On Consumers' Attitudes and Willingness to Pay for Improved Drinking Water Quality and Infrastructure

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There is a significant interest in values that consumers place on water quality and drinking water infrastructure. Problems with drinking water infrastructure threaten the safety, quality and health values of drinking water for the public. Recently the failure rate of home and/or public infrastructure has increased in certain areas (Bosch et. al., 2006), causing consumer concerns. Consumers have reported an increasing number of leaks in drinking water pipes due to copper corrosion as well as breaks in the water main due to aging and deteriorating public infrastructure that affect water quality and water service. These failures have been geographically uneven with certain areas facing significantly higher incidence of problems (Scardina, et al. 2008).

Leaks in water mains and household water systems may result in increased public health risks such as water-borne disease in addition to degraded water taste, odor, and/or appearance. A national survey by the Water Quality Association (2001), determined that 86 percent of Americans are concerned about the quality of their tap water. Additionally, the survey found that 41 percent use water treatment devices in their homes or bottled water or both. Preventive measures are necessary to avoid water contamination and leakage that may result in serious health risks associated with medical costs. The water infrastructure in the US is in immediate need for investment (Clark et. al., 1999). A survey by the Environmental Protection Agency (US EPA, 1997) determined that community systems nationwide have an urgent need for $12.1 billion in water infrastructure investment mainly to protect from contaminants that might create serious health risks and to assure continued compliance with the Safe Drinking Water Act. In addition, $130 billion are required to maintain and replace existing infrastructure.

Brongers (2002) states that in the US alone 10-32% of the public drinking water infrastructure value is lost to corrosion, costing approximately $22 billion per year. The cost is nearly twice that for corrosion to private drinking water infrastructure including residential, commercial, and school buildings (Edwards, 2003).

Efficient investments in public infrastructure need to reflect the value that the user of such infrastructure places on the resulting improvements. Previous research has mainly focused on water quality improvements, in particular on contamination of groundwater from agricultural activities or the quality of recreational water (Desvousges et. al., 1987, Jordan and Elnagheeb, 1993, Powell et. al., 1994, and Poe and Bishop, 1999). Research on issues regarding water infrastructure in the US has primarily examined its condition and estimated the costs of maintenance and new investments necessary. To our knowledge little research is conducted on consumers' willingness to pay for improvements in drinking water infrastructure and/or water quality, even though the maintenance and replacement of public infrastructure is considered to be one of the major challenges related to drinking water in the 21st century (Clark et. al., 1999). In addition, little empirical research has focused on examining consumers' perceptions and attitudes regarding drinking water and their behavior to avert these concerns.

The objective of this paper is to examine the effects of consumer risk perceptions and sources of information on their willingness to pay for improved water quality and related infrastructure improvements. The analysis examines the extent and sources of consumer information about water quality and infrastructure, the relative advantages of different ways of providing such information, and their effects on consumer attitudes and subsequent willingness to pay. The analysis is based on data from a survey of Northern Virginia and Maryland suburbs of Washington DC. Results provide insightful information to policymakers and water utilities regarding consumers' perceptions and willingness to support programs aimed at improving drinking water quality and infrastructure.

Conceptual Model

The theoretical model in this paper is based on a model of the consumer decision process developed by Engel, Blackwell and Miniard (1986) (EKB model). This model is traditionally used in studies of market behavior and consumer choices. It describes consumer behavior in five main stages consisting of problem recognition, information searching, information processing, evaluating alternatives and making a choice.

The original model is revised to illustrate consumers' information searching and processing regarding concerns of water quality and infrastructure, and the relationship between their perceptions and choices. The model assumes that the information consumers accumulate about drinking water from various information sources, accumulated knowledge and experience, affect the choices they make. On the other hand, consumer choices are also affected by perceptions and attitudes towards water quality. Since objective risk information is rarely available, subjective risk-related behaviors based on consumers' perceptions are developed instead. Consumer perceptions are translated into attitudes through a cognitive process (Huang, 1993); then behavioral intentions are formed and the consumer makes a choice among the available alternatives.

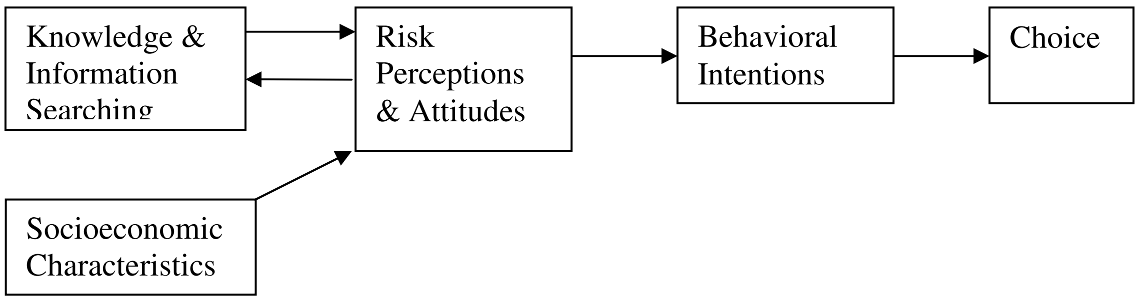

Figure 1. Consumer decision process

In Figure 1, knowledge and information searching includes previous knowledge and information obtained by consumers via the search process. Perceptions represent the formation of an individual's state of mental awareness and can change continuously over time. An individual's cognitive process converts perceptions into attitudes via evaluative criteria. Attitude is a learning predisposition to respond to an object or concept in a consistent favorable or unfavorable manner (Huang, 1993). Behavior intentions represent consumers' mental construct in connection with their knowledge, information, perceptions and attitudes (Huang, 1993).

Data and Methods

The data for this study are collected via a mail survey sent to a random sample of households residing in the Northern Virginia and Maryland suburbs of Washington DC in the fall/winter of 2007. This study area was chosen due to the high number of reported failures in public (Clark et. al., 1999) and private plumbing systems (WSSC, 2007), its aging infrastructure and relatively high incidence of other water quality issues such as lead in the water (reported in the District of Columbia (Edwards et al., 2009)) and microbial contamination. The pool of participants was a randomly selected group of households from the zip codes that are serviced by the Fairfax Water Utility Authority and the Washington Suburban Sanitary Commission (WSSC). The sample consisted of 5200 households and was provided by the Survey Sampling International (SSI). The design method for the survey followed the format for mail surveys suggested by Dillman (1978) in order to maximize response rate. The survey process consisted of an initial survey which was followed by a reminder card and a second survey sent approximately three and six weeks after the first mailing, respectively. The total number of surveys returned was 1,232, constituting a response rate of 24 percent, of which 1,030 were included in the analyses. 202 observations were missing information on important variables included in the regression and were deleted from the sample. An additional 160 observations were only missing income. Income for these observations was imputed based on education, age, gender and race and the observations were included in the analysis.

One of the goals of this study is to examine how respondents obtain and use prior and new information, and how this information shapes their willingness to pay for drinking water. To accomplish this, the sample surveyed was randomly split into three different subsamples with each subsample receiving a different informative statement at the beginning of the survey. The first group did not receive any information in the survey and the participants responded based on the information they had already acquired on their own. The second group received general information on the water quality in their homes including ways the water is treated, how often it is tested, what is it tested for and whether it complies with the EPA standards of drinking water. The informative statement reads as follows:

> *Water that is treated by drinking water utilities in the Washington D.C. metropolitan area goes through several treatment processes. Utilities monitor for over 120*

contaminants in the drinking water. The water is typically tested at least 240 times a day. Treated drinking water is in compliance with all State and Federal regulations.

The third group also received information related to water quality but, in contrast to the second group, this information was somewhat negative. Respondents received a description of some of the problems that had occurred and current issues with water quality in the area where they live. This group received the following information:

Water utility infrastructure in the Washington D.C. metropolitan area is aging and deteriorating. Leaks and breaks in water mains that interrupt services to water utility customers are occurring more often and for longer periods. Such interruptions cause inconvenience and, in some cases, property damages to customers.

Respondents were also asked of their knowledge regarding their drinking water quality and whether they had heard or searched for information on quality of water.

To measure consumer risk perceptions and attitudes towards water quality and infrastructure, questions were asked to reveal respondents' perceived risk and risk related behavior with regards to their tap water. More specifically, respondents were asked about their tap water use, whether they use their water for all households needs or if they restrict tap water for uses other than drinking and/or cooking. Other questions asked if respondents believe their water is safe to drink and if they use bottled water and other treatment methods (including filters, pitchers and water softeners) for safety purposes. The answers to these questions are used to construct a risk index (RI) that measures individuals' risk perceptions and risk related beliefs and behaviors. The index is constructed by incorporated responses from five risk-related questions and takes values from 0 to 5, with 5 being the highest level of risk perception.

Respondents' willingness to pay for improvements in water quality and infrastructure is elicited using the contingent valuation method. Participants were asked to evaluate three water improvement programs. The first program is targeted to further improve the quality of water including taste, odor, color and safety. The second program is an insurance program to cover all future costs of pinhole leak damage and repairs including collateral damage to home and personal property. The third program proposes an upgrade to the public water distribution infrastructure (see appendix A for an example of the contingent valuation question). Each program would cost respondents a certain amount in addition to the water bill per quarterly billing cycle. The three programs were incorporated in one question in order to avoid bias based on the order programs were presented. A fractional factorial design was used to generate the different combinations of values. The cost for the programs was allowed to be the same for two programs and different for the third one, resulting in 60 different combinations. The values for the costs were randomly selected from \$40, \$70, \$85, \$105 and \$180. These payments were based on quarterly water bill values for residents in the study area. More specifically, these values are the 20^{th}, 40^{th}, 50^{th}, 60^{th} and 80^{th} percentiles of the distribution of the bill values which include water and sewer. Respondents were given the choice to pay for any of the programs or chose not to support any of the programs and not pay anything. Seventeen percent of respondents choose to support the water quality program, 8 percent supported the pinhole leak program and 27 percent supported the public infrastructure program. The rest of the respondents, about 48 percent, did not support any of the programs.

Finally, a series of socioeconomic questions were included at the end of the survey. Respondents were asked about their annual household income, years of education, age, gender and race. Economic theory suggests that respondents' characteristics might affect their willingness to pay choices.

Empirical Model

An empirical model is developed to explore the role of information, risk-related perceptions and attitudes on behavioral intentions. Since consumer choices regarding water infrastructure are unobservable, this study will consider consumer behavioral intentions (willingness to pay for improvements) which are observed using survey techniques. True willingness to pay (WTP*) is unobserved, but we observe for each individual i and each program j whether the program was supported at a randomly assigned price P_{ij}. Consumer choices are thus modeled as follows:

$$WTP_{ij} = f\ (INFO_i, MSG_i, RP_i, SE_i. P_{ij}) + \varepsilon \qquad (1)$$

where WTP_{ij} is an indicator variable that is equal to one if consumer i supported program j and equal to 0 otherwise. $INFO_i$ represents consumer i's knowledge and information searching regarding water quality and infrastructure; MSG_i is an exogenous variable that denotes an informative statement given to consumers at the beginning of the survey. RP_i stands for consumers' risk perceptions towards drinking water use, SE_i represents socioeconomic and demographic characteristics that may be correlated with consumer's behavior, P_{ij} is the vector of prices that was randomly assigned to each program for each consumer i, and ε is an error term.

The availability of information related to water issues and the decision to acquire more information from various sources may influence consumers' decisions to support improvement programs. Varying amounts of information were provided to respondents via a random selection process, to provide an exogenous effect to the information searching process. The collection of primary data for the analysis offered the unique advantage of being able to include questions in the data collection instrument that ask consumers about tap water usage, concerns regarding drinking water and water treatment methods that will enable the construction of a risk index. Various socio-economic variables that are assumed to be correlated with willingness to pay for water improvements include household income, education, age, gender and race. Finally, a price was randomly assigned to each program for each consumer. Since consumers were asked to only support one of the programs or none, the vector of prices for each of the choices will influence each choice for each consumer, so prices for program j and each of the other two are included in the analysis.

Each consumer can make an exclusive choice between one of three programs or none, so the choice effect of each variable on the decision is estimated using a random-effects logistic regression model.

Table 1. Variable Definitions and Summary Statistics

Variable	Definition	Mean	Standard Deviation
INFO	Dummy; 1 if respondent heard, saw or read news related to the quality of tap water	0.377	0.485
RI	Risk index taking values of 0 to 5 depending on perceived risk	0.939	0.898
PRICE	Exogenous bid amount asked in the WTP question	97.058	46.804
PMESSAGE	Dummy; 1 if "positive" informative statement was given to respondent	0.273	0.446
NMESSAGE	Dummy; 1 if "negative" informative statement was given to respondent	0.403	0.491
READ	Dummy; 1 if respondent read the annual report from water utilities	0.667	0.471
CHILD	Dummy; 1 if a child under 18 lives in the household	0.331	0.471
WOMEN	Dummy; 1 if women between 18 and 40 live in the household	0.294	0.456
HSIZE	Household size	2.685	1.383
MALE	Dummy; 1 if respondent is male	0.594	0.491
WHITE	Dummy; 1 if respondent is white	0.774	0.418
EDUCATION	Number of years of schooling (midpoints)	16.549	2.418
AGE	Age (years)	55.562	14.216

Empirical Results

Estimation results from the random–effects logistic model are summarized in Table 2. As expected, willingness to pay for improvements in water quality and infrastructure increases as the price respondents would have to pay for the program decreases (Table 2). The risk index coefficient has a positive and significant effect on supporting a program. As individuals become more wary of their tap water, their willingness to pay to avoid any water safety risks increases and vice versa. Individuals who perceive some risk associated with tap water will choose to reduce this threat and support improvement programs. Information that respondents have acquired (INFO) increases willingness to accept a program possibly because most news in the media focus on issues and problems with drinking water. In addition, consumers that read the annual reports sent by the utilities were less likely to support a program. The reason might be that the report serves as a reassurance from the water authority that all is fine with the water. The model controls for multiple household characteristics and demographics however only education appears to affect willingness to pay. The likelihood of supporting a program increases with the education level of respondents. Informative statements given in the beginning of the survey do not make a difference in consumers' choice. This may imply that only information obtained through "traditional" channels matters.

Both information and the risk index significantly affect individuals' choices to support improvement programs. As noted in the conceptual model, risk perceptions may affect willingness to pay directly or indirectly through information searching. For instance, individual who perceive more risk may be more willing to spend time to gather information on water safety.

In order to distinguish between the direct and indirect effects we ran a regression that omits the information variable. Results (Table 3) show that the effect of the risk aversion index on willingness to support a program remains unchanged indicating that the estimated effects of information and risk on consumer choices are independent.

Table 2. Random Effects Logistic Model for Willingness to Pay

Variable	Willingness to Pay (WTP) Estimated Coefficient	Marginal Effects
INTERCEPT	-1.315**	-
	(0.504)[a]	
INFO	0.180*	0.025*
	(0.108)	(0.015)
RI	0.117**	0.016**
	(0.056)	(0.007)
PRICE	-0.008**	-0.001**
	(0.001)	(0.000)
PMESSAGE	0.088	0.012
	(0.127)	(0.017)
NMESSAGE	-0.006	-0.001
	(0.117)	(0.016)
READ	-0.235**	-0.032**
	(0.117)	(0.017)
CHILD	0.099	0.013
	(0.157)	(0.021)
WOMEN	0.041	0.005
	(0.129)	(0.017)
HSIZE	0.025	0.003
	(0.052)	(0.007)
MALE	-0.063	-0.008
	(0.104)	(0.014)
WHITE	-0.201	-0.028
	(0.125)	(0.018)
EDUCATION	0.047**	0.006**
	(0.023)	(0.003)
AGE	-0.006	-0.001
	(0.005)	(0.001)

[a] Values in parentheses are standard errors
*Indicates significance at the 10% level
** Indicates significance at the 5% level
Note: Marginal effects are computed on the probability that the respondent answers the choice questions in the affirmative (respondent supports one of the three programs). In the case of discrete variables, the marginal effects show the probability for a discrete change of the variable from 0 to 1.

Table 3. Random Effects Logistic Model for Willingness to Pay without Information

	Willingness to Pay (WTP)	
Variable	Estimated Coefficient	Marginal Effects
INTERCEPT	-1.383**	-
	(0.494)[a]	
RI	0.112**	0.015**
	(0.055)	(0.007)
PRICE	-0.007**	-0.001**
	(0.001)	(0.000)
PMESSAGE	0.095	0.013
	(0.124)	(0.017)
NMESSAGE	-0.015	-0.002
	(0.115)	(0.015)
CHILD	0.109	0.015
	(0.153)	(0.021)
WOMEN	0.041	0.005
	(0.127)	(0.017)
HSIZE	0.018	0.002
	(0.051)	(0.007)
MALE	-0.060	-0.008
	(0.102)	(0.014)
WHITE	-0.206*	-0.029*
	(0.122)	(0.018)
EDUCATION	0.050**	0.007**
	(0.022)	(0.003)
AGE	-0.006	-0.001
	(0.004)	(0.001)

[a] Values in parentheses are standard errors
*Indicates significance at the 10% level
** Indicates significance at the 5% level

Conclusion

The objective of this study was to examine the effects of information sources and risk perceptions on individuals' willingness to pay for improved water quality and infrastructure. Concerns for water safety risk affect individuals' willingness to pay to reduce these risks. Empirical results confirmed the expectations that as individuals' become more risk averse, their willingness to reduce the risk increases. Besides education, demographic characteristics and family circumstances are not significant determinants of individual's willingness to pay for water quality improvements. The information gathered from media sources affects individuals' behavior which implies that there is potential for information campaigns to gather public support for expenditures in water infrastructure. However, information dispersed through traditional media channels may be a more desirable strategy as the information provided in the survey did not influence decisions to support any of the programs.

The link between willingness to pay, information sources and risk perceptions provides helpful insights on individuals' valuation decisions. Individual concerns for water quality and infrastructure will significantly affect their decisions and behavior and should be accounted for in willingness to pay analysis.

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Appendix A.

Willingness to Pay Question

1. Suppose your water utility is considering three improvement programs:

Program 1

Your water utility tests the water multiple times a day and your water is of high quality. Suppose there is a program to further improve the quality (taste, odor, color and safety) of your tap water supply. The cost of this program per quarterly billing cycle is shown in the table below. This cost would be in addition to your current water bill.

Program 2

Consider the current condition of the drinking water plumbing system in your house. Nationwide, about 8 percent of homeowners have reported pinhole leaks. Suppose you can stay with your current plumbing system, fixing any problems which may arise or replacing the plumbing system if necessary. Or, as another alternative, there is an insurance program to cover all future costs of pinhole leak damage and repairs including collateral damage to home and personal property. The cost of this program per quarterly billing cycle is shown in the table below. This cost would be in addition to your current water bill.

Program 3

Consider the quality and reliability of water services from your utility. Suppose a program were proposed to upgrade water distribution infrastructure in your utility service area. Fees collected for such a program would be entirely dedicated to replacing aged water distribution infrastructure. The cost of this program per quarterly billing cycle is shown in the table below. This cost would be in addition to your current water bill.

Program	1. Water Quality Improvement	2. Pinhole Leak Damage Insurance	3 Water Utility Infrastructure Upgrade
Cost per quarterly billing cycle	$70	$105	$105

Which program would you support? (CIRCLE ONE NUMBER)

1. Program 1
2. Program 2
3. Program 3
4. None 0