RECLAMATION
Managing Water in the West

The Influence of Rebates on the Purchase of and Willingness to Pay for Water Conservation Devices

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Executive Summary

Water conservation is an important factor in addressing water supply-demand imbalances in California and the rest of the western United States. Several approaches have been used by water agencies and municipalities to encourage the adoption of water saving devices and conservation practices, including financial incentives such as rebates to purchase water conserving devices. This analysis focuses on the effect of rebates on the likelihood of purchasing a “smart” timer or controller (smart timer) and the effect of rebates on the willingness to pay for a smart timer.

Smart timer and general socio-economic data were gathered by a consultant to the Metropolitan Water District of Southern California (MWD) using an online survey. The survey targeted single family detached home owners with a lot size less than one acre and who currently had an in-ground sprinkler system. A total of 500 questionnaires were completed and the data was provided to the Bureau of Reclamation by MWD. The survey included 31 questions related to the potential purchase of a smart timer, willingness to pay for a smart timer, motivation for purchasing a smart timer, assistance that would be useful in installing and using a smart timer, and demographic characteristics.

The survey data were used to estimate models of the likelihood of purchasing a smart timer and the willingness to pay for a smart timer. An ordered logit model was estimated to evaluate the factors that influence the decision to purchase a smart timer and an ordinary least squares model was estimated to evaluate variables influencing willingness to pay for a smart timer.

The results of the ordered logit model indicated that the cost of the smart timer and the age of the respondent/head of household both had a negative influence in the likelihood of purchasing a smart timer. The availability of a rebate, knowing that a smart timer could reduce water use by as much as 20%, the availability of an on-line video demonstrating the use of a smart timer, and income all had a positive influence in the likelihood of purchasing a smart timer.

The results of the willingness to pay model indicated that income, an email reminder of seasonal changes that change watering requirements, and knowing that a smart timer could reduce water use by as much as 20% all had a positive influence on willingness to pay. Age and choosing to water early in the morning both had a negative impact on willingness to pay. The availability of a smart timer rebate did not have a significant effect on willingness to pay.

The modeling results are useful in providing information on the factors that can influence the adoption of and willingness to pay for smart timers and, therefore, the extent to which water agencies can influence the use of smart timers. Providing rebates will increase the likelihood of purchasing a smart timer by lowering the pricing point of the device, but has no significant effect on the willingness to pay for the device. The modeling results also indicate that providing information and assistance on the effectiveness of smart timers in reducing water use and how to use smart timers can increase the likelihood of purchase and willingness to pay. Finally, an older population appears less likely to purchase a smart timer and is willing to pay less than a younger population. Therefore, rebates as well as information and assistance programs could be used to counteract the effects of an aging population on the adoption of water saving devices.

Introduction

Water conservation is an important part of the equation addressing water supply-demand imbalances in California and the rest of the western United States. California Senate Bill 7 (SB X7-7) set an overall goal of reducing per capita water use by 20% by December 31, 2020 and required incremental progress towards this goal (California Department of Water Resources, 2013). A minimum 10% reduction in per capita water use is required by December 31, 2015. The California Urban Water Conservation Council (CUWCC) was created to help increase water use efficiency through public-private partnerships with the goal to promote water conservation Best Management Practices (BMP's) as an important part of water planning (California Urban Water Conservation Council, 2013). Water conservation BMP's can help water agencies meet the 20% reduction by 2020 mandate. One of the BMP's specifically included in the BMP list is water efficiency improvement devices.

Several methods have been used by water agencies and municipalities to encourage the adoption of water saving devices and conservation practices. Some of these methods include mandatory and voluntary outdoor watering restrictions, plumbing codes that require the use of low flow fixtures, tiered pricing schedules that increase the price per unit of water as water use increases, the use of water budgets to determine the amount of water required for a particular household based on the characteristics of the home and lot, and providing financial incentives such as rebates to purchase water conserving devices. This analysis focuses on the effect of rebates on the likelihood of purchasing a "smart" timer or controller (smart timer) and the effect of rebates on the willingness to pay for a smart timer.

Smart timers are controllers that automatically change the watering schedule to account for changes in water needs throughout the year. There is a wide variety of smart timers that use different sources of weather data to determine when and how to adjust the watering schedule. Different sources of information used to adjust the watering schedule include the following.

1. Historical weather and water use data for a specific area to determine the typical amount of water required for a particular time.
2. Historical data with a sensor, usually a temperature sensor. The historical data is used to determine an initial reduction in watering time, but then water use is further adjusted based on sensor readings.
3. Use of off-site data, where water and weather data is provided remotely. The controller uses a radio, internet, or phone connection to obtain the data from either a central data provider or a local weather station.
4. Use of a weather station that is installed with the controller. The weather station provides real-time data from the weather station to adjust the watering times.
5. Use of moisture sensors, where sensors are placed under the irrigation system to measure the actual amount of moisture in the soil. Irrigation time is based on the amount of moisture present.

The cost of a smart timer can range from less than $100 to several hundred dollars, depending on the features and the source of smart timer information.

Background and Source of Data

A great deal of work has been done addressing potential water use reductions from implementation of water saving devices such as smart timers. Examples of these studies include a comparison of different brands and types of timers (Irrigation Association, 2013), reviews of various smart controller study results (U.S. Bureau of Reclamation, 2008), and water use and water quality effects of smart timers (Kennedy/Jenks, 2008). However, this analysis looks at the potential factors influencing the purchase of a smart timer as well as the willingness to pay for a smart timer. These are important considerations in the ability to meet water conservation goals because the conservation program will be more effective in reducing water use if barriers to smart timer adoption are identified and addressed.

Smart timer and general socio-economic data were gathered by Hardwick Research through the use of an online survey. The survey was funded by the Metropolitan Water District of Southern California (MWD). Survey invitations were sent to 54,495 households who were members of a panel that receives periodic emails to participate in survey opportunities. The target population for the survey was single family detached home owners who live in Zip Codes within the MWD boundaries. In addition, in order for a household's questionnaire to be included as part of the survey database, the lot size of the home must be less than one acre and the yard must have an in-ground sprinkler system. This sub-group of residents was identified as the group that would potentially provide the greatest water-saving benefit from implementation of programs and policies aimed at increasing the use of smart timer technology.

Of the 54,495 households contacted, 1,834 chose to take the survey. Of those who chose to take the survey, 500 actually met the target population qualifications. The survey data was collected over the period of December 8 through December 16, 2011. This data set was provided to the Bureau of Reclamation by MWD. Since all of the households surveyed were home owners, each respondent would be responsible for paying their own water bills and would have information available to them regarding the cost of water and water use. This information is likely to be an important part of the decision to purchase a water-saving device assuming a home owner will balance the benefits and costs of such a purchase.

The primary goal of the survey was to gain a better understanding of the attitudes of households regarding the purchase of smart timers and the characteristics of these households. A total of 31 questions were asked regarding:

- type of home and yard
- type of sprinkler system and timer
- number of days spent watering
- sprinkler timer features
- where a smart timer would be purchased
- where to get information about a smart timer
- smart timer costs and willingness to pay for a smart timer
- likelihood of buying a smart timer at different costs
- what kind of help would be needed to install and use a smart timer
- motivation for buying a smart timer and watering efficiently

- activities used to improve water use efficiency
- economic and demographic household questions

It should be noted that all of the survey questions were not answered by all 500 survey respondents. For example, 422 of those surveyed responded to the question asking how likely they were to purchase a smart timer given a specific price point. Only 309 responded to the question asking for the willingness to pay for a smart timer and 292 of those surveyed could provide an estimate of what a smart timer costs.

Rather than simply evaluating household attitudes as reflected by patterns of answers determined by correlation analysis, this analysis estimates models looking at the factors that influence the likelihood of purchasing a smart timer and factors that influence the willingness to pay for a smart timer. Factors included in the likelihood analysis of smart timer purchases are the availability of rebates, price, motivation for buying a smart timer, and socio-economic variables. One important use of the estimated model is to evaluate the potential influence of rebates and other factors that could be influenced by water agencies on the likelihood of purchasing a smart timer.

The willingness to pay model includes watering practices, availability of a rebate, motivation for purchasing a smart timer and socio-economic variables to explain the magnitude of willingness to pay. The likelihood of purchasing a smart timer and the willingness to pay for a smart timer are closely related because price is one of the variables that influence the smart timer purchase decision and willingness to pay represents a pricing limit. The results from both models can be used to help understand the influence of rebates and other factors on smart timer purchases and the resulting effects on water conservation.

Modeling the Likelihood of Purchasing a Smart Timer

One of the questions included in the Hardwick research survey asked about the likelihood of purchasing a smart timer at different price points on a scale of 1 to 5, where a 1 response indicates the household is not at all likely to purchase a smart timer at a given price and a 5 indicates the household is very likely to purchase a smart timer. Prices of $100, $150, $200, $300, or $400 were provided in the questionnaires for respondents to react to. These prices can be interpreted as a proposed purchase price or price point. Each questionnaire included one of the five prices to which the respondent indicated their likelihood of paying that price. Of the 422 responses to the likelihood of purchasing a smart timer question, 90 had a price point of $100, 80 had a price point of $150, 88 had a price point of $200, 77 had a price point of $300, and 87 had a price point of $400.

The likelihood response can be modeled as the dependent variable in a model of the probability of a household purchasing a smart timer. The price point is one of the independent (explanatory) variables included in the model to explain the likelihood of a smart timer purchase. Other factors represented by responses to questions included in the survey questionnaire can be used in the model of the likelihood of purchasing a smart timer. Some of these factors are discussed below.

The survey questions included a great level of detail regarding current sprinkler timer characteristics such as location and features, sprinkler settings, who operates the timer, where the timer would be purchased, and where to get information regarding smart timers. These types of questions, while very relevant when looking at the practical aspects of purchasing and using smart timers, are not likely to be as relevant in the actual purchase decision. Responses related to questions regarding motivation for purchasing a smart timer (e.g. reducing water use, availability of a rebate, saving money, environmental considerations) and sources of help in increasing landscape watering efficiency (e.g. how to videos, website instructions, instruction booklets) were considered for inclusion in the probability model. The existence of current mandatory watering restrictions was also considered for inclusion in the model. In addition, socio-economic variables (household income, education level, and age and sex of household respondent) were considered to account for differences in household characteristics. Finally, average annual precipitation and temperature variables were considered to account for cross sectional differences in climate. It should be noted that the climate variables represent differences in average climate and may not be representative of the actual period when the survey was implemented.

As discussed above, the model of the smart timer purchase decision includes the likelihood of purchasing a smart timer as the dependent variable. As a dependent variable, the likelihood of purchase has some unique characteristics that complicate modeling. First, the likelihood variable is discrete and bounded. Therefore, modeling likelihood as a continuous and unbounded variable could result in infeasible estimates and biased results. Second, the order of the variable has meaning and it can be assumed that the differences between numbered responses have similar meaning. In other words, the difference in the likelihood of purchasing a smart timer represented by a change from 1 to 2 is similar to the difference of a change from 3 to 4. Last, the dependent variable represents a probability of something occurring (in this case the purchase of a smart timer). Therefore, the coefficients of the explanatory (independent) variables can be interpreted as the influence of the variable on the probability of purchasing a smart timer. The most important characteristics of the coefficients are the sign and statistical significance.

In order to account for the unique characteristics of the dependent variable, an ordered logit model is estimated. An ordered logit model uses maximum likelihood methods to find a combination of regression model coefficients that best predict values of the probability that the dependent variable falls into one category rather than another. The probabilities are modeled using a logistic function, which is characterized as an S-curve representing values between 0 and 1.

It is assumed in ordered models that there is an underlying, unobservable true outcome variable, occurring on an interval scale. The interval-level information about the outcome is not observed, but it is known if the unobserved value crosses some threshold that puts the outcome into a lower or higher category. These categories are ranked, therefore ordinal but not interval-level information is revealed and the ordinal information is the basis for the estimated model.

An ordered logit regression essentially runs multiple equations, with the number of equations equaling one less than the number of options on the scale of the dependent variable. As a result, ordered logit models generate “cut point” estimates. These cut points represent an estimate of the value and significance between the categories of the dependent variable. For example, assume that the dependent variable is ranked on a 5 point scale. The first equation compares the likelihood that $y = 1$ and that $y \neq 1$, that is $y = 2, 3, 4$, or 5. The second equation compares the likelihood the $y = 1$ or 2 to the likelihood that $y = 3, 4$, or 5. The third equation compares the likelihood the $y = 1$ or 2 or 3 to the likelihood that $y = 4$, or 5. Finally, the fourth equation compares the likelihood the $y = 1$ or 2 or 3 or 4 to the likelihood that $y=5$. The cut points represent comparisons of likelihood. It should be noted that ordered logit regression modeling reports only one coefficient for each independent variable. The model constrains the coefficients to be constant across all categories.

Descriptive Results for the Likelihood of Purchasing a Smart Timer

Descriptive survey results regarding the likelihood of purchasing a smart timer can help in the evaluation of the modeling results. Observed patterns should be reinforced by the modeling results. Table 1 shows a simple comparison of purchasing likelihood percentages for different smart timer costs. A total of 422 of the surveyed households responded to the likelihood question. The cost of the smart timer represents the pricing point presented to a survey respondent in their specific questionnaire. The N in Table 1 represents the number of observations for each category of costs.

Table 1 – Likelihood of purchasing a smart timer at different timer prices

Likelihood of purchasing a smart timer	**Cost of smart timer**				
	\$100 (N=90)	**\$150 (N=80)**	**\$200 (N=88)**	**\$300 (N=77)**	**\$400 (N=87)**
1 = Not at all likely	10.7%	19.5%	26.8%	46.6%	52.4%
2	15.5%	19.5%	25.6%	21.9%	17.8%
3	22.6%	45.5%	23.2%	15.1%	21.4%
4	25.0%	6.5%	14.6%	8.2%	3.6%
5 = Very likely	26.2%	9.0%	9.8%	8.2%	4.8%

The data presented in Table 1 indicates that beyond a timer cost of \$100 the likelihood of purchasing a smart timer shifts from a relatively high likelihood to a relatively low likelihood of purchasing. As would be expected, a higher smart timer cost results in a greater percentage of respondents that are not likely to purchase a smart timer. However, the comparison of percentages does not quantify the extent of this relationship and does not account for other factors that may have a significant influence on the smart timer purchase decision.

The Estimated Model of the Likelihood of Purchasing a Smart Timer

A wide range of potential explanatory variables were considered, as mentioned above in the discussion of survey questions, and were included in the model that was initially estimated. The online survey included questions regarding nine different types of help that could be provided to assist in the use of smart timers (such as on-line videos and providing instruction booklets) and ten different potential motivations for using less water (such as mandatory water restrictions or to save money). Respondents were asked to indicate which type of assistance would be useful to them and what would motivate them to purchase a smart timer. They could answer yes to more than one type of assistance and motivation. Each of these assistance and motivation categories could be included as explanatory variables in the model estimating the likelihood of purchasing a smart timer. The initial model included smart timer cost, availability of a smart timer rebate, number of days and time of day watering, five different types of help that would be needed to install and adjust a smart timer, five different motivations for buying a smart timer and watering efficiently, and temperature and precipitation variables indicating if the respondent zip code is above or below the average for the group of respondents. The types of help and motivation for purchasing a smart timer were all included as dummy variables, where a value of 1 indicates a condition exists and a value of 0 indicates a condition does not exist. For example, if an individual believes that an on-line video would be useful in using a smart timer than the on-line video variable would take on a value of 1.

The initial modeling results indicated that there were several collinear and insignificant explanatory variables. Variables are collinear when they are highly correlated, meaning that they tend to move together over a set of observations. Including a set of collinear explanatory variables in an econometric model leads to a problem called multicollinearity. This is a problem because the individual influence of the collinear variables on the dependent variable cannot be separated from each other and it becomes impossible to determine the influence of individual explanatory variables on the dependent variable, so the individual coefficient estimates may be inaccurate. An example of two collinear variables is education and income, where those with higher levels of education tend to also have higher incomes. A common solution is to combine collinear variables into one variable or to drop variables if they cannot be combined. The collinear variables were mostly dummy variables and combining such variables is not an option, so these variables were dropped from the model.

An interesting result of the initial model was that the effect of the potential for increased water rates in the future was not a statistically significant variable in explaining the likelihood of purchasing a smart timer. It would be expected that future increased rates would encourage the use of smart timers, but perhaps increasing rates have to occur before the switch to smart timers takes place.

Finally, the zip code level precipitation and temperature variables were dropped from the model because they were poor indicators of the actual difference in climate experienced by the households surveyed. First, the climatic data represented annual averages and not specific conditions during the period when the households were surveyed. Second, there was very little variation in temperature and precipitation for the zip codes represented in the survey, so variation in the influence of climatic variables on the likelihood of adopting smart timers to reduce water consumption is also likely to be small. It is likely that the climatic data are not site specific enough to capture differences between household locations.

The highly insignificant and severely multi-collinear variables were dropped from the estimated model. The final model used to estimate the likelihood of purchasing a smart timer is shown below. A total of 400 observations included responses to all of the variables included in the likelihood model.

Likelihood of smart timer purchase = f(timer cost, available smart timer rebate, on-line video, knowing that a smart timer could reduce water use, age, income) (1)

Where:

Timer cost = The cost indicated in the questionnaire for a smart timer that the respondent reacts to for likelihood of purchasing a smart timer.
Available smart timer rebate = Available smart timer rebate as a motivation (1=yes, 0=no).
On-line video = On-line video available to help water landscape efficiently (1=yes, 0=no).
Knowing that a smart timer could reduce water use = Knowledge that use of a smart timer could reduce water use by as much as 20%? (1=yes, 0=no).
Age = Age of respondent, head of household.
Income = Household income based on mid-point of ranges presented in the survey.

Timer cost

Timer cost is expected to have a negative impact on the likelihood of purchasing a smart timer. A higher timer cost would reduce the incentive for a household to make that investment.

Available smart timer rebate

The availability of a smart timer rebate would effectively reduce the cost of a smart timer and would therefore be expected to have a positive influence on the likelihood of purchasing a smart timer. The smart timer rebate question was a yes/no question with no rebate amount provided. However, there was a follow-up question asking for a rebate amount that would be needed to purchase a smart timer. A total of 164 respondents, or 41% of the total, indicated they required a rebate to purchase a smart timer. The average rebate identified for the 400 observations included in the likelihood of purchasing a smart timer model data set was $91.33. Therefore, if it is assumed that the average respondent would expect a rebate that would be equal to an amount needed to change purchasing behavior, the existence of a rebate could be equivalent to a cost reduction of about $90.

On-line video

The existence of an on-line video to help customers use their smart timers would be expected to have a positive impact on the likelihood of purchasing a smart timer. This essentially represents a reduced cost and improved effectiveness of implementing smart timer technology.

Knowing that a smart timer could reduce water use

Knowledge of potential water savings of 20% from using a smart timer would be expected to increase the likelihood of purchasing a smart timer because this represents knowledge of the benefits provided by a smart timer. Otherwise only the costs of a smart timer may be known by the respondent. Income is clearly expected to have a positive effect on the purchase of a smart timer because a greater income increases the ability to pay for all goods and services, including smart timers.

Age
There is no prior expectation of the influence of age on the purchase of smart timers. It is possible that someone who is older may be less likely to change their habits than a younger person. However, use of a smart timer may be seen as reducing the amount of time and effort needed to water.

Income
It is expected that income will have a positive effect on the likelihood of purchasing a smart timer because higher income will increase affordability. The income categories included in the survey were less than $30,000, $30,000 to $49,999, $50,000 to $74,999, $75,000 to $99,999, and $100,000 or more. For income less than $30,000 a value of $15,000 was used and for greater than $100,000 a value of $120,000 was used. The mid-point of the range was used for all of the other income categories.

Modeling Results
There were 400 survey observations used to estimate the model because 100 of the observations did not include responses to all of the variables included in the ordered logit model. The modeling results are shown below in Table 2.

Table 2 – Smart timer ordered logit modeling results

Independent Variable	Coefficient	z-statistic	Level of significance
Timer cost	-0.007493	-7.30	1%
Smart timer rebate	0.758887	2.33	2%
On-line video	0.516508	2.57	1%
Income	0.000008	2.65	1%
Knowing a smart timer can reduce use by 20%	1.212201	4.70	1%
Age	-0.019171	-2.47	1%
Cut point 1	-1.822573	-3.22	1%
Cut point 2	-0.733418	-1.32	Not significant
Cut point 3	0.690086	1.24	Not significant
Cut point 4	1.662429	2.93	1%

Interpreting the Likelihood of Purchasing a Smart Timer Modeling Results

A statistic that is frequently used to evaluate regression models is the adjusted R^2. The adjusted R^2 indicates how well an estimated line or curve fits the observed data and essentially measures the amount of variation that is explained by the model. The adjustment is based on the number of explanatory variables in the model. An adjusted R^2 statistic is not produced by ordered logit model regression but a comparable pseudo R^2 statistic is generated by EViews8 (HIS Global

Inc.,2013). The estimated pseudo R^2 was 0.11 and can be interpreted in essentially the same way as the adjusted R^2statistic.

Another method that can be used to evaluate the performance of an ordered logit model is through the use of a prediction evaluation, or the predicted response based on the estimated model for each observation. EViews8 performs the classification based on the response category with the maximum predicted probability. For example, if the probability of category 1 is estimated to be 0.1, category 2 is 0.3, and category 3 is 0.6, then the result is predicted to be category 3. The percentage of correct predictions can then be compared to a constant probability model specification where it is assumed that none of the estimated coefficients have any influence on the probability of purchasing a smart timer. The percentage of correct predictions from the model was 42.75% compared to 31.0% for the constant probability model. This is a typical result for this type of model with a relatively small sample size. The percentage of correct predictions indicates there are many other factors that influence the decision to purchase a smart timer, but those factors included in the model improve the prediction of the correct outcome compared to a naïve assumption that all outcomes are equally likely.

The significance of the overall relationship between the independent variables and the dependent variable can be evaluated in the ordered logit model by calculating log-likelihood ratios. This ratio is calculated as the difference between the log likelihood statistic for the estimated model and a model assuming the value of all explanatory variables is zero and multiplying by 2. This ratio can then be compared to critical chi-squared values. The calculated log-likelihood ratio is 137.8, which is statistically significant at the 1% level of significance. This is similar to the use of the F-statistic in ordinary least squares modeling to test the significance of the model as a whole.

The estimated effect of individual explanatory variables on the dependent variable is interpreted a little differently than for typical regression results. The coefficients for a logistic regression indicate the effects of a unit increase of the explanatory variable on the log odds of the dependent variable taking a higher value, not on the dependent variable itself, given the other variables are held constant in the model. Therefore, Table 2 indicates that if the cost of a smart timer were to increase by $1, the log-odds of being in a higher category of likelihood to purchase a timer would decrease by 0.0075. The z-statistics indicate the statistical significance of individual variables in explaining the dependent likelihood variable.

As discussed above in the modeling section the cut points represent an estimate of the value and significance between the categories of the dependent variable. The results indicate that there is a significant difference in likelihood between the likelihood represented by 1 and likelihoods represented by 2, 3, 4, or 5 and likelihoods represented by 1, 2, 3, or 4 and the likelihood represented by a 5. Other categories of comparison did not indicate a significant difference.

The modeling results indicate that the cost of the smart timer and age both have a negative effect on the likelihood of purchasing a smart timer. The cost result was expected and the age result may simply indicate an unwillingness to convert to new technology at a higher age. The existence of a smart timer rebate, an available on-line how-to smart timer video, and knowing a smart timer can reduce water use by 20% all have a positive influence on the likelihood of purchasing a smart timer. These all have the effect of reducing smart timer cost or simplifying the conversion to a smart timer. Income had a significant positive effect on the likelihood of purchasing a smart timer, as expected. An interesting interpretation of the modeling results is that the effect of a rebate on likelihood of purchasing a timer is equivalent to an average price reduction of $101. The survey data indicated that for those who indicated a rebate was needed to purchase a smart timer, the average required rebate was $91.33. These results would seem to be very consistent.

Modeling the Willingness to Pay for a Smart Timer

Willingness to pay can be generally defined as the value placed by an individual on a good or service in monetary terms. A market demand curve for a good is derived from what individuals are willing to pay for that good. This analysis uses individual estimates of willingness to pay combined with socio-economic and attitude data to evaluate the factors that appear to influence willingness to pay. This information could be useful in understanding changes in willingness to pay that would be expected to occur over time and in developing strategies to increase willingness to pay.

One of the survey questions asked what the respondent was willing to pay for a smart timer. Willingness to pay can be modeled as a function of socio-economic variables such as household income, age, education, and gender as well as other variables that represent conditions or attitudes that could influence willingness to pay. Some variables included in the survey questionnaire that were considered for the model included the existence of mandatory watering restrictions, the existence of smart timer rebates, actions taken by the household to reduce water use (increase efficiency), and motivation for the household to reduce water use. All of these variables represent attitudes or household characteristics that could influence the desire to purchase a smart timer (or the utility derived from purchasing a smart timer) and would therefore influence willingness to pay.

The willingness to pay model is estimated using ordinary least squares, with the non-dummy variables (for example willingness to pay and income) converted into natural logs. This transformation into natural logs is frequently used to estimate water demand relationships. Dummy variables take on a value of 1 when a condition exists (for example, a smart timer rebate is available) and 0 when a condition does not exist (a smart timer rebate is not available). The coefficients for variables converted into natural logs represent an elasticity, which measures the effect of the independent variable on the dependent variable which is also converted into logs.

Descriptive Results of Willingness to Pay

The survey questionnaire included a question asking respondents to estimate the cost of a smart timer as well as their willingness to pay for a smart timer. A total of 309 survey respondents provided willingness to pay responses and 292 respondents provided an estimate of what they thought a smart timer would cost. The average willingness to pay for all those responding to the willingness to pay question was $109.31 and the average estimate of what a smart timer would cost was $119.62. On average the willingness to pay for a smart timer was $10.32 less than the estimated cost of a smart timer. In other words, the average willingness to pay was $31.75 less than the estimated smart timer cost. The difference between the average willingness to pay and average estimated smart timer cost is not the same as the average difference between willingness to pay and smart timer cost because several respondents were able to estimate willingness to pay but could not estimate the cost of a smart timer and vice versa. A total of 261 respondents answered both questions. The average willingness to pay for those who answered both questions was about $144 and the estimated cost of a smart timer for those who answered both questions was $172, a difference of $28. These simple descriptive results indicate a rebate would be needed to bridge the gap between average willingness to pay and estimated average cost regardless of the subgroup considered.

The Estimated Model of Willingness to Pay For a Smart Timer

Similar to the model estimating the likelihood of purchasing a smart timer, several potential explanatory variables were considered and included in preliminary estimated models. Insignificant and severely multi-collinear variables were dropped from the estimated model. The final model used to estimate the willingness to pay for a smart timer is shown below.

Willingness to pay for a smart timer = f(income, age, email season reminder, water in morning, knowing that a smart timer could reduce water use, available smart timer rebate) (2)

Where:

- Income = Household income based on mid-point of ranges presented in the survey.
- Age = Age of respondent, head of household.
- Email season reminder = Landscape watering efficiency could be improved with an email reminder to change sprinkler timer setting seasonally (1 = yes, 0 = no).
- Water in morning = How often do you water yard before 8am? (1 = sometimes or always, 0 = occasionally or never).
- Knowing that a smart timer could reduce water use = Knowledge that use of a smart timer could reduce water use by as much as 20%? (1=yes, 0=no).
- Available smart timer rebate = Available smart timer rebate as a motivation (1=yes, 0=no).

The income categories are the same as was described in the likelihood of purchasing model. It is expected that income will have a positive impact on willingness to pay since paying for a smart timer is less of a burden with more income. The expected effect of age on willingness to pay is uncertain, although an older person may be less likely to want or accept change in something that has been done in the past (a negative coefficient). An email season reminder is interpreted as a way to improve landscape watering efficiency, which frees up some available income. The expected coefficient is therefore positive. Watering in the morning could both be interpreted as an action already taken to reduce water use, so the respondent may not be willing to take on the additional cost, or burden, of purchasing a smart timer. A negative coefficient would be expected for the water in morning variable. Knowing a smart timer could reduce water use by 20% is an indication of information that would increase the value of a smart timer. Therefore, the expected sign for this variable would be positive. The existence of a smart timer rebate would be the equivalent of an increase in income, which should have a positive influence on willingness to pay.

Econometric Issues and Willingness to Pay Modeling Results

Education was initially included as an explanatory variable for willingness to pay, where education represented an overall understanding of the potential benefits of a smart timer. However, an initial run indicated a problem with multicollinearity. As mentioned above multicollinearity refers to the case where some of the independent (explanatory) variables in an estimated model are highly correlated. In the case of perfect multicollinearity, two or more variables are an exact linear function of one or more of the independent variables. Imperfect multicollinearity means that the relationship between two or more variables is not exact, but it is strong enough to influence the variance and standard errors of the estimators and will make it difficult to determine the separate effects attributable to each explanatory variable.

One method for detecting multicollinearity when using ordinary least squares is the use of Variance Inflation Factors (VIFs). VIFs are a method of measuring the strength of collinearity between the independent variables in an equation. VIFs show how much of the variance of a coefficient estimate has been inflated due to collinearity with the other regressors. They can be calculated by simply dividing the variance of a coefficient estimate by the variance of that coefficient had other regressors not been included in the equation.

The VIF test indicated that both income and age have potential multicollinearity problems associated with the other explanatory variables as a group. In addition, simple correlation coefficients were also estimated for education, income, and age as an additional indicator of possible multicollinearity. The simple correlation coefficient between education and income is 0.362 and the correlation coefficient between income and age is -0.091. A correlation coefficient of 0.1 is considered to represent a small amount of correlation, 0.3 is considered moderate correlation, and 0.5 a large amount of correlation (Cohen, 1988). A value of 1.0 indicates two variables are perfectly correlated. Therefore, multicollinearity is likely to be a problem for education and income. In addition, it was decided that the level of education attained may be a poor proxy for knowledge of smart timers since that knowledge is more related to specific research and experience rather than formal education. Therefore, education was dropped as an explanatory variable.

Another potential problem of concern for the estimated model was heteroskedasticity. One of the general assumptions that must be met when applying ordinary least squares is that the variance in the error of the estimated dependent variable is constant across all observations. In other words, the amount by which the model willingness to pay is underestimated or overestimated compared to the observed willingness to pay is constant for all observations. Heteroskedasticity occurs when the variance of the error term is not constant for all observations and the consequence is that tests of significance are unreliable. Heteroskedasticity is frequently a problem with cross-sectional data.

Heteroskedasticity was tested for the willingness to pay model using two tests, the Breusch-Pagan-Godfrey test and the White test. Both tests indicated that heteroskedasticity is a problem. Heteroskedasticity is similar to multicollinearity in that the tests of significance of individual coefficients are no longer reliable. However, heteroskedasticity creates a more serious issue because the tests of significance are biased in the direction of inflating significance. In other words, a coefficient may appear to be statistically significant when heteroskedasticity exists when in fact the coefficient is not statistically significant. The heteroskedasticity problem is addressed by estimating White heteroskedasticity-consistent standard errors and t-statistics available in EViews8. The corrected standard errors are adjusted to account for heteroskedasticity and the resulting t-statistics are adjusted downward to better indicate statistical significance.

The willingness to pay model was estimated using the 309 survey observations for which data were available for all of the model variables. The willingness to pay modeling results are shown below in Table 3.

Table 3 – Willingness to pay for a smart timer modeling results

Independent Variable	**Coefficient**	**t-statistic**	**Level of significance**
Intercept	3.159545	-	-
ln Income	0.266737	3.66	1%
ln age	-0.525316	-2.35	2%
Email season remainder	0.563969	1.96	5%
How often water in morning	-0.118399	-2.52	2%
Knowing a smart timer will reduce use	0.444143	2.73	1%
Available smart timer rebate	0.069146	0.91	Not significant

The adjusted R^2 for the willingness to pay model was 0.20, indicating 20% of the variation in willingness to pay was explained by the model. The F statistic for the model was 13.98, indicating the overall model was statistically significant and each of the explanatory variables were statistically significant except for the available smart timer rebate variable. Each of the significant variables had the expected coefficient sign. The coefficient for income was approximately 0.27, which can be interpreted as an income elasticity. A 1% increase in income is estimated to increase the willingness to pay for a smart timer by 0.27%. The results also indicate that an email reminder on the change in watering season and improving information on the potential water savings from using smart timers can be effective in increasing willingness to pay for smart timers. The results also indicate that as the population gets older the willingness to pay for smart timers would tend to decrease. Finally, the availability of a rebate does not appear to have a significant effect on willingness to pay for smart timers. It appears that households are consistent in defining willingness to pay as a set value or benefit from a smart timer and the rebate is seen as a supplement to income that could be used for any good or service separate from the smart timer. Therefore, the effect of any rebate provided on willingness to pay would be through the income variable.

Summary and Policy Implications

The successful implementation of a water conservation plan through the use of increased efficiency devices requires knowledge of essentially two different pieces of information. First, what are the factors that influence the decision to purchase a water conservation device? Clearly the price of the device is one very important factor in that decision. It is expected that the higher the price the lower the likelihood of purchasing a water conservation device, all other factors held constant. Rebates can increase the likelihood of purchasing a water saving device by reducing the effective price of those devices. Second, what is the willingness to pay for water conservation devices? If the willingness to pay of the device is less than the cost, then a rebate or some other type of supplement to willingness to pay is needed to encourage the purchase of a water saving device.

The results of the likelihood of purchasing a smart timer model provide information that can be used to evaluate the effects of several variables, including rebates, on the decision to purchase a smart timer. These effects can be separated into variables that are influenced by water agency policies and variables that are not under water agency control. Household income is primarily influenced by macroeconomic conditions, state and regional business and financial decisions, and individual preferences. The age of the head of household is one component of demographic change that is potentially influenced by factors such as patterns of in and out migration and quality of health care. However, there are significant factors that are under the control of water agencies that can be used to change the likelihood of purchasing a smart timer and therefore change water usage patterns. These include the availability of a smart timer rebate, the provision of on-line how-to videos, and improving knowledge about the amount of water that can be saved using smart timers. The smart timer rebate provides a focus on smart timers as a water conservation option, lowers the effective cost of a smart timer, and to some extent can increase household income.

The willingness to pay for water conservation devices has an impact on adoption of new water conservation technology through the acceptability of different pricing points. The results of the willingness to pay model indicate a smart timer rebate does not have a significant effect on willingness to pay. However, water agency policies and programs that provide email reminders on changes in irrigation requirements (irrigation season) and encourage early morning watering can influence willingness to pay. Income and age were also significant variables in explaining willingness to pay. These variables are outside the influence of water agencies but can be monitored by water agencies to account for expected changes in willingness to pay for a smart timer over time.

Although this analysis focuses on smart timers as a water conservation device, the results can be generalized to other types of devices as well. Water users will have an increased likelihood of purchasing any type conservation device at a lower price, or with the availability of a rebate, because the trade-off between cost of the device and the money saved due to the device is reduced. For those that purchase a water saving device to conserve water for the social good rather than for financial reasons, they will have a reduced income constraint with the availability of a rebate. Additional research using data for other water saving devices is needed to determine if the smart timer results are generalizable to different types of conservation devices.

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Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.