Reports of Water Quality Violations induce Consumers to buy Bottled Water

Seo, Misuk and Pape, Andreas Duus

SUNY Binghamton, SUNY Binghamton

January 2011

REPORTS OF WATER QUALITY VIOLATIONS INDUCE CONSUMERS TO BUY BOTTLED WATER

MI SUK SEO
AND ANDREAS DUUS PAPE

JANUARY 2011

Abstract. The 1996 Safe Drinking Water Act Amendments require that water utilities mail drinking water quality reports to their customers annually. The public uses this information; the news of a water quality violation makes a household 21% more likely to purchase bottled water in the following year.We measure reports of violations with Environmental Protection Agency (EPA) data about violation reports from 1,300 water utilities, with a service population of approximately 10 million people total. We measure the consumer response using the Consumer Expenditure (CEX) survey from 2006-2008 with 10,874 households, and we match consumers to utilities geographically.

JEL Codes: Q25, Q53
Keywords: Water Quality Reports, Environmental Information, Consumer Response to Information, Bottled Water Expenditure, Consumer Expenditure Survey

---

Seo (corresponding author): Department of Economics, Binghamton University, Binghamton, NY. E-mail: mseo1@binghamton.edu. Pape: Department of Economics, Binghamton University, Binghamton, NY. E-mail: apape@binghamton.edu. Binghamton University provided helpful comments. **DRAFT to be presented at EEA 2011.**

1. Introduction

Water quality is a serious public health concern for the developed world; according to the New York Times (Duhigg [2009]), as many as 19 million Americans become ill due to parasites, viruses, and bacteria in drinking water each year. The 1996 Safe Drinking Water Act Amendments (SDWAA96) require that the public be informed about drinking water contaminants through annual reports. We find that the public uses this information: a report of a water quality violation issued by a local utility induces consumers to be 21% more likely to purchase bottled water in the following year. This implies about .8 million Americans started drinking bottled water because of reported violations.

In the sections that follow, we review the literature on drinking water quality information (section 2); describe the data (section 3); show our Probit and two-step Heckman regressions (section 4); and briefly conclude with policy implications (section 5).

2. Literature

Tables 1 and 2 summarize the relevant academic literature.

Based on a survey of households in Boston, Smith and Desvousges [1986] report that nearly 30% of their sample self-report that they purchase bottled water to avoid hazardous waste, and news of hazardous waste statistically significantly determines bottled water purchases. In a similar study about Georgia residents, Abrahams et al. [2000] find 23% consider tap water somewhat unsafe or unsafe, and about 32% show their satisfaction with their water quality. The authors show that concerns about the safety and tap water quality are important determinants but, in contrast to our results, they find notification of local water problems with tap water is not significant determinant in the decision to buy bottled water. A few years later, unlike Abrahams et al. [2000], Jakus et al. [2009] found that directly perceived water quality (taste, smell, clarity) has a greater influence than perceived risk in prompting people to buy bottled water in the decision. But, all else equal, those with greater perceived risks are willing to spend more money on bottled water than those with lower perceived risks.[1]

In a working paper similar to ours, Zivin et al. [2011] use bottled water consumption as a measure of consumer avoidance of tap water in the presence of SDWAA96 violations and find, like we do, that this impact is significant. Their measure of bottled water consumption differs from ours: while we use Consumer Expenditure survey data representative of one third of the U.S. population, they use data from what appears to be 200 grocery stores in northern CA and NV (compared to approximately ten thousand

[1] As a similar vein, by Jakus et al. [2009], people will behave according to their personal perception of risk and not according to the objective measure risk as calculated by scientists.

households which we are able to use). They focus on month-by-month announcements of water violations, and seek an immediate effect of consumer behavior on bottled water consumption, while we rely on the the annual Water Quality Reports as the means by which consumers would learn of violations. Their data, therefore, is richer in the time dimension but sparser cross-sectionally. They find expenditures on bottled water increased by 17 to 22 percent upon receiving news of a violation, which is comparable of our result, which finds consumers are 21 more likely to purchase bottled water upon receiving news of a violation.

Bennear and Olmstead [2008] study the impact of WQRs mailed to consumers brought about by SDWAA96, but look at water suppliers' response, not consumer response. They find that utilities required to mail these WQRs reduced their violations by between 30 and 44%.

According to Jalan et al. [2003], measures of awareness such as schooling and exposure to mass media have statistically significant effects on adoption of different home purification methods in India. In contrast to our work, most researchers have used information measures from non-health related water quality and reported beliefs about health risks, so has less to say about a public information campaign such as one as undertaken by the 1996 Safe Drinking Water Act Amendments. Two papers are similar to ours, in that they involve a public information campaign. Madajewicz et al. [2007] tested the water in each of 6,500 wells across Bangladesh; they then labeled each well as safe or unsafe and reported the result to the users of the well: people with labeled unsafe wells are over four times as likely to change to another well within one year. Jalan and Somanathan [2008] selected households in an Indian city, informed people whether their drinking water had tested positive for fecal contaminant. Non-purifying households who learned that their water is "dirty" are 11 percentage points more likely to change their averting behavior than households who received no information.

Apart from a subject of drinking water quality, consumer response to information that has been addressed in different topics such as eco-labeling (Teisl et al. [2002]), food safety concerns (Piggott and Marsh [2004]), price information on water bills (Gaudin [2006]), and different formats of water quality reports (Johnson [2003]). Generally, they find, like we do, that the public responds to information about environmental concerns.

3. Data

There are two primary sources of data used in this study: the BLS's Consumer Expenditure Survey (CEX)[2] and EPA's Health-Based Violations of Drinking Water Standards (VIOLATIONS).[3] Table 3 contains the variable means and standard deviations of all variables, broken down by those who

[2]Available from The Bureau of Labor Statistics at `http://www.bls.gov/cex`.
[3]Available from The United State Environmental Protection Agency at `http://www.epa.gov/safewater/databases`.

Table 1. Literature Review Section Summary 1

No.	Author (year)	Data Source	Country	LHS variable	Good	Source of information
1	Seo & Pape (This paper)	Consumer Expenditure Survey	America	Purchase bottled water	Tap water	Water quality reports (Contamination)
2	Smith & Desvousges (1986)	A survey of households in suburban Boston	America	Purchase bottled water	Hazardous waste	News[a] & Action[b] (About town)
3	Abrahams et al. (2000)	University of Georgia Survey Research Center	America	Averting behavior[c]	Tap water	Notification/Risk/Quality[d]
4	Paul Jakus et al. (2009)	Outagamie County/ Appleton region in WI	America	Purchase bottled water	Private well	Perceived risk of Arsenic exposure &
5	Zivin et al. (2011)	A major supermarket chain (CA and NV)	America	Sales bottled water	Tap water	Public notification rule
6	Bennear & Olmstead[e] (2008)	U.S. EPA (MA)	America	Number of drinking water violations	Tap water	Water quality reports (Contamination) Perceived water quality
7	Jalan et al. (2003)	National Family Health Survey(98-99)	India	Adoption of different home purification[f]	Tap water	Awareness (Schooling/Exposure to media)
8	Madajewicz et al (2007)	A project in Bangladesh	Bangladesh	Changed to another well	Well	Label on the well (Arsenic)
9	Jalan & Somanathan (2008)	National Family Health Survey(2003)	India	Changes in purification behavior	Tap water	Inform water quality (Bacteria of fecal)
10	Teisl et al. (2002)	U.S. SCANTRACK Scanner	America	Expenditure share of canned tuna	Canned tuna	Label on canned tuna (Dolphin-safe)
11	Johnson (2003)	NJ customers Survey	America	Reaction by different format reports	Alternative vesions of water reports	Water quality reports (Contents & design))
12	Piggott & Marsh (2004)	U.S. Food Availability Data System		Purchase meat	Meat	Food safety indices (Recalls/Outbreak/Salmonella)
13	Gaudin (2006)	Waterstats Water Utility Database	America	Residential Consumption	Tap water	Marginal price on the bill (Tap water)

[a]Respondent read hazardous waste news articles about his/her town
[b]Community experiencing several contamination incidents since 1978.
[c]Tap water use/bottled water use/filtration use
[d]Respondent has knowledge or has received notification from the local water authority of a specific water contamination event/Risk perception about the safety of tap water/ Dissatisfaction about the taste, odor, and appearance of tap water
[e]Their paper is not related to consumer response but supplier behavior. We include this because it is only paper in context of water quality reports, like we do, until now we've found
[f]No purification/Straining/Ordinary filter/Electronic filter/Boiling

TABLE 2. Literature Review Section Summary 2

No.	Author (year)	Infomation as regulation	Inform directly to people	Information about health	Response by information
1	Seo & Pape (This paper)	Yes	Yes	Yes	Yes
2	Smith and Desvousges (1986)	No	No	Ambiguous	Yes for News No for Action
3	Abrahams et al. (2000)	No	No	No for Quality	Mixed[a]
4	Paul Jakus et al. (2009)	No	No	Yes	Yes
5	Zivin et al. (2011)	Yes	No	Yes	Yes
6	Bennear & Olmstead (2008)	Yes	Yes/No	Yes	Yes
7	Jalan et al. (2003)	No	No	Yes	Yes
8	Madajewicz et al (2007)	No	Yes	Yes	Yes
9	Jalan & Somanathan (2008)	No	Yes	Yes	Yes
10	Teisl et al. (2002)	Yes	Yes	No	Yes
11	Johnson (2003)	Yes	Yes	Yes	Yes
12	Piggott & Marsh (2004)	Yes	No	Yes	Yes
13	Gaudin (2006)	Depend on each state	Yes	No	Yes Yes

[a]Averting behavior for bottled water: yes for Risk &Quality but no for Notification and averting behavior for using filtering system: yes for notification but no for Risk & Quality

Table 3. Description and Sample Mean/Std.Dev.

Variables	**Description**	**Sample Value**[a]	**Purchase**	**No Purchase**[b]
ExpBottle($)	Weekly average expenditure for bottled water	1.9185	4.8259	0.0000
		(3.8628)	(4.8480)	(0.0000)
Violation	Population weighted violations	0.1315	0.1292	0.1330
		(0.2774)	(0.2719)	(0.2809)
Familysize	Number of members in CU(consumer unit)	2.7674	2.9123	2.6718
		(1.5144)	(1.5436)	(1.4872)
Income($K)	Amount of CU income before taxes in past 12 months	80.0434	85.6536	76.3412
		(73.9566)	(77.1254)	(71.5544)
Education (Yrs)	Schooling years of household (pseudo years) [c]	14.0837	14.2045	14.0040
		(2.6811)	(2.6302)	(2.7115)
AgeHH	Age of head of household	48.0109	46.9292	48.7248
		(15.5354)	(14.7839)	(15.9731)
HH64Dummy	Equals one if head of household over 64 in CU	0.1960	0.1735	0.2108
		(0.3970)	(0.3787)	(0.4079)
Child5Dummy	Equals one if head of household has less than 6 years	2.0829	2.2679	1.9608
	old children, zero otherwise	(2.6174)	(2.6478)	(2.5901)
WhiteDummy	Equals one if head of household is White,	1.3441	1.3743	1.3242
	zero otherwise	(0.8848)	(0.9270)	(0.8553)
ExpTea($)	Average weekly expenditure on tea and coffee	1.8412	1.7274	1.9162
		(3.8673)	(2.7532)	(4.4509)
ExpOther($)	Average weekly expenditure on other nonalcoholic	2.6192	2.6192	3.0269
	beverages	(3.4283)	(2.9773)	(3.6872)
	No. of Households	10,874	4,323	6,551

[a]Standard deviations are in parentheses.

[b]About 40% of the sample reported bottled water expenditures on average per week

[c]0 if never attended school, 8 if first through eighth grade, 12 if high school graduate (no H.S. diploma), 14 if some college, less than college graduate or associate's degree (occupational/vocational or academic), 16 if Bachelor's degree, 18 if Master's degree, 20 if Professional/Doctorate degree

purchased bottled water versus those who did not. Observations in this table are households from CEX from 2006 to 2008 who live in geographical areas which could be mapped to VIOLATIONS

CEX collects information from the nation's households and families on their buying habits, income, and household characteristics. The survey consists of two components: a quarterly interview survey and a weekly diary survey. Largely self-reported values from the quarterly interview survey are the demographic variables used here. The diary survey provides bottled water expenditure (and other expenditure) variables. Respondents are asked to keep track of all purchases made each day for two consecutive weeks. The CEX from 2006 to 2008 includes exactly 10,874 households which we are able to match (see section 3). CEX reports that weekly average expenditure for bottled water as $1.91 per household unit for all households and $4.83 amoung those who purchased any (see Table 3). The percent of households who consumed any bottled water rose one percentage point per year from 39% to 41%.

VIOLATIONS is a record of the water quality reports (WQRs) which were sent or made available by water utilities to consumers. SWDAA96 focuses on public water systems which the EPA defines as not publicly-owned but rather any water system which provides water for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly serve at least 25 individuals. The 1996 Amendments in the United States require water utilities to issue annual water quality reports. In particular, community water system must directly mail their reports to households by July 1 each year if they serve 10,000 or more people. This water quality report must include health based violations if violations occur at systems. EPA collects the information, the number of health based violations of drinking water standards, from public water utilities.

Our primary dependent variable is bottled water expenditure from the CEX. The ideal variable would be direct human tap water consumption, but such data are not available. Aggregate residential tap water consumption data is the closest data which exist, but they include tap water used for all purposes, including all bathroom uses, laundry, and watering lawns. Direct human consumption, according to American Water Works Association [1999], is only 15.7% of total usage. Therefore we follow the literature (Smith and Desvousges [1986], Larson and Gnedenko [1999], Abrahams et al. [2000] and Jakus et al. [2009]) and use bottled water consumption as a substitute for direct human consumption of tap water.

Our primary explanatory variable is the number of reported health violations from VIOLATIONS. The observations in these data are public water systems (defined above).

The EPA defines three types of public water systems, only one of which considered in this study: community water systems, which supply water to the same population year-round. The excluded utilities are non-transient non-community water systems and transient non-community water systems which provide water either not year-round or not the same population, such as schools, factories, gas stations, or campgrounds. According to United States Environmental Protection Agency [2009], there are approximately 52,000 community water systems.

SWDAA96 requires that water utilities which serve 10,000 or more people to directly mail their annual water quality reports to their households by July 1 each year and post the reports online.[4] Water utilities which serve fewer than 10,000 people need only post on-line or in local newspapers. We restrict our analysis to community water systems which serve more than 10,000 people. Although these two restrictions limit us to only 2.7% of all water systems in the U.S., they serve 78% of the U.S. population.

To construct our data, we had to map utility-level VIOLATIONS data to household-level CEX data. We used two two criteria: time and geography.

Time: CEX households in each year (2006, 2007, 2008) are matched to VIOLATIONS from the previous year (2005, 2006, 2007). A, for example, 2007 VIOLATIONS observation contains the data which were sent to consumers in 2008; therefore, we match with 2008 CEX data.

Geography: The key geographic matching variable is county: The CEX has sampling units which contain counties, and water utilities serve counties. Given our data structure, we compute an expected number of violations for each CEX household, given their location. CEX provides codes for the largest 21 Primary Sampling Units or PSUs, which similar to MSAs. See figure 1 for a U.S. map of the 21 PSUs; note that the largest US cities are covered about one-third of the US population lives in one of these PSUs. VIOLATIONS provide the counties that utilities serve, so we requested a list of counties in each PSU from BLS. Then we constructed the expected number of reported violations each person in a PSU received by: (a) multiplying the population served by each utility by the number of violations by each utility; (b) adding this poplation-weighed number of violations across all utilities which serve counties in a given PSU; and then (c) dividing this sum of population-weighted number of violations by the population of the PSU. Formally, consider suppose utilities $u = 1, \ldots, U$ are in a given PSU PSU_A. Let pop_u be the population served by utility u and let vio_u be the number of violations by utility u. Then, for all individuals i who live in PSU_A, let

$$violations_i = \frac{\sum_{u=1}^{U} (pop_u vio_u)}{\sum_{u=1}^{U} pop_u} \tag{1}$$

$$\implies violations_i = \mathrm{E}\big(\text{violations}|\text{individual } i \text{ lives in } PSU_A\big) \tag{2}$$

[4]Office of water (4604), Public access to information & public involvement in EPA 816-F-04-039 June 2004

Two notes about the geographical match. First, since we use only PSUs, the sample is weighted toward urban households and thus may not accurately describe rural Americans. Second, the violations variable measures a probability that the household received a WQR which indicated a violation, instead of certainty that the household received such a WQR. This means the data likely underestimates the true impact of WQRs on bottled water purchases. The geographic restriction to PSUs further limits the data to 32% of valid community water systems, which as mentioned above, serve about one-third of the U.S. population.

Table 4 shows the number of household sampled, the number of water utilities that serve $\geq 10,000$ population, $10,000$ or more populations served by the water utilities, and average $10,000$ or more population served by water utilities with Violations over three years in the study. At least one time, 10.37 % of people received water quality reports with violations from 2006 to 2008.

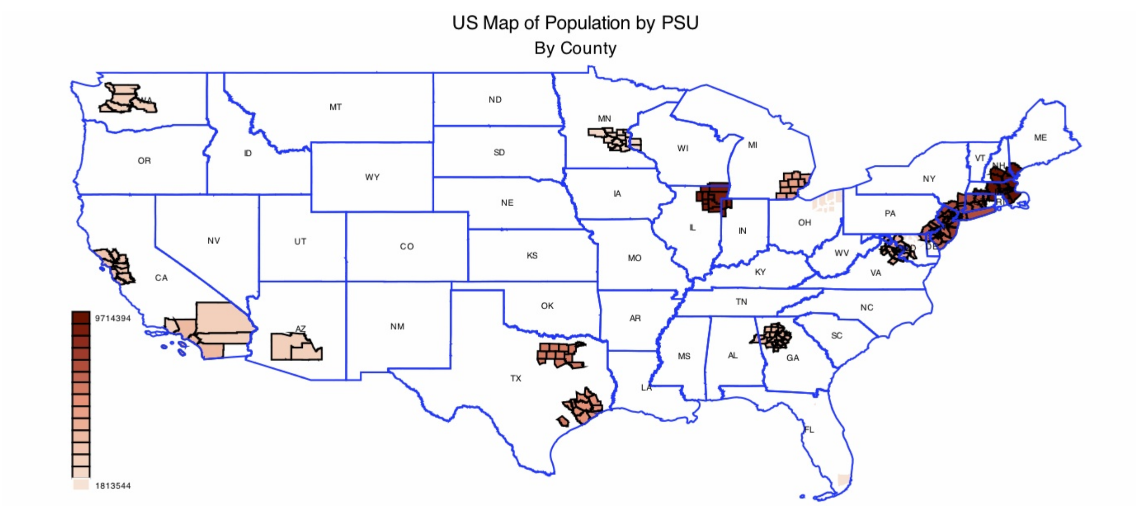

Figure 1. U.S. Map: Population by the 21 PSUs Served by Water Utilities in County Level

4. Empirical Analysis

Consumers directly receive water quality reports, news of health violations in drinking water, from their water utilities annually. If a consumer receives the report containing many health violations and read these potential health effects of any detected contaminant level that violates drinking water quality standard, she may find tap water less appealing for direct consumption. If so, provision of water quality information induces those who receive violations for drinking water to start finding alternatives to water

Table 4. Percent of Household Sampled by PSUs

21 PSU Code	Number of Household Sampled(%)	Number of [a] Water Utilities	*pop*1[b]	*pop*2[c]
1102	592(5.44)	85	5,745,896	317,251
1103	740(6.81)	162	8,447,005	351,798
1109	584(5.37)	3	8,070,718	5,368,479
1110	796(7.32)	92	6,116,332	850,200
1111	588(5.41)	113	6,270,762	409,193
1207	1,170(10.76)	171	8,212,501	486,398
1208	593(5.45)	89	4,366,684	48,010
1210	292(2.69)	31	2,787,723	100,000
1211	295(2.71)	62	2,649,979	145,325
1312	460(4.23)	31	4,590,334	402,500
1313	262(2.41)	14	2,442,626	105,385
1316	512(4.71)	73	5,657,220	122,000
1318	406(3.73)	59	4,244,811	71,277
1319	366(3.37)	45	4,535,247	125,991
1320	373(3.43)	28	1,771,896	16,090
1419	1,026(9.44)	64	4,443,397	34,518
1420	377(3.47)	48	3,157,317	70,074
1422	531(4.88)	32	4,207,028	131,563
1423	367(3.38)	63	3,392,230	134,763
1424	220(2.02)	20	4,515,463	-[d]
1429	324(2.98)	31	3,863,602	299,245
Total	10,874(100.00)	1316	99,488,771	9,590,058

[a]Number of water utilities that serve $\geq 10,000$

[b]*pop*1: 10,000 or more population served by water utilities in the United States.

[c]*pop*2: Average 10,000 or more population served by water utilities with Violations over three years, 2005-2007

[d]There are no violations reported

for avoiding consumption of low quality water. In the study, we consider bottled water as an alternative to tap water.

Our principal hypothesis is that news of health violations in drinking water causes consumers to purchase bottled water; i.e. along the extensive margin. To test our hypothesis, we take a standard Probit approach. Namely:

$$Pr(y=1) = \Phi(\beta_1 + \beta_{i2}x_{i2} + ... + \beta_K x_{iK}) = \Phi(x_i^{'}\beta) \quad (3)$$

where $Pr(y=1)$ is 1 if consumer i decides to buy bottled water and 0 if the consumer decides not to buy bottled water. $\Phi(\cdot)$ is the CDF of the normal distribution function. $x_i^{'}$ is the vector of variables explaining the probability of buying bottled water. β is a parameter vector to be estimated.

Table 5. Estimated Coefficients in Probit Models

	Model 1 Coef. (Std.Err)		Model 2 Coef. (Std.Err)		Model 3 Coef. (Std.Err)[a]	
Violation	–.0273		.1498		.2058	
	(.0443)		(.0793)	*	(.0819)	**[b]
Familysize	.0368		.0323		.0393	
	(.0109)	***	(.0110)	***	(.0110)	***
Income($K)	.0006		.0006		.0007	
	(.0002)	***	(.0002)	***	(.0002)	***
Education	.0132		.0154		.0162	
	(.0051)	***	(.0051)	***	(.0051)	***
AgeHH	–.0034		–.0033		–.0030	
	(.0012)	***	(.0012)	***	(.0012)	***
HH64Dummy	.0024		–.0023		–.0117	
	(.0435)		(.0438)		(.0439)	
Child5Dummy	.0145		.0154		.0151	
	(.0060)	**	(.0061)	**	(.0061)	**
WhiteDummy	.0344		.0299		.0273	
	(.0138)	**	(.0140)	**	(.0141)	*
ExpTea($)					–.0130	
					(.0039)	***
ExpOther($)					–.0293	
					(.0041)	***
TimeTrend					.0447	
					(.0155)	***
PSU Fixed Effects	No		Yes		Yes	
Constant	–.5133		–.4245		–.4627	
	(.0964)	***	(.1196)	***	(.1244)	***
No. of households	10874		10874		10874	
Pseudo-R2	.008		.018		.023	
Log likelihood	–7245.316		–7176.381		–7138.379	
LR Chi2	124.184		262.053		338.057	
Prob>Chi2	.000		.000		.000	

[a]Standard errors are in parentheses

[b]Star,*, indicates statistical significance at $p < 0.10$, ** at $p < 0.05$, and *** at $p < 0.01$

Table 5 shows the results of three different Probit models. Model 1 excludes PSU fixed effects. Models 1 and 2 exclude two expenditure variables for tea and coffee and other nonalcoholic beverages. In Model 3, we add a

TABLE 6. Estimated Marginal Effect (Model 3)

	dy/dx	Std.Err		X-bar
Violation	.0792	.0315	**[a]	.1315
Familysize	.0151	.0042	***	2.7674
Income($K)	.0003	.0001	***	80.0433
Education	.0062	.0020	***	14.0837
AgeHH	−.0012	.0004	***	48.0109
HH64Dummy	−.0045	.0169		.1960
Child5Dummy	.0058	.0023	**	2.0829
WhiteDummy	.0105	.0054	*	1.3441
ExpTea($)	−.0050	.0015	***	1.8412
ExpOther($)	−.0113	.0016	***	2.8648
TimeTrend	.0172	.0060	***	1.9862
PSU Fixed Effects	Yes			

[a]* indicates statistical significance at $p < 0.10$, ** at $p < 0.05$, and *** at $p < 0.01$

time trend variable.[5] Table 6 displays the estimated marginal effects at the mean associated with the parameter values. We found that the coefficients on Violation variables in Model 2 and Model 3 are positive and statistically significant; this indicates that the effect of more violation reports increases the likelihood that people buy bottled water. In Model 3, the marginal effects give the increase in likelihood of buying bottled water by 0.08 for those who received water quality violation report. Table 7 reports the results of the predicted probabilities for purchasing bottled water in the specification of the model 3. (The violation variable is set to 0, 1, and 2, and the other independent variables set at the sample average values.) We ask: what is the estimated increase in the probability of purchasing bottled water as the number of violations reported increases from zero to one? We get roughly 0.4646 - 0.3841 = 0.0805. This means that the probability of switching to drinking bottled water is about 8 percentage points (21%) higher when consumers received a report of a water quality violation. As shown in Table 4, average population served by water utilities with violations reported over three years, 2005-2007, were about 9,600,000. It implies that about 768,000 people started drinking bottled water because of violations holding all other factors constant.

Household income is positively and statistically related to expenditures on bottled water. Marginal effects give the increases in the expected people's expenditure on bottled water by 0.0003 with a $1,000 increase in annual income, and by 0.015 for the family which has more members than the family which has less. While the dummy variable of head of households

[5]We also add Quarter dummies as well as time trend variable. The result are almost same as in Model3.

TABLE 7. Predicted Probabilities of Purchasing Bottled Water

x =Violation	Pr(y=1| x)	95% Conf. Interval
0	0.3841	[0.3718, 0.3964]
1	0.4646	[0.4084, 0.5207]
2	0.5465	[0.4273, 0.6656]

over 64 years old are not statistically significant, the number of members in consumer unit, Family size, are positive and statistically significant. The coefficients on AgeHH are negative and statistically significant, indicating that older people are less likely to spend their money on buying bottled water than those who are younger. Household with children are more likely to consume bottled water than those who are with no children. More educated people are more likely to purchase bottled water than people with less education. About both expenditures on tea and other nonalcoholic beverages, results indicate that consumer's expenditures for them are negatively related to the probability of buying bottled water, suggesting these other beverage are gross substitutes for bottled water.

We ran the Probit regression with lagged population weighted violations, which were not statistically significant.

4.1. **The impact on the amount of bottled water purchased (the intensive margin).** In the previous analysis, we established that receiving news of health violations in drinking water increases consumers' probability of purchasing bottled water. One way also ask: does the news of violations increase the amount of bottled water purchased? To investigate this question, we use the two-step procedure by Heckman [1979]. In first step, using model 3 in Table 5, we ran a probit model: decision equation for the decision to spend. In second step, we ran an ordinary least squares model to predict expenditure. To get the full effects of water quality information on purchasing bottled water, we obtained the inverse of the Mill's ratio from probit model. Then, we augmented the expenditure regression equation with the inverse of the Mill's ratio. Thus, we can derive consistent estimates of the regression disturbance variance. Appendix A reports the results of bottled water expenditure in these models. The two specifications in models for both probit model and ordinary least square model are the same. In the model 2, we performed bootstrap estimation in second step to obtain consistent estimates of standard errors. We found that Violation from water quality reports is statistically significant in model 2 unlike model 1. We could say that people's weekly average expenditure to purchase bottled water increases $0.78 by one more violation. The coefficient on lambda term (the inverse of the Mill's ratio) suggests that the error terms in decision regression and expenditure regression are positively correlated.

5. Conclusion

Using the Consumer Expenditure Survey from 2006 to 2008, this paper offers direct micro-level information on an actual action that households are undertaken to avoid or reduce the effects of consumption of bad tap water quality. The main purpose of this paper is to test whether receiving news of health violations in drinking water increases consumers' probability of purchasing bottled water. About 40 percent of our sample was weekly percent reporting any bottle water and weekly average expenditure for bottled water was $4.83 per household unit. We found that one reported water quality violation increases the likelihood that individuals buy bottled water about 8 percentage points, or 21%, higher. It implies that about 768,000 people in the study started drinking bottled water because of water quality violations.

Appendices

Appendix A. Bottled Water Expenditures in Heckman Models

	Model 1 Coef. (Std.Err)[a]		Model 2 Coef. (Bootstrap)[b]	
Violation	.7821		.7821	
	(.5254)		(.4010)	*[c]
Familysize	.2491		.2491	
	(.0560)	***	(.0557)	***
Income ($K)	.0075		.0075	
	(.0011)	***	(.0015)	***
TimeTrend	.4076		.4076	
	(.0942)	***	(.0870)	***
lambda[d]	4.7420		4.7420	
	(.8661)	***	(.9228)	***
PSU Fixed Effects	Yes		Yes	
Constant	–3.1064		–2.8162	
	(1.3697)	**	(1.0208)	***
No. of obs.	4323		4323	
F Statistics	6.599			
Wald Chi2			218.78	
Prob>Chi2	.000		.000	
R-squared	.037		.037	
Adjusted R-squared	.031		.031	

[a]Standard errors are in parentheses

[b]To obtain consistent estimates of standard errors, we performed bootstrap estimation

[c]* indicates statistical significance at $p < 0.10$, ** at $p < 0.05$, and *** at $p < 0.01$

[d]lambda is the inverse of the Mill's ratio obtained from Probit model

Appendix B. List of PSU's Geographic Areas in the CE Survey

PSU	PSU Name	Region/Definition (County,State)[a]
		NORTHEAST
A109	New York, NY	Bronx, Kings, New York, Queens, Richmond, NY
A110	New York-Connecticut-Suburbs	Fairfield, Hartford, Litchfield, Middlesex, New Haven, Tolland, CT; Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk, Westchester, NY
A111	New Jersey Suburbs	Bergen, Essex, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Passaic, Somerset, Sussex, Union, Warren, NJ
A102	Philadelphia-Wilmington-Atlantic-City, PA-NJ-DE-MD	New Castle, DE; Cecil, MD; Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Salem, NJ; Bucks, Chester, Delaware, Montgomery, Philadelphia, PA
A103	Boston-Brockton-Nashua, MA-NH-ME-CT	Windham, CT; Bristol, Essex, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, Worcester, MA; York, ME; Hillsborough, Merrimack, Rockingham, Strafford, NH
		MIDWEST
A207	Chicago-Gary-Kenosha, IL-IN-WI	Cook, DeKalb, Du Page, Grundy, Kane, Kankakee, Kendall, Lake, McHenry, Will, IL; Lake, Newton, Porter, IN; Kenosha, WI
A208	Detroit-Ann-Arbor-Flint, MI	Genesee, Lapeer, Lenawee, Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, Wayne, MI
A210	Cleveland-Akron, OH	Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, Summit, OH
A211	Minneapolis-St. Paul, MN-WI	Anoka, Benton, Carver, Chisago, Dakota, Hennepin, Isanti, Ramsey, Scott, Sherburne, Stearns, Washington, Wright, MN; Pierce, St. Croix, WI
		SOUTH
A312	Washington, DC-MD-VA-WV	District of Columbia, DC; Calvert, Charles, Frederick, Montgomery, Prince George?s, Washington, MD; Alexandria city, Arlington, Clarke, Fairfax, Fairfax city, Falls Church city, Fauquier, Fredericksburg city, King George, Loudoun, Manassas Park city, Manassas city, Prince William, Rappahannock, Spotsylvania, Stafford, Warren, VA; Berkeley, Jefferson, WV
A313	Baltimore, MD	Anne Arundel, Baltimore, Baltimore city, Carroll, Harford, Howard, Queen Anne's, MD
A316	Dallas-Fort Worth, TX	Collin, Dallas, Delta, Denton, Ellis, Henderson, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, Wise, TX
A318	Houston-Galveston-Brazoria, TX	Austin, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, San Jacinto, Waller, TX
A319	Atlanta, GA	Cleburne, AL; Barrow, Bartow, Butts, Carroll, Cherokee, Clayton, Cobb, Coweta, Dawson, De Kalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Haralson, Henry, Newton, Paulding, Pickens, Pike, Rockdale, Spalding, Walton, GA
A320	Miami-Fort Lauderdale	Broward, Miami Dade, FL
		WEST
A419	Los Angeles-Orange, CA	Los Angeles, Orange, CA
A420	Los Angeles Suburbs, CA	Riverside, San Bernardino, Ventura, CA
A422	San Francisco-Oakland-San Jose, CA	Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, Sonoma, CA
A423	Seattle-Tacoma-Bremerton	Island, King, Kitsap, Pierce, Snohomish, Thurston, WA
A424	San Diego, CA	San Diego, CA
A429	Phoenix-Mesa, AZ	Maricopa, Pinal, AZ

[a]2000 Census-Based Sample Design(starting in 2005)

References

Nii Adote Abrahams, Bryan J. Hubbell, and Jeffrey L. Jordan. Joint production and averting expenditure measures of willingness to pay: Do water expenditures really measure avoidance costs?. *American Journal of Agricultural Economics*, 82(2):427, 2000.

American Water Works Association. *Residential End Uses of Water*. American Water Works Association Research Foundation, 1999.

Lori S. Bennear and Sheila M. Olmstead. The impacts of the "right to know": Information disclosure and the violation of drinking water standards. *Journal of Environmental Economics and Management*, 56(2):117 – 130, 2008.

Charles Duhigg. Millions in u.s. drink dirty water, records show. The New York Times, 12 2009. URL `http://www.nytimes.com`.

S. Gaudin. Effect of price information on residential water demand. *Applied Economics*, 38(4):383 – 393, 2006.

James J Heckman. Sample selection bias as a specification error. *Econometrica*, 47:153–161, 1979.

Paul Jakus, W Shaw, To Nguyen, and Mark Walker. Risk perceptions of arsenic in tap water and consumption of bottled water. *Water Resour. Res.*, 45(5), May 2009.

Jyotsna Jalan and E. Somanathan. The importance of being informed: Experimental evidence on demand for environmental quality. *Journal of Development Economics*, 87(1):14–28, 8 2008.

Jyotsna Jalan, E.Somanathan, and Saraswata Chaudhuri. Awareness and the demand for environmental quality: Drinking water in urban india. Indian Statistical Institute, Delhi Planning Unit, 2003.

Branden B. Johnson. Do reports on drinking water quality affect customers' concerns? experiments in report content. *Risk Analysis: An International Journal*, 23(5):985 – 998, 2003.

Bruce A. Larson and Ekaterina D. Gnedenko. Avoiding health risks from drinking water in moscow: An empirical analysis. *Environment and Development Economics*, 4(4):565–581, 1999.

Malgosia Madajewicz, Alexander Pfaff, Alexander van Geen, Joseph Graziano, Iftikhar Hussein, Hasina Momotaj, Roksana Sylvi, and Habibul Ahsan. Can information alone change behavior? response to arsenic contamination of groundwater in bangladesh. *Journal of Development Economics*, 84(2):731 – 754, 2007.

Nicholas E. Piggott and Thomas L. Marsh. Does food safety information impact u.s. meat demand?. *American Journal of Agricultural Economics*, 86(1):154 – 174, 2004.

V. Kerry Smith and William H. Desvousges. Averting behavior: Does it exist? *Economics Letters*, 20(3):291 – 296, 1986.

Mario F. Teisl, Brian Roe, and Robert L. Hicks. Can eco-labels tune a market? evidence from dolphin-safe labeling. *Journal of Environmental*

Economics and Management, 43(3):339 – 359, 2002.

United States Environmental Protection Agency. Factoids: Drinking water and ground water statistics for 2009. Office of Water (4601M) EPA 816-K-09-004, Wahsington, DC, 2009.

Joshua Graff Zivin, Matthew Neidell, and Wolfram Schlenker. Water quality violations and avoidance behavior: Evidence from bottled water consumption. Working Paper 16695, National Bureau of Economic Research, January 2011.