

Residential Water Use and Persuasion in Kelowna: Persistence Pays.

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Abstract

Convincing residential households to use less water is seen as an important challenge in Kelowna, British Columbia. A mixed methods survey conducted between 2009 and 2010 measured self reported conservation investments and behaviors of 512 Kelowna residents. There is no significant difference reported between the five water providers, only two of which use volume based pricing. Perceived wasteful behavior by others is a strong predictor of the compulsion to conserve, as is the strength of a respondent's environmental perspective. However, the compulsion to conserve is at best only weakly related to actual conservation choices. A consistent predictor of conservation choices is the number of different information sources from which a respondent reports having heard about conservation. These results suggest that water conservation is more of a habitual or herd behavior, where people make conservation choices because they become accustomed to doing so and/or believe everyone else is doing so. Efforts to promote water conservation should therefore be directed more at building a water conservation 'culture' than at searching for some ideal instrument such as price or moral suasion.

1 Background

The Okanagan valley is, on a per capita basis, one of the most water scarce watersheds in Canada [Statistics Canada, 2003, p8]. Kelowna is the largest city in the Okanagan Valley, with a population of 117,310 in 2012, having grown 9.3% over the preceding five years [Statistics Canada, 2012]. Various agencies have

been actively encouraging Okanagan residents to conserve water. Some efforts focus on education and moral suasion, attempting to convince residents that water is not abundant and that the morally right thing to do is to conserve. Other efforts are directed at having residents pay a price that reflects the true 'value' of water in the Okanagan. This research seeks to shed some light on the relative merits of these different approaches to encouraging water conservation.

A number of studies have examined patterns of residential water use. Using data from a number of US communities, Mayer et al. [1999] find that the toilet is the largest single water use inside the home, followed by cloths washing and then bathing and showering. In contrast, for the Gold Coast of Australia, Willis et al. [2009] find that toilets at most are the third most significant use, while showers and baths are the first and clothes washing is second. The pattern is similar for the Yarra Valley in Australia [Roberts, 2005]. A poster produced by Natural Resources Canada [Turner, 2006] asserts that the toilet accounts for the largest share of household water use in the Okanagan.

[NOTE: LITERATURE REVIEW INCOMPLETE]

2 Modeling Perspective

The overall modeling perspective is focuses on predicting the choices made by individuals. One fundamental assumption is that the behaviors being predicted are subject to free choice on the part of the individuals being observed. From this foundation, economics tends to treat the workings of the mind as something of a black box, which produces a preference ordering over the available choices. An individual makes a choice by setting this preference ordering against a budget constraint, choosing the most preferred bundle that can be afforded. Psychology tends to delve more deeply into the black box to examine the role of beliefs, attitudes, norms, etc. in predicting behavior. In what follows, we analyze a dataset collected primarily from the perspective of economics to explore both understandings.

2.1 The Demand for Conservation

The extensive literature on household demand for water [see surveys by Arbués et al., 2003, Worthington and Hoffman, 2008] assumes that consumers desire consumption of water. Water conservation allows consumers to gain the same enjoyment while using less water. So long as water conservation is costly, consumers will not invest in conservation unless some benefit, such as a reduced water bill, is worth at least as much as the investment and any inconvenience or displeasure generated. All else equal, an increase in the price of water should increase the investment in water conservation. Likewise, the downward slope of the demand for water is at least partially explained by consumers substituting water conservation for water use as the price

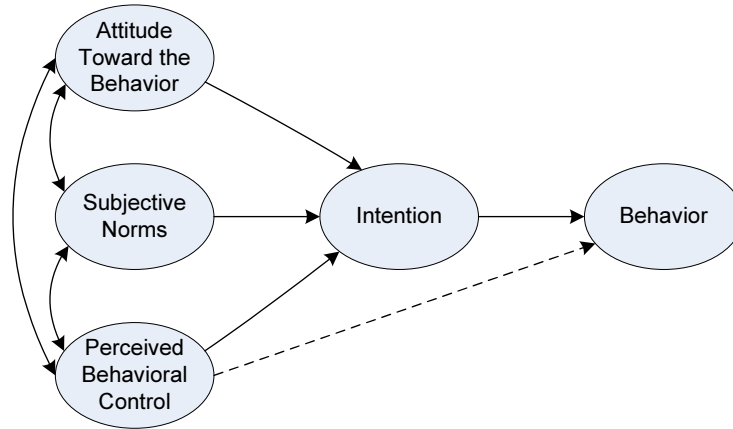


Figure 1: The Theory of Planned Behavior (Figure 1 in Ajzen [1991]).

of water increases. To the extent that water conservation is an imperfect substitute for water use, or that the marginal utility generated by saving money is decreasing in income, the demand for water conservation will be decreasing in income.

Water conservation activities may also generate utility independent of the water conservation effect. If people believe that water conservation is the right thing to do, or if there is a social norm whereby water conservation is a desirable activity, then we would expect a demand for water conservation activity that is independent of the price of water. This preference for water likely depends on factors such as environmental beliefs, attitudes about water use and the importance of conservation, etc. If water conservation is a normal good, then expenditures on water conservation should be increasing in income. This contrasts with the direct conservation effect, the demand for which is likely decreasing in income.

2.2 The Theory of Planned Behavior

The theory of planned behavior was described by Ajzen [1991], with figure one from Ajzen [1991] reproduced as Figure 1 below. If the behavior of interest is water conservation, then conservation actions are predicted by the intention to conserve, potentially modified by the perceived behavioral control. Intentions themselves are a consequence of attitudes towards the behavior, subjective norms, and modified again by the perceived behavioral control. Finally, attitudes, subjective norms and perceived behavioral control are themselves mutually interdependent.

The survey was designed with the demand for water conservation as the underlying paradigm. Therefore, measured variables touch on elements of the theory of planned behavior, but are not direct measures of these elements. Most analysis of the theory note that it is typically difficult to construct a precise measure of the

theory elements, and use structural equation modeling methods where some or all of the theory elements are assumed to be underlying latent variables. Given the limitations of the measured data, the present analysis restricts itself to a recursive set of simultaneous equations, focusing on a proxy for intentions as the vehicle whereby attitudes, norms and constraints may influence water conservation behavior.

2.3 Hypotheses

The modeling approaches suggest several hypotheses.

A positive marginal price for water will result in more water conservation investments. This hypothesis follows from the economic model where water conservation is seen as stretching the services that can be provided by a given unit of water. The more costly water is, the more water conservation households are expected to engage in. Within the survey area, three water providers charge a flat rate, while two charge by volume. Support for this hypothesis exists if there is a positive and significant impact on water conservation when the water provider charges a volumetric price.

The intention to undertake water conserving behaviors will predict water conserving behaviors. This hypothesis follows from the theory of planned behavior. While intention itself was not directly measured, a proxy can be constructed. If this measure is a good proxy, then it should have predictive power for water conservation activities. This will be assessed by looking for a statistically significant relationship between the intention proxy and conservation behavior.

Attitudes towards water conservation and subjective norms will affect behavior only through intentions. The theory of planned behavior sees attitudes about the behavior and subjective norms as impacting behavior through intentions. The absence of any statistically significant effect of measures closely tied to attitudes and subjective norms on behaviors supports this hypothesis.

Perceived behavioral control variables may affect both intentions and behaviors. Variables that relate to perceived behavioral control may influence intentions directly, or may prevent intentions from becoming actions. Such variables may therefore impact both intentions and behaviors. We therefore expect to see significant statistical effects from such variables both on intentions and on behaviors.

3 Data

From the summer of 2009 through to the fall of 2010 a sample of Kelowna residents was invited to participate in a household water use survey. The sample was build from a list of addresses and telephone numbers harvested from the website Canada411TM(www.canada411.com), keyed on the forward sortation area identifiers in the postal code for Kelowna addresses (www.canadapost.ca). These addresses where then classified by water provider using a GIS layer provided by the City of Kelowna, and distance to the nearest water provider boundary calculated in ArcGISTM. The sample was stratified to ensure representation from residences close to the boundary between water supplier service areas.

The survey instrument was designed in consultation with several local water use experts for content and tested with a small set of volunteers for comprehension. The survey itself was built as a web form that connected with a dedicated database that was designed and implemented by the author. The system managed the contact list for the interviewers, to avoid duplicate calls and ensure that the sampling protocol was maintained. It also permitted the interviewer to take a participant's email address and enter it into the system, which would send the participant up to four email reminders with information to enable the participant to complete the survey online. Two interviewers made cold calls and conducted interviews for one week, with 26 surveys completed, after which the survey was again reviewed for comprehension and a few question and wording changes were made. As most of the survey was unchanged, these 26 responses are included in the sample.

Data collection by telephone interview took place during the summer of 2009. The interviewers attempted to contact 741 residences. These contacts lead to 81 completed surveys, with 67.9% the result of people who opted to complete the internet version. Given the preference for internet over telephone on the part of these participants, the survey was continued as a mail survey with an internet option. In the spring of 2010 the remaining sample was sent a letter inviting them to participate in the survey. This letter served both as the initial contact [following Dillman et al., 2008] and contained details for accessing the survey through the internet. About three weeks later a paper survey was mailed to all in the sample for whom the original mailing address was valid and who had neither completed the survey on-line nor indicated through the website that they did not want to participate. About two months later a reminder letter was sent, which again contained the access information for the internet version of the survey. Against the initial sample of 2273 residential addresses, the response rate is 22.7%. As 56 of the 741 telephone contacts were not in service, and a similar share of the mail surveys were either incomplete addresses or people who had moved (not separately coded in the data), the final response rate is likely above 25%.

Data summaries are presented in Table 1. They are loosely grouped into the five categories of the Theory

of Planned behavior. They are also reported for the total data set, and broken down into customers of the five different water providers and a residual category OTHER. Economic theory suggests that price should be an important driver of water conservation investments. Of five providers, CITY and RWW charge a volumetric price, while BMID, GEID and SEKID charge a flat monthly fee. The OTHER category contains some homes with wells and others with water licenses for surface sources. Many of these will pay something of a volumetric price in the form of pumping costs. If the marginal price paid for using water drives behavior, then behaviors should differ by water provider.

Differences between water providers are tested using an analysis of variance assuming a normal distribution for variables that are approximately continuous (e.g. Likert scale), an analysis of variance assuming a Poisson distribution for count variables, and a contingency table analysis for binary variables. Significance is based on $\alpha = 0.05$.

Five variables are included in the Attitudes Towards the Behavior category. The New Ecological Paradigm (NEP), developed by developed by Dunlap et al. [2000] as an update of the earlier New Environmental Paradigm [Dunlap and van Liere, 1978], provides a measure of ecological beliefs or values. While the NEP incorporates five dimensions, it is frequently used as a single scale, which is done here. A confirmatory factor analysis [see Amburgey and Thoman, 2011] does not show any significant gain from using five dimensions instead of one. The measure reported here is a sum of the fifteen items that make up the NEP, scaled to lie between one and seven, with a larger value indicating stronger alignment with the NEP. There is no evidence for differences in attitudes among respondents served by different water providers.

Respondents score highest on the ABUNDANCE scale if they agree that water is abundant in the Okanagan now, will be in 40 years, and that climate change will not cause water problems. There is a significant difference between SEKID and GEID, although neither is significantly different from the others. SEKID has water restrictions more often than the others, so that the somewhat greater concern about water availability in SEKID is not surprising. The QUALITY variable sums perceived severity of odor, taste, color and clarity measures. The two irrigation districts, SEKID and GEID, are well known for water quality problems, which is reflected here. While BMID is also an irrigation district, its water sources are of higher quality. Finally, the RISK variable sums measures of health risk, such as pesticides, human waste, heavy metals, etc. The two irrigation districts, SEKID and GEID, again stand out. Land use in these two districts exposes people more often to agricultural activities, which may raise the profile of agriculture related risks. At the same time, the water quality concerns may also express themselves about risks related to the lower water quality.

Nine variables are grouped under the Subjective Norms category. Almost 25% of households have school age children, while nearly eight percent report having preschoolers in the household. Just over 95% spend

Table 1: Data Summaries. Variables are grouped into categories loosely consistent with the Theory of Planned Behavior. Results for multiple comparison analyses are labeled with superscripts to indicate statistically indistinguishable means. Where all means are the same, no superscript is shown.

Variable	N	Mean	P	BMID	CITY	GEID	OTHER	RWW	SEKID
Attitudes Toward the Behavior									
NEP	516	4.98	0.291	4.998	4.976	4.837	4.864	5.134	5.121
MALE	495	0.59	0.707	0.569	0.612	0.543	0.533	0.697	0.606
ABUNDANCE	516	3.05	0.038	3.150 ^{ab}	3.082 ^{ab}	3.310 ^a	2.833 ^{ab}	2.878 ^{ab}	2.713 ^b
QUALITY	516	3.38	0.000	2.246 ^a	1.616 ^a	6.053 ^b	2.000 ^a	2.429 ^a	8.301 ^c
RISKS	516	1.39	0.001	1.677 ^{ab}	1.257 ^{ab}	1.760 ^a	0.438 ^b	0.914 ^{ab}	1.767 ^a
Subjective Norms									
OTHERS_CONS	516	4.95	0.008	5.172 ^{ab}	4.786 ^a	5.077 ^{ab}	4.551 ^{ab}	5.037 ^{ab}	5.203 ^b
LEADER	482	4.15	0.529	4.048	4.081	4.091	4.688	4.294	4.314
GROW_BAD	516	4.81	0.027	4.993 ^b	4.790 ^{ab}	4.805 ^{ab}	5.203 ^{ab}	4.745 ^{ab}	4.624 ^a
ABOVE_AVG	491	5.21	0.000	5.523 ^{bc}	5.018 ^a	5.232 ^{ab}	6.125 ^c	5.000 ^{ab}	5.408 ^{abc}
SCHOOL	507	0.24	0.062	0.111	0.278	0.200	0.188	0.314	0.225
PRESCHOOL	508	0.08	0.339	0.127	0.085	0.067	0.125	0.086	0.028
RETIRED	509	0.31	0.003	0.188 ^b	0.323 ^{ab}	0.440 ^a	0.188 ^{ab}	0.143 ^b	0.361 ^{ab}
YEARS_KEL	509	22.4	0.000	27.078 ^{ab}	20.712 ^a	21.615 ^a	39.094 ^b	26.303 ^{ab}	19.911 ^a
ALL_YEAR	516	0.95	0.799	0.969	0.958	0.947	0.938	0.943	0.918
Perceived Behavioral Control									
AGE	337	56.6	0.811	58.651	56.139	57.438	52.182	56.235	56.547
EDUC	483	3.683	0.000	3.172 ^{bc}	4.036 ^a	3.507 ^{ab}	4.000 ^{ab}	2.406 ^c	3.743 ^{ab}
INCOME	423	82.1	0.000	68.704 ^{ab}	89.021 ^a	78.095 ^{ab}	132.115 ^c	51.953 ^b	87.016 ^{ac}
YARD	512	0.98	0.565	0.984	0.979	0.973	1.000	0.970	1.000
OWN	479	0.93	0.700	0.969	0.941	0.941	0.867	0.909	0.922
ALT_WAT	516	0.15	0.001	0.123 ^{ab}	0.097 ^a	0.133 ^{ab}	0.188 ^{ab}	0.114 ^{ab}	0.329 ^b
TREAT_WAT	516	0.29	0.236	0.262	0.274	0.400	0.250	0.200	0.329
OCCUPANTS	513	2.73	0.482	2.692	2.784	2.480	2.688	3.171	2.685
MSG_PRIV	516	3.01	0.962	3.123	3.063	2.933	2.750	3.029	3.096
MSG_SOC	516	0.91	0.908	0.969	0.890	0.840	1.062	1.000	0.945
KNOW	506	0.31	0.111	0.340	0.306	0.307	0.352	0.284	0.369
Intention									
COMPULSION	516	5.57	0.785	5.575	5.547	5.524	5.646	5.673	5.698
Behavior									
IN_HOUSE	516	2.55	0.751	2.754	2.624	2.440	2.250	2.429	2.658
ON_YARD	516	2.55	0.893	2.523	2.591	2.507	2.688	2.486	2.795
BEHAVE	516	4.04	0.688	4.292	4.021	4.013	3.875	3.714	4.288

at least nine months of the year living in Kelowna. The average person neither agrees nor disagrees that they can identify a water conservation leader. There are no differences between the water providers on these variables. The OTHERS_CONS variable sums three items that measure the respondents perceptions of other people's water conservation behavior, with higher scores when people see others as wasting water. Those supplied by SEKID are somewhat more likely to agree that other people waste water than those in the city, with no significant differences among the others. People who agree that urban growth is an important contributor to water stress score high on GROW_BAD. The only significant difference is between SEKID and BMID customers, with SEKID customers less concerned. There is a fair degree of variation in whether people see themselves as above average in water conservation (ABOVE_AVG), with the OTHER category most prominent. Many of those in this category are responsible for their own water treatment, and as such may be significantly more water conscious. A greater than average report being retired (RETIRED) in the GEID service area, while less than average reported retired in BMID and RWW. The latter is a more working class area, while the area serviced by GEID includes a number of developments targeted at seniors. When it comes to how long respondents have lived in Kelowna (YEARS_KEL) those reporting another water source are the highest. As these other sources (wells, individual licenses) are often legacy arrangements, with few new connections, this is not surprising.

Eleven variables are grouped as relating to perceived behavioral control. The average for respondent age (AGE), presence of a yard (YARD), ownership of the property (OWN), rate of water treatment (TREAT_WAT), number of occupants (OCCUPANTS), and level of knowledge about Okanagan water issues (KNOW) do not differ by water provider. The survey also asked people to choose media sources from a list where they had heard about water conservation. These sources were subsequently divided into privately consumed (MSG_PRIV) and more socially engaged (MSG_SOC). The former might include magazines and the internet, while the latter from ones children or friends. The average number of such sources reported does not differ between water providers. Average education level is significantly lower in the area serviced by RWW, which reflects the working class history of this part of Kelowna. Average education is slightly above the overall average for the CITY region, but not that much. Finally, the average rate of water treatment within the home (TREAT_WAT) is significantly lower for the CITY area, which draws its water from the lake and tends to be of high quality. This contrasts with those serviced by SEKID, known for poor water quality.

One variable, COMPULSION, is included as a measure of intention. This variable collects three measures of respondents agreement that water conservation is an imperative. For example, agreement with the statement "People should reduce their water use, even if it costs them money to do so." While not precisely an intention to undertake water conservation, agreement with such statements should be closely correlated

Table 2: Conservation investments and behavior counts.

Type	<i>N</i>	Tap Aerator	Low fl. Shower	Low fl. Toilet	Effic. Washer	Effic. D. Washer	Grey System	Gravel	Xeriscape
All	516	196	366	294	245	212	5	164	134
Own	443	173	320	263	217	192	4	143	117
Not Own	36	8	21	10	10	4	0	9	7
Yard	501							162	132
No Yard	11							1	2

		Water Less	Low wat. Grass	Moisture Probe	Timed Irrig	Rain Barrel	Grey System	Soil Amend	Pool Cover
All	516	261	69	12	356	61	2	200	58
Own	443	228	62	10	317	53	2	180	51
Not Own	36	12	1	0	13	3	0	6	1
Yard	501	260	67	12	348	61	2	198	57
No Yard	11	1	1	0	5	0	0	1	1

		Scrape Dishes	Wash in Basin	Off Teeth	Shower Off	Yellow Mellow	D. Washer Full	Washer Full
All	516	257	203	414	74	248	435	455

with the intention. On this measure, there is no significant difference between respondents from the different water providers.

Three water conservation behaviors were measured, broadly classed as conservation investments inside the home (IN_HOUSE), conservation investments outside the home in the yard (ON_YARD), and conservation behaviors inside the home (BEHAVE). The survey presented respondents with a list of activities in each category, which they were to check if they undertook that activity. The aggregate measures are sums of those activities. The investment activities are dependent on the presence of a yard, or unlikely to be undertaken if the respondent owns the home. There are no differences between any of the water providers on the amount of conservation activity being undertaken.

Table 2 shows the total number of respondents reporting that they undertake each of the listed conservation investments or activities. The first six investments take place inside the home. The most popular of these is installation of a low flow toilet. Somewhat surprisingly, 21 of the 36 people who indicated they don't own their home also report having a low flow toilet. There are also a number of other water conserving investments inside the home that those who don't own the home report. It is unclear whether respondents themselves made these investments, or that they were made by the owner of the home.

The most popular reported water saving investments in the yard is timed irrigation. Ironically, the water saving effect of timed irrigation isn't completely clear, as timer systems are often unrelated to actual water need. Sprinklers will be run in the rain by a timer! The other stated investments are likely to save water. As for the investments inside the home, a surprisingly large share of people who don't own their home also

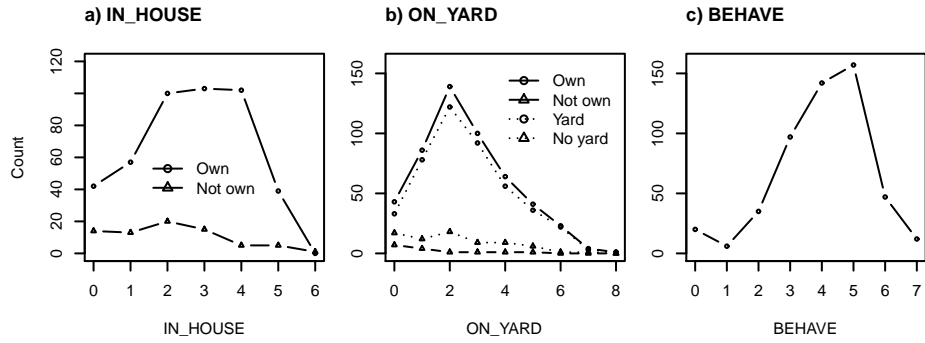


Figure 2: Distribution of behavior counts.

report water saving investments. This too may be something done by the property owner. What is more surprising is that a number of people who report not having a yard also report water saving investments in the yard. Given that the highest reported investment is timed irrigation, perhaps people who live in an apartment complex are reporting the timed system for their building.

Finally, the most popular water saving behavior is waiting until one has a full load before doing laundry. The next most popular is waiting till the dishwasher is full, and then turning off the tap when brushing. By contrast, most people seem to enjoy the shower too much to turn it off when soaping up.

Figure 2 shows the empirical distribution of these three behavior measures. In the first panel, IN_HOUSE is divided into investments made by those who own the home and those who don't. There are 443 respondents who report owning their home, and 36 who report the opposite. The remaining 36 of the 516 respondents didn't answer this question. Clearly the mean number of investments is higher among those who own their home, and the relative proportion of zeros is higher for those that don't. Visually the two plots appear to have different distributions, suggesting that they should be estimated separately. However, with 27 dependent variables and missing values for some of them, there is insufficient data to estimate a full model and compare it for home owners and those that don't own their home.

In the middle panel, the same data is plotted for water conservation investments on the yard. Numbers are plotted both for respondents reporting owning their home and not, and having a yard and not. A similar difference between own and not own exists for both IN_HOUSE and ON_YARD. As noted above, there are people who report not having a yard that simultaneously report making water saving investments in the yard.

4 Results

A two stage least squares approach was used to estimate the relationship between respondent characteristics and attitudes and conservation behavior. Regression results for the first stage regression are presented in Table 3. COMPULSION is the sum of three different Likert measures of the degree to which respondents feel people 'should' conserve water, scaled to lie between 1 and 7, the range of the original scale. It therefore spans a 19 point range from 1 to 7, which may be sufficient to assume normality. The first stage regressions are therefore estimated using OLS.

The first regression includes AGE, resulting in 230 usable observations. AGE is not a significant predictor, and is therefore dropped for the second regression, expanding the usable data set to 356 observations. Both regressions are strongly significant, and have reasonable explanatory power for a cross sectional regression.

The New Ecological Paradigm (NEP) is a strong predictor of compulsion. This supports the first linkage in the theory of planned behavior model, where beliefs/attitudes about the behavior predict intentions. The degree to which respondents believe that there is plenty of water in the Okanagan (ABUNDANCE) has a negative influence, again consistent with the beliefs/attitudes linkage.

The more strongly respondents agree that others are wasting water (OTHERS_CONS), the more likely that the respondent will assert that water should be conserved. In other words, the more a respondent is aware of waste by others, the more that respondent believes something should be done. Respondents who see continued growth as putting stress on water resources (GROW_BAD) also report a higher compulsion to conserve. Those who see their own water conservation behavior as above average also report a higher compulsion to act. There is potential endogeneity here, as one would expect those with a stronger compulsion to conserve more. However, as barriers to actions - perceived behavioral control - are a key part of the theory of planned behavior, compulsion may not always lead to water conserving behavior. Likewise, people may undertake many conservation activities but still consider themselves as below average, since this is a subjective assessment. Therefore, it is left in. Those who are retired are more likely to report a higher compulsion as well. Finally, in the regression that includes age, those who live in Kelowna at least nine months of the year are more likely to report a higher compulsion to conserve.

Gender, perceptions about own water quality, concerns about water related health risks, presence of school or preschool children in the home, length of time in Kelowna, education, income, use of water sources, messages received, knowledge about Okanagan water issues, and water source all have no measure influence on compulsion.

The results for the second stage regressions are divided into three tables, one for each dependent variable. Regressions were run using a two stage least squares instrumental variables approach, a generalized method

Table 3: First stage regression results. Dependent variable COMPULSION.

	Model #1		Model #2	
	Estimate	Std.Error	Estimate	Std.Error
(Intercept)	1.5064	0.7974	2.0809***	0.6234
NEP	0.2749***	0.0739	0.1775**	0.0603
MALE	-0.1002	0.1139	-0.0624	0.0895
ABUNDANCE	-0.0715	0.0499	-0.1087**	0.0411
QUALITY	-0.0128	0.0155	-0.0268	0.0127
RISKS	-0.0270	0.0340	-0.0219	0.0281
OTHERS_CONS	0.1416**	0.0489	0.1430***	0.0407
LEADER	0.0014	0.0353	-0.0028	0.0291
GROW_BAD	0.1778*	0.0689	0.2019***	0.0559
ABOVE_AVG	0.1331**	0.0491	0.1175**	0.0389
SCHOOL	0.0883	0.1424	-0.0329	0.1162
PRESCHOOL	-0.1719	0.1789	-0.2213	0.1566
RETIRED	0.4289**	0.1342	0.2258*	0.1089
YEARS_KEL	-0.0034	0.0034	-0.0053	0.0028
ALL_YEAR	0.4596*	0.1997	0.2701	0.1919
AGE	-0.0039	0.0036		
EDUC	0.0735	0.0367	0.0242	0.0305
INCOME	-0.0000	0.0010	0.0010	0.0008
YARD	0.0257	0.4195	0.2429	0.2926
OWN	0.1616	0.2826	0.0167	0.2073
ALT_WAT	-0.0790	0.1632	-0.1787	0.1264
TREAT_WAT	0.1514	0.1151	0.1259	0.0940
OCCUPANTS	0.0377	0.0456	0.0322	0.0392
MSG_PRIV	-0.0083	0.0301	0.0004	0.0254
MSG_SOC	0.0447	0.0544	0.0709	0.0437
KNOW	0.0716	0.2889	0.0451	0.2312
CITY	-0.0697	0.1568	-0.0377	0.1314
GEID	-0.1668	0.2039	0.0853	0.1650
OTHER	-0.2078	0.3180	-0.0828	0.2107
RWW	0.4904	0.2629	0.3474	0.1963
SEKID	0.2092	0.2076	0.3442	0.1751

$$R^2 = 0.435$$

$$F_{30,200} = 5.132***$$

$$R^2 = 0.343$$

$$F_{29,327} = 5.876***$$

of moments instrumental variables approach, and a Poisson regression where COMPULSION was replaced by its predicted values from the regression reported above. The Poisson regression is more appropriate for count data, making it a more consistent estimation approach. However, since the dependent variable is not a traditional count, such as number of visits to the doctor, etc., a more robust approach like GMM that rests less on distributional assumptions may be superior. Using GMM on the moment conditions for a Poisson regression is left for further work.

A series of diagnostics are reported for each regression. The conditions for the usual R^2 do not apply in any of these regressions. For the 2SLS regressions, the R^2 from the second stage regression is given. For the GMM IV, the squared correlation between the fitted values and the observed values is shown. The deviance R-squared [Cameron and Windmeijer, 1996] is reported for the Poisson regressions. For both the 2SLS and Poisson regressions, a Sargan test for overidentifying restrictions is run, where the second stage residuals are regressed on the instruments [Sargan, 1958]. While not necessarily valid for the Poisson regression, it is included for completeness. The RESET test [Ramsey, 1969] tests for model misspecification by regressing the squared residuals on the squared fitted values¹. The Shapiro test [Royston, 1982] is rejected if there is evidence against normality for the residuals. Normality is primarily a concern for inference with the 2SLS regressions. Finally, SOURCE reports the results of testing the joint hypothesis that there is no significant change when the water provider is dropped from the model.

Table 4 reports results for regressions where the dependent variable is the count of conservation investments made in the home. COMPULSION is predictive in two of the three regressions, although not that strongly. Education does not have any predictive power. Income is significant and positive in all three regressions. This suggests that water conservation is itself a normal good, rather than a derived demand based on the value of water saved. Ownership is significant in two of three regressions, consistent with the fact that people who don't own their home are less likely to make investments that will stay with the home. People who get their water from an alternate source are less likely to make conservation investments inside the home, and such investments are also more likely in homes with more occupants. The strongest predictor of water conservation is the number of information sources where a respondent reports having encountered a water conservation message. For investments inside the home, those messages that are social are not significant while those that are more private have the impact. Like education, knowledge about Okanagan water issues also has no influence. Water provider also does not have a significant impact. This is consistent with the positive income effect. People do not seem to be investing in water conservation to save money.

For all three models, the overidentifying restrictions are not rejected. Thus, the instruments do not provide any additional explanatory power beyond that provided through COMPULSION. The RESET test

¹Note, the test may need to be adjusted for IV regressions.

Table 4: Regression results for investments in the house, IN_HOUSE.

	2SLS		GMM IV		Poisson	
	Estimate	Std.Error	Estimate	Std.Error	Estimate	Std.Error
(Intercept)	2.8659**	0.9463	3.0317**	0.9500	1.5778	0.7976
COMPULSION	-0.2958 ⁺	0.1563	-0.3666*	0.1731	-0.5332	0.3316
EDUC	0.0234	0.0531	0.0263	0.0548	0.0092	0.0241
INCOME	0.0034*	0.0015	0.0042*	0.0017	0.0012*	0.0006
YARD	-0.1288	0.5209	0.1048	0.4166	-0.0993	0.3003
OWN	0.8710*	0.3633	0.7727*	0.3758	0.4770	0.2087
ALT_WAT	-0.4633*	0.2208	-0.4937*	0.2154	-0.1859	0.1061
TREAT_WAT	-0.1206	0.1679	-0.1378	0.1654	-0.0434	0.0763
OCCUPANTS	0.1000 ⁺	0.0556	0.1098*	0.0479	0.0408 ⁺	0.0247
MSG_PRIV	0.1580***	0.0441	0.1680***	0.0444	0.0606**	0.0199
MSG_SOC	-0.0005	0.0755	0.0127	0.0773	-0.0041	0.0341
KNOW	-0.4479	0.4011	-0.5989	0.3933	-0.1653	0.1843
CITY	-0.2011	0.2296	-0.1978	0.2217	-0.0779	0.1026
GEID	-0.2294	0.2802	-0.2454	0.2807	-0.0894	0.1258
OTHER	-0.5939	0.3716	-0.4897	0.4194	-0.2674	0.1850
RWW	-0.1329	0.3461	-0.1237	0.3191	-0.0537	0.1577
SEKID	0.0085	0.2836	0.0921	0.2959	0.0059	0.1283
R^2	0.1355		0.0841		0.1101	
Overiden.	15.1137	0.9997	11.0566	0.6061	40.9729	0.3414
RESET	49.8583	0.0000	6.1579	0.0135	6.3406	0.0125
Shapiro	0.9867	0.0023	0.9855	0.0007	0.9642	0.0000
SOURCE	0.0368	0.9993	3.2209	0.6660	3.7751	0.5822

Table 5: Regression results for investments in the yard, ON_YARD.

	2SLS		GMM IV		Poisson	
	Estimate	Std.Error	Estimate	Std.Error	Estimate	Std.Error
(Intercept)	-1.2315	1.0645	-0.6145	1.0900	-1.1966	0.8301
COMPULSION	0.1664	0.1758	0.0991	0.1824	0.2999	0.3385
EDUC	0.0730	0.0597	0.0511	0.0580	0.0278	0.0241
INCOME	0.0041*	0.0016	0.0042*	0.0017	0.0014*	0.0006
YARD	0.4403	0.5860	0.2771	0.5276	0.3884	0.3368
OWN	0.8891*	0.4087	0.8321*	0.3333	0.4368*	0.1985
ALT_WAT	0.2902	0.2484	0.3302	0.2756	0.1216	0.1003
TREAT_WAT	0.1261	0.1888	0.1227	0.1772	0.0584	0.0762
OCCUPANTS	0.1020	0.0625	0.1002*	0.0491	0.0405 ⁺	0.0246
MSG_PRIV	0.0999*	0.0496	0.1393**	0.0510	0.0382 ⁺	0.0199
MSG_SOC	0.2572**	0.0849	0.2109*	0.0943	0.0933**	0.0329
KNOW	0.3104	0.4512	0.4503	0.4600	0.1285	0.1816
CITY	-0.0248	0.2583	-0.1730	0.2644	-0.0079	0.1067
GEID	0.2160	0.3152	0.0298	0.2983	0.0883	0.1271
OTHER	-0.2419	0.4180	-0.4359	0.4385	-0.1193	0.1834
RWW	0.3767	0.3893	0.3233	0.3804	0.1480	0.1558
SEKID	0.0557	0.3190	-0.0400	0.3148	0.0127	0.1296
R^2	0.1595		0.1183		0.0990	
Overiden.	24.3565	0.9578	24.3776	0.0278	38.2129	0.4598
RESET	11.7794	0.0007	9.4128	0.0023	1.1386	0.2867
Shapiro	0.9828	0.0003	0.9834	0.0002	0.9912	0.1806
SOURCE	2.6438	0.7547	3.6626	0.5989	2.7362	0.7406

strongly suggests that there is a specification problem with the 2SLS model. The problem is less when the RESET test is applied to the GMM and Poisson forms, but it is not eliminated. Exploration of alternate specifications and functional forms is left to future work. Normality of the residuals is violated strongly for all the models. However, given how far from significant both the overidentifying restriction test and the test of the impact of water source are, these results are likely to hold for other specifications.

Table 5 reports results for the count of conservation investments in the yard. COMPULSION and education have no significant influence. Income does, and again in a positive direction. The sign on YARD is positive, but overall having a yard does not significantly impact on the likelihood of making water conservation investments in the yard. In part this likely reflects the fact that there are few observations without a yard. As for investments in the home, owning the home has a significant and positive effect on the number of conservation investments in the yard. The number of occupants in the house has a weakly positive influence on conservation. However, as for investments inside the home, the number of reported information sources for the conservation message is again an important predictor. In contrast to investments made inside the home, for the yard social information sources are more prominent. Again, knowledge has no influence and neither does water source.

For investments in the yard, the J test for overidentifying restrictions is rejected for the GMM specification. This suggests that there is information contained in the instruments that isn't captured by COMPULSION. However, these restrictions are not rejected for the other two specifications. As for IN_HOUSE, the model specification is questionable, and higher order polynomial terms may improve the fit. Likewise, normality of the residuals is strongly rejected for the 2SLS and GMM IV specification. This is not the case for the Poisson form though. These results repeat that for the IN_HOUSE regressions, in that dropping the water provider identity does not significantly reduce the fit. Given the value of the test statistic, the specification problems are unlikely to change this result.

The final regression results are shown in Table 6, where the dependent variable is the number of reported water conservation behaviors undertaken. COMPULSION is now the strongest predictor. It is strongly significant in the 2SLS and GMM regressions, and while only weakly significant in the Poisson regression, it is the only significant predictor. Among the remaining regressors, the number of occupants in the home, and both private and social message sources are significant. The GMM regression shows respondents serviced by Rutland Waterworks as significantly different. However, a joint test of zero for all sources cannot reject the null. Therefore, as for the other two behaviors, there is little indication that saving money is motivating water conservation behavior.

For behavior, normality is again rejected for all three model specifications. However, the RESET test is not rejected for the GMM IV and Poisson versions. The J test is rejected with the GMM form, suggesting that there is information in the instruments that is not captured by COMPULSION. The GMM IV results also stand out for the test of the predictive power of water source. While the rejection is weak, for BEHAVIOR, with the GMM IV specification, source may have some influence.

5 Discussion

5.1 Hypotheses Revisited

We now revisit the four hypotheses proposed at the start of this paper.

A positive marginal price for water will result in more water conservation investments. This hypothesis was at best only weakly supported in one test, and for only one of the three behaviors studied. Within this data there is therefore little if any support for the influence of price on water conservation. Those behaviors that may be impacted by the price of water are those that have little cost to the household.

One possible explanation is that water is so cheap that by comparison, the cost of making water conserving investments will not be recovered with a reasonable time frame. Behavior changes that do not cost anything

Table 6: Regression results for reported conservation behaviors, BEHAVE.

	2SLS		GMM IV		Poisson	
	Estimate	Std.Error	Estimate	Std.Error	Estimate	Std.Error
(Intercept)	0.7271	0.8332	0.5972	0.7456	0.0517	0.6276
COMPULSION	0.4203**	0.1376	0.4727***	0.1336	0.4657 ⁺	0.2650
EDUC	0.0594	0.0468	0.0432	0.0461	0.0141	0.0190
INCOME	-0.0012	0.0013	-0.0001	0.0013	-0.0003	0.0005
YARD	0.2974	0.4587	0.2839	0.4069	0.0880	0.1995
OWN	0.2092	0.3199	0.1617	0.2595	0.0497	0.1328
ALT_WAT	0.0118	0.1944	-0.1154	0.2062	0.0032	0.0797
TREAT_WAT	-0.1357	0.1478	-0.1656	0.1424	-0.0311	0.0606
OCCUPANTS	0.1100*	0.0489	0.1277*	0.0600	0.0244	0.0189
MSG_PRIV	0.1029**	0.0388	0.0839*	0.0396	0.0239	0.0157
MSG_SOC	0.1204 ⁺	0.0665	0.1441*	0.0642	0.0274	0.0263
KNOW	-0.3847	0.3532	-0.5190	0.3266	-0.0927	0.1445
CITY	-0.0908	0.2022	-0.2706	0.2180	-0.0208	0.0824
GEID	0.0081	0.2467	-0.0744	0.2623	0.0022	0.1005
OTHER	-0.0500	0.3272	-0.1473	0.3097	-0.0112	0.1348
RWW	-0.4845	0.3047	-0.6114*	0.2574	-0.1142	0.1267
SEKID	0.1386	0.2497	0.0486	0.2606	0.0309	0.1003
R^2	0.1249		0.1121		0.1252	
Overiden.	24.5554	0.9550	23.4973	0.0361	39.8222	0.3890
RESET	255.3384	0.0000	0.0453	0.8316	1.1843	0.2772
Shapiro	0.9867	0.0023	0.9886	0.0040	0.9491	0.0000
SOURCE	2.7126	0.7442	9.8853	0.0786	1.4258	0.9215

have a net financial benefit and no financial cost, and are therefore worth undertaking. Kelowna residents are presently charged \$0.322 per cubic meter for the first 30 cubic meters used per month, increasing in four steps until reaching a maximum rate of \$1.314 per cubic meter for consumption beyond 125 cubic meters per month [City of Kelowna, 2012]. Kelowna residents use about 444 litres per person per day, or about 13.5 cubic meters per month [The City of Kelowna, 2010]. A household approaching the upper block will pay around \$80 per month. This bill is likely less than the phone and cable bill for the average household, even in those parts of the city where people pay a volumetric price. Low income households likely cannot afford to make water conservation investments, but can adopt water conserving behaviors. High income households are unlikely to pay much attention to the cost of water, but may invest in water conservation as a consumption good, rather than as a way to save money.

The intention to undertake water conserving behaviors will predict water conserving behaviors.

If intention is well proxied by the strong belief that people should save water, then this hypothesis receives qualified support. The compulsion to conserve is a consistent predictor of behaviors that do not involve investment. It is a weak predictor of investments inside the home, and the effect has the opposite sign to that expected. It has no significant predictive power for water conserving investments in the yard. Intentions lead to behavior where that behavior has limited cost. When the behavior is costly, the impact of intentions is limited or cannot be detected. From one angle, this suggests that compulsion is a poor proxy for intention, which is consistent with Ajzen [1991] assertion that intention needs to be measured in a way that clearly relates to the behavior one is interested in. However, if compulsion is closer to an attitude about the behavior than it is an intention, the fact that the effect on behavior is negative would seem to be cause for concern.

Attitudes towards water conservation and subjective norms will affect behavior only through intentions. This hypothesis also receives qualified support. In only two of the nine regressions run were the overidentifying restrictions rejected, suggesting that the compulsion to conserve has captured the influence of attitudes and beliefs, and of subjective norms. However, if GMM is the most robust estimation technique in this situation, then the rejection of the overidentifying restrictions in two of three GMM regression makes this conclusion questionable. In the one regression where the overidentifying restrictions are not rejected by GMM, the compulsion to conserve has a negative and statistically significant effect. Taken in isolation of the other estimation methods, the GMM results challenge the proposed linkage.

Of course this could also be a consequence of model misspecification, which is suggested by the RESET test results. Exploring alternative specifications is left to future work.

Perceived behavioral control variables may affect both intentions and behaviors. The variables categorized as measuring perceived behavioral control seem to have their main effect directly on the conservation investments and behaviors. The effect of income and ownership on conservation investments inside and outside the home is not surprising, if one interprets these behaviors as consumption rather than an investment to save money. The impact of more occupants can either be interpreted as a nod towards money savings, or as an extra voice that enhances the preference for water conservation as a consumption expenditure. That income and ownership do not impact on behaviors supports this interpretation. Since the number of occupants continues to have an impact, this also supports the idea that when there are more occupants, there is more likely to be someone lobbying for conservation.

Several other variables are interesting. Neither education nor knowledge about Okanagan water issues have a significant impact on the compulsion to conserve or on the conservation investments and behaviors. Considerable efforts are made to increase the awareness of water scarcity in the Okanagan. The fact that people who are more informed about Okanagan water issues are no more likely to conserve water suggests that education about water scarcity has little impact on behavior. The strong impact of sources of conservation messages is striking. The number of privately consumed information sources where a conservation message was received was significant in all regressions, but most strongly for investments inside the home. The number of social information sources for conservation messages was strongly significant for investments in the yard and about equal to privately consumed messages for behaviors. Other research by the author finds support for a neighbor effect with household water consumption. The current results suggest that people are strongly influenced by messages from friends, neighbors, through community forums, etc., when it pertains to their yard - an important investment that is visible to the neighbors - and to daily behavioral choices.

Taking together with the absence of a price effect and the weak or even negative influence of the compulsion to conserve on investment inside the home, the strong impact of message sources may indicate that water conservation is more a habitual behavior than a response to beliefs or attitudes. Over time, people in the Okanagan may simply habituate to the practice of water conservation. This is not on account of their believing it is the right thing to do or knowing about water scarcity in the Okanagan. Rather, they simply internalize the messages that they are exposed to. The more messages that people are exposed to, the more rapidly they internalize this habit.

5.2 Policy Implications

Water suppliers, local government, provincial and federal agencies, NGOs, and other stakeholders invest considerable resources in the Okanagan towards encouraging water conservation. Both the City of Kelowna

and Rutland Waterworks have adopted increasing block pricing, consistent with most economists view that price can play an important role in encouraging conservation. However, there are no measurable differences in water conservation behavior among the five different Kelowna water providers, three of whom have no volumetric component to their pricing. Unfortunately, the three water providers who charge a connection fee do not have household level water use records that can firmly establish the absence of a price effect. Assuming that the observed results are accurate, the volumetric price charged in part of the city is at best serving as a small reward for those who conserve water, but is ineffective as an incentive to encourage additional water conservation.

Information campaigns that attempt to change people's 'environmental ethic' seem to have limited impact. Respondents who score higher on the New Ecological Paradigm are more likely to agree with statements about the importance of water conservation. However, this agreement only seems to translate into behavior changes. It does not impact on water conservation investments. Efforts to change people's environmental values as a relatively short term solution to water conservation challenges is therefore unlikely to be effective.

Educating people about Okanagan water issues has no measurable effect. The assessment of local knowledge was based loosely on information in such an education program, including a fact filled poster and a teachers guide, jointly sponsored by the Okanagan Basin Water Board, the Geological Survey of Canada, and Science Opportunities for Kids Society [Turner et al., 2006, Science Opportunities for Kids Society, 2008]. Such campaigns are costly, and at least within this dataset, there is no measurable influence of the knowledge conveyed having any impact on water conservation decisions.

The strong effect of the number of conservation message sources is striking. The more communication media where the conservation message is presented, and the more frequently that message is presented, the more likely people are to encounter it and internalize it. Much like advertizing, the goal is not to demonstrate that your product is clearly superior to the competition, be that in terms of ethics or performance or price, but rather that when a potential customer has a need for a service your product provides, your product is the first to come to mind. The results here suggest that encouraging water conservation is a marketing challenge more than a conversion or education challenge.

The distinction between private and social messages, and the importance of the behavior of others in the compulsion to conserve regressions, highlights a social dimension to both intentions and conservation behaviors. This connection is particularly strong for conservation investments in the yard. The yard is an important visual statement about the owners, and as such social pressures can be expected to play a larger role here than with other conservation behaviors that are not that visible. Efforts to encourage conservation can exploit this by helping innovators to adopt visually appealing conservation investments in their yard. Being both notable and appealing is likely to promote conversations among neighbors, conversations that

appear to play an important part in encouraging the adoption of conservation investments in the yard.

Rappaport [1984] is credited with defining culture as the way that a population maintains itself within an ecosystem. This is a mixture of practices, beliefs, rules and laws, etc. that enables the population to sustain itself in relationship with its environment. The results of this analysis suggest that single factors such as economic incentives, ecocentric beliefs and local knowledge cannot be relied upon to encourage water conservation. The fact that a stronger awareness of conservation messages is the one consistent predictor, and that for some behaviors message sources with a social dimension are particularly strong, is not inconsistent with conservation choices are part of a 'water conservation culture.' Those Kelowna residents who engage in more water conservation activities are for the most part not that different from those who don't, except in their stronger awareness of conservation messages. Regardless of their attitudes or beliefs, or the economic incentives they face, they seem to have internalized these messages and are more likely to choose to conserve water. Thus, promoting water conservation would seem to be more about promoting an Okanagan culture that includes water conservation, a culture that is reinforced with a large set of instruments, than it is about identifying some single effective instrument that will get everyone to conserve water. Given the high rate of immigration and the presence of many wealthy retirees who are only temporary residents, the challenge is to find ways to speed up the rate at which Okanagan residents adopt such an Okanagan culture.

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