	0.039	0.257	0.047	0.548	0.040	0.308	0.049	0.277	0.042
	S D	0.020	0.005	0.043	0.011	0.098	0.022	0.023	0.006	0.078	0.018	0.023	0.006	0.041	0.010
Dodge City,	S A	0.093	0.012	0.203	0.021	0.063	0.009	0.061	0.009	0.030	0.005	0.106	0.014	0.091	0.012
KS	A	0.524	0.022	0.608	0.009	0.372	0.024	0.585	0.024	0.279	0.027	0.584	0.019	0.592	0.020
	D	0.354	0.028	0.149	0.015	0.458	0.020	0.318	0.026	0.587	0.019	0.287	0.027	0.275	0.025
	S D	0.028	0.004	0.039	0.006	0.105	0.012	0.034	0.005	0.101	0.014	0.021	0.003	0.041	0.006
Plainview,	S A	0.055	0.019	0.168	0.054	0.046	0.016	0.054	0.014	0.014	0.005	0.120	0.040	0.058	0.021
TX	A	0.428	0.072	0.609	0.016	0.313	0.067	0.572	0.066	0.163	0.050	0.601	0.037	0.508	0.071
	D	0.467	0.074	0.174	0.049	0.500	0.040	0.336	0.072	0.631	0.010	0.259	0.069	0.365	0.069
	S D	0.048	0.017	0.047	0.018	0.138	0.044	0.036	0.013	0.190	0.059	0.018	0.007	0.067	0.024
Hastings,	S A	0.093	0.012	0.259	0.027	0.090	0.012	0.062	0.009	0.035	0.005	0.051	0.007	0.119	0.016
NE	A	0.522	0.022	0.592	0.012	0.438	0.023	0.585	0.024	0.306	0.027	0.450	0.029	0.615	0.016
	D	0.354	0.029	0.118	0.014	0.396	0.024	0.318	0.027	0.568	0.021	0.451	0.030	0.231	0.024
	S D	0.028	0.004	0.029	0.005	0.074	0.010	0.033	0.005	0.089	0.012	0.047	0.007	0.032	0.005
Wheatland,	S A	0.047	0.012	0.382	0.057	0.057	0.014	0.104	0.024	0.034	0.008	0.027	0.007	0.127	0.030
WY	A	0.394	0.051	0.533	0.038	0.354	0.047	0.664	0.023	0.302	0.046	0.324	0.053	0.630	0.021
	D	0.500	0.049	0.068	0.019	0.473	0.036	0.212	0.041	0.573	0.035	0.567	0.042	0.213	0.041
	S D	0.056	0.014	0.015	0.004	0.113	0.025	0.018	0.004	0.090	0.020	0.081	0.020	0.028	0.007
Clayton,	S A	0.053	0.017	0.256	0.060	0.113	0.031	0.067	0.020	0.048	0.015	0.055	0.018	0.099	0.029
NM	A	0.421	0.065	0.600	0.022	0.479	0.044	0.607	0.047	0.371	0.063	0.472	0.066	0.603	0.038
	D	0.474	0.066	0.114	0.030	0.348	0.057	0.295	0.057	0.515	0.058	0.428	0.071	0.259	0.054
	S D	0.049	0.016	0.028	0.009	0.058	0.017	0.029	0.009	0.064	0.020	0.042	0.013	0.037	0.011

CO=Colorado; KS=Kansas; NE=Nebraska; NM=New Mexico; TX=Texas; WY=Wyoming; NM=New Mexico. SA=Strongly Agree; A=Agree; D=Disagree; SD=Strongly Disagree. Prob.=Predicted Probability; S.E.=Standard Error. S.R.=Short Run; L.R.=Long Run. Standard errors were calculated using the Delta method.

<u>Dodge City, Kansas</u>

Across the board, the predicted probabilities for Dodge City are nearly identical to those for Burlington, with the exception of how many claim they would be affected by a general price increase, and those agreeing with long run regulatory policy. There is only a 62% chance that someone in Dodge City, versus a nearly 70% chance in Burlington, would say that they would be affected by an increase in the price of municipal water. And a 7% lower chance that one would appreciate more long run regulation. With these exceptions, the policy prescription would be nearly the same as it is for Burlington. *The policy prescription for Dodge City would be one of a temporary price increase during periods of drought, combined with regulatory water restrictions. Long run regulatory policy should be investigated, although cautiously.*

<u>Plainview, Texas</u>

On the other hand, constituents of Plainview would respond quite differently to many of the questions we ask. In particular, there is less than a 50% chance that the constituents of Plainview would reduce their consumption of municipal water if the price were increased. And with only a 36% chance of approving of an increase during periods of drought, this policy is not an option; in fact, the percentage that someone would strongly disagree with this policy is almost 14%--the largest percentage of all communities. Regulatory policy in the short run remains agreeable; however, members of the Plainview community strongly believe that others in the community would ignore such restrictions. Thus, the burden of enforcement falls disproportionately on the various community agencies (of which the community sees as effective), substantially increasing the cost of overseeing such policy. There is support for long run regulation at nearly 63%, but the standard errors are rather large indicating that a thorough community-level study should be implemented to determine if this option is actually viable. Having said that, given the fact that there is a 72% chance that a respondent thinks their neighbors would ignore any regulation, the findings of such a study would likely indicate it is not. *The policy prescription for Plainview would be one of regulatory water restrictions during periods of drought. Long run regulatory* *policy is probably not an option for this community as it would likely be ignored, and the burden on the community agencies would likely be substantial.*

Hastings, Nebraska

With the exception of a permanent increase in prices, members of the community of Hastings would find all other options as quite agreeable. There is greater than a 61% chance that members of the community would be affected by an increase in the price of water. Furthermore, short run regulatory policy is supported with 90% acceptance, with a 65% chance that there is support for long run regulation. A short run price increase is supported with a 53% probability (although when standard errors are taken into consideration, proper marketing of such a plan would still be a good thing to do). There is only about a 50% chance one would believe that others in the community would ignore a regulatory prescription, and there is also a strong belief that community officials would enforce it. *The policy prescription for Hastings would be one of a temporary price increase during periods of drought, combined with regulatory water restrictions. The community should investigate a policy of long term regulation as well.*

Wheatland, Wyoming

The members of the Wheatland community would resoundingly prefer regulation over pricing. Firstly, there is only about a 44% chance that these residents would be affected by an increase in the price of municipal water. Secondly, there is only about a 41% chance that they would like to see prices increase during periods of drought; and lastly, there is nearly a 65% probability that they would vote against a permanent price increase. On the other hand, there is more than a 90% probability that they would agree with restrictions during drought, a 40% chance of strongly agreeing, and a 75% probability they would agree with using regulation on a long-term basis. Those in Wheatland also think that regulation would not be a large burden to community officials. *The policy prescription for Wheatland would be one of short and long-term regulation.*

Clayton, New Mexico

Constituents of Clayton would be roughly split in the reduction of water consumption if its price were increased. There is considerable support for short-run regulation and price increases to the tune of 86% and 59% agree probabilities respectively. Also important in these areas is the fact that there is roughly a 26% strongly agree probability of the former, and over 11% the latter. And while there is about 67% support for long-run regulation, there is little support for a long-run increase in prices at approximately 42%. However, the standard errors for this policy are rather large, indicating that the community may want to perform their own feasibility study to further investigate increasing prices. Members of Clayton have significant confidence in their officials to support regulation (by about 70%), but they also do not believe that other members of their community will ignore it either. In fact, they are about split on the issue of whether regulatory measures would be ignored. *The policy prescription for Clayton would be one of a temporary price increase during periods of drought, combined with regulatory water restrictions. The community should investigate a policy of long term regulation.*

Conclusion

With the quasi-finite water supply held in the Ogallala aquifer, combined with increasing corn and ethanol production, the 2.3 million residents on the aquifer's portion of the High Plains must take measures to identify new sources of water. With this in mind, conservation of current water becomes increasingly important. And while it is true that 95% of the water drawn from the aquifer is used for irrigation, making farmers predominantly liable for its conservation, it is also the case that communities need to conserve as well. The question then becomes what municipal water conservation options are available, what are the most efficient in terms of applicability and effect, and what are most acceptable by the general public.

The options that are available are regulation and price rationing. We made the argument above that regulation is less efficient than price rationing due to regulations' ease of circumvention, and its relatively high cost. Their effect and acceptability we modeled from the responses of a variety of phone survey questions from nearly 3,000 individuals across 29 communities. In short, our first finding is that price will indeed have an effect on water consumption, and short run pricing is not totally rejected by the populations of most communities. Furthermore, the need for long run regulation should be explored.

Our second contribution is the model we constructed to generate out-of-sample predictions of these effect and attitudes for communities that are on the Ogallala, yet outside of our sample. We believe that the model was successful in generating logical outcomes given the demographic heterogeneity in the region. Having said this, we also constructed a platform upon which others can model their own regions and areas. Our survey, combined with the out-of-sample econometric technique we used, is applicable anywhere the question of regulation versus pricing arises. There are many arid sections of the United States, as well as yearly droughts occurring in different regions. Surveys and analyses such as these are particularly useful in helping communities determine the more efficient course to take when implementing water conservation policy.

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