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The Private Rationality of Bottled Water Drinking

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THE PRIVATE RATIONALITY OF BOTTLED WATER DRINKING

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This article examines evidence for the private rationality of decisions to choose bottled water using a large, nationally representative sample. Consumers are more likely to believe that bottled water is safer or tastes better if they have had adverse experiences with tap water or live in states with more prevalent violations of EPA water quality standards. Perceptions of superior safety, taste, and convenience of bottled water boost consumption of bottled water. Blacks and Hispanics are more likely to drink bottled water due to their relatively greater exposure to unsafe water and greater risk beliefs. The coherent network of experiences, beliefs, and actions is consistent with rational consumer choice. (*JEL* D12, D80, Q50)

I. INTRODUCTION

Drinking bottled water has become both increasingly popular and increasingly controversial. Annual U.S. consumption of bottled water tripled from 12 billion bottles in 2000 to 36 billion bottles in 2006 (Container Recycling Institute 2008). Per capita consumption of bottled water in 2010 was 28.3 gallons annually, exceeding the per capita amounts for milk (20.4 gallons), coffee (18.4 gallons), and tea (10.3 gallons), but less than the comparable amount for all sodas (44.7 gallons).[1] Bottled water has come under particular attack because of the perceived irrationality of the consumer choice. Some critics view bottled water as an entirely frivolous consumer good without any desirable product attributes.[2] They claim that those who drink bottled water are victims of hype and that bottled water is not superior on any dimension to tap water and can be riskier than tap water. Moreover, to the extent that bottled water is purified tap water, they suggest that there is often no taste difference. This article examines these critiques and provides an exploration of the private rationality of bottled water drinking.

Despite the widespread claims of consumer irrationality in the media and by environmental groups, there has been little empirical attention paid to the assessment of whether there is a potentially sound basis for bottled water consumption. In this instance, as with many other personal consumption decisions and expressions of paternalistic concerns, individual preferences vary and critiques may be a form of second guessing the choices of others based on one's own preferences. However, irrespective of the heterogeneity of individual preferences, such critiques may nevertheless be valid if the consumption choices are driven by misperception of

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1. The data are from Advertising Age, http://adage.com/article/news/consumers-drink-soft-drinks-water-beer/228422/.

2. Royce (2008) coined the term "bottlemania" to characterize victims of irrational bottled water drinking. Examples of other critiques are Erik D. Olsen, "Bottled Water: Pure Drink or Pure Hype?" National Resources Defense Council, February, 1999, http://www.nrdc.org/water/drinking/bw/bwinx.asp; Emily Arnold and Janet Larsen, "Bottled Water: Pouring Resources Down the Drain," Earth Policy Institute, February 2, 2006, http://www.earth-policy.org/Updates/2006/Update51.htm; Brian C. Howard, "Despite the Hype, Bottled Water Is Neither Cleaner Nor Greener than Tap Water," *E/The Environmental Magazine*, September-October, 2002; and Michael Blanding, "The Bottled Water Lie," AlterNet, October 26, 2006, www.alternet.org/story/43480.

ABBREVIATIONS

EPA: Environmental Protection Agency
FDA: Food and Drug Administration
KN: Knowledge Networks

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the attributes of the product by consumers. It is the soundness of consumer perceptions and the coherence of individual choice that we examine in this article.

Whether consumers properly assess risks and how information affects these risk beliefs is of continuing interest in a variety of consumer choice contexts. Much attention has been devoted to tests of the perception of the risks of smoking, which are analyzed in Viscusi (1990), among others. Information about other less prominent hazards has also been shown to be influential in altering consumer behavior as in the case of consumer responses to mercury advisories for fish (Shimshack, Ward, and Beatty 2007).

Our analysis is unique both in its focus on linkages between water quality experiences, risk beliefs, and precautionary behaviors from a nationally representative sample. There are several important antecedents in the literature that address issues that are relevant to the topics addressed here. This research has largely focused on arsenic risks in water, likely stimulated in part by the controversial U.S. Environmental Protection Agency (EPA) regulation reducing allowable arsenic levels in drinking water.[3] For instance, in a mail survey in 30 Minnesota communities with high levels of arsenic contamination in water, residents express adverse individual experiences with taste, color, and odor in the water even though arsenic is tasteless, odorless, and colorless (Cho, Easter, and Konishi 2010). While this result suggests that consumers apparently lack understanding of the determinants of arsenic risks, it also may reflect consumers' belief that sensory water characteristics on these dimensions can provide information with respect to risk components that cannot be readily monitored. After the study provided respondents with information on current and historical information of arsenic levels, only the taste attribute continued to play a significant role as a predictor of assessed arsenic risks (color and odor were no longer influential). The dominant role of taste in governing arsenic risk beliefs is consistent with the leading role that taste considerations play in our respondents' risk beliefs of water quality risks generally as well as their water usage decisions.

The study by Konishi and Adachi (2011) used the same Minnesota arsenic sample as in Cho, Easter, and Konishi (2010) and extended the analysis to examine the relationship of risk beliefs and experiences to arsenic-averting behaviors, which the authors categorize as taking place if the respondent either undertakes arsenic-related water treatment or uses bottled water. Thus, whereas Cho, Easter, and Konishi (2010) considered the relationship of water experiences to arsenic risk beliefs, Konishi and Adachi (2011) show that arsenic risk beliefs and adverse experiences with water increase this precautionary behavior measure. The use of bottled water (among other self-protection activities) based on bad taste experiences is consistent with our results and generalizes the behavior as a response to reduce risk exposures from tap water.

Shaw et al. (2012) also focus on arsenic risks, but utilize a sample of 733 respondents from arsenic hot spots in different states. Consistent with rational updating, risk beliefs are higher when the arsenic concentrations in the area are greater. However, respondents appear to underestimate arsenic risks even after receiving an information booklet, though smokers did understand that arsenic posed relatively greater risks to them than to nonsmokers. Despite their higher risk beliefs, smokers undertook fewer precautions than nonsmokers, a relationship that is possibly reflective of the risk preferences and rates of time preference embodied in smoking behavior. Arsenic risks entail low probabilities and arise from exposures that are difficult for consumers to monitor.

The overall message from these three studies of arsenic risks in water is that risk beliefs are systematically related to actual risk levels, but there may be perceptional shortfalls in terms of processing risk information and drawing on personal experiences if, for example, arsenic exposures are not correlated with water taste, smell, and odor. Higher risk beliefs with respect to arsenic risks do, however, tend to generate a precautionary response. The demands placed on consumers by arsenic risks are considerable as the risks generated involve low probabilities of deferred risks that are difficult for consumers to assess. In contrast, our study focuses on more immediate and more apparent water quality hazards for which the challenges posed to individual beliefs and decisions should be less pronounced.

The study of Zivin, Neidell, and Schlenker (2011) is more similar to ours in that it focused on the effect of drinking water quality violations related to contaminants more broadly (chemical and microorganisms), rather than the presence of less-understood arsenic risks. Using a sample

3. EPA 816-F-01-004, issued in January of 2001, lowered the standard for arsenic in drinking water from 50 ppb to 10 ppb with a required compliance date of 2006.

of stores in Northern California and Nevada, the authors found that purchases of bottled water increased after adverse water quality reports. Our analysis likewise finds that water quality violations lead to changes in individual purchases of bottled water. By using detailed individual data, we also are able to examine the specific mechanisms at work and show how water quality violations influence risk beliefs and subsequent behavior.

Our article, using a large, nationally representative sample of households, examines the following questions: Who drinks bottled water? What do they believe about bottled water? Is there reasonable basis for these beliefs? Do these beliefs influence bottled water consumption in the expected manner?

We address these issues in the following order. Section II describes the sample used in our study and frames the discussion. The analysis follows standard consumer choice theory in assuming that the valuation of the commodity is based on an assessment and valuation of product attributes. In this instance, the key product characteristics are consumer perceptions of safety, taste, and convenience. Section III explores the perception of these product attributes and the determinants of these perceptions for each of the product characteristics. We examine whether there is any legitimate basis for the beliefs regarding the characteristics of bottled water over tap water drawing on objective risk data, past individual experiences with water, and the role of personal characteristics. Our examination of risk beliefs includes an assessment of the effect of violations of EPA water quality standards for tap water on risk beliefs and changes in bottled water consumption. A series of regression analyses in Section IV examines the effect of these product attributes and personal characteristics on whether a person drinks bottled water, drinks tap water, the amount spent on bottled water, and total consumption of bottled water. These estimates indicate that the different attributes of bottled water and tap water influence usage in the expected manner. As a check on the responsiveness of consumers to safety concerns, Section V presents an additional set of results pertaining to changes in behavior. Analysis of changes in bottled water consumption shows that increases in bottled water consumption likewise are linked to regions with unsafe water. Section VI concludes with our general result that the patterns of bottled water consumption appear to be internally consistent.

II. SAMPLE DESCRIPTION AND EMPIRICAL HYPOTHESES

A. Sample and the Variables

The sample used for the empirical analysis is drawn from the authors' survey administered through the Knowledge Networks (KN) Web-based panel[4] in October 2009. The KN panel is a probability-based nationally representative sample that is generally regarded as the highest quality Web-based panel. KN provides Internet access to those who would not otherwise have it so that they can participate in the panel. A total of 1,639 panelists were invited to participate in the survey. Of the 1,066 who agreed, 58 did not give an answer to one or more of the key analysis variables and therefore were excluded. Table 1 shows that the characteristics of the 1,008 respondents closely correspond to those of the adult U.S. population. Table 2 provides summary statistics for the all the variables in the analysis.

The survey, focusing on drinking water issues, took about 25 minutes. Respondents answered a series of questions regarding their water consumption. Bottled water drinkers answered "yes" to the following question: "Do you use bottled water? (distilled, filtered, or spring water bought in small bottles, gallon jugs, or a water cooler)." Of the sample, 66.4% indicated they are bottled water drinkers, 21.8% drink water only from bottles, 44.6% from both bottled water and tap water, and 29.5% only from the tap. Four percent of the sample indicated that they drink neither tap nor bottled water, though they drink other beverages such as coffee and sodas. The survey also elicited information about bottled water consumption both in terms of the monthly household expenditure on bottled water as well as changes in bottled water consumption.

To assess perceptions of the characteristics of bottled water, the survey included a series of questions about the decision of whether to drink bottled water. We used these responses to construct dummy variables for each of the three principal product characteristics—whether they believed bottled water is safer (Safer), tastes better (Tastes Better), or is more

4. The authors' water surveys using the KN sample have been reviewed and approved by the Office of Information and Regulatory Affairs, U.S. Office of Management and Budget. A summary of the Knowledge Networks panel design is available at http://www.knowledgenetworks.com/knpanel/docs/KnowledgePanel%28R%29-Design-Summary-Description.pdf.

TABLE 1
Comparison of 2009 Sample to the National Adult Population

Demographic Variable	U.S. Adult Population Percent	2009 Survey Participants Percent
Gender		
Male	48.7	48.7
Female	51.3	51.3
Age		
18 to 24 years old	13.1	7.4
25 to 34 years old	17.9	12.0
35 to 44 years old	17.9	17.5
45 to 54 years old	19.2	21.0
55 to 64 years old	15.0	23.3
65 to 74 years old	8.9	13.2
75 years old or older	8.1	5.6
Educational attainment (25 and older)		
Less than HS	13.3	11.5
HS diploma or higher	57.2	57.7
Bachelor or higher	29.5	30.9
Race/ethnicity		
White	80.9	80.7
Black/African American	12.2	11.9
Other	6.9	6.5
Hispanic	13.6	13.6
Household income		
Less than $15,000	12.9	12.1
$15,000 to $24,999	11.8	8.8
$25,000 to $34,999	10.9	10.6
$35,000 to $49,999	14.0	16.3
$50,000 to $74,999	17.9	20.6
$75,000 to $99,999	11.9	14.7
$100,000 or more	20.5	16.9

Notes: $N = 1{,}008$. U.S. Census Bureau (http://www.census.gov/). 2009 adult population (18 years+) except as noted, income uses 2008 data.

convenient (More Convenient) for them than tap water.[5]

B. *Empirical Hypotheses*

The discrete decision of whether to drink bottled water or tap water provides a useful framework for highlighting the empirical matters of interest. We first consider a binary choice situation of a consumer choosing between bottled water and tap water based on the different characteristics of the products. The framework is quite consistent with conventional models of choice with multiple product characteristics and multiattribute utility theory.[6] Let y be the person's income, w be the price of bottled water, and x be a measure of personal experiences. The information incorporated in x includes experiences drinking tap water and bottled water, as well as other water quality information the person may have received, such as alerts regarding water quality violations.

5. We analyze three Yes/No questions about "reasons when they decide to drink bottled water." "I feel that bottled water is *safer* than my tap water." "Bottled water *tastes better* than my tap water." "Bottled water is *more convenient* for me than tap water." Product characteristics related to smell and color did not have a statistically significant influence and are not included in the analyses shown.

6. See Lancaster (1990) and Keeney and Raiffa (1993).

TABLE 2
Means, Standard Deviations, and Availability of Analysis Variables[a]

Variable	Mean	Std. Dev.
Water consumption		
Drink water only from bottles	.2183	.4133
Drink from both bottles and tap	.4464	.4974
Drink water only from tap	.2946	.4561
Spend more than $10 on bottled water per month	.2262	.4186
Change in water consumption vs. last year[b]		
Increased bottled use vs. last year	.1335	.3403
Greatly increased bottled use vs. last year	.0477	.2132
Bottled use up, tap use down vs. last year	.0590	.2357
Change in bottled use vs. last year (0 = decrease, 1 = same, 2 = increase)	1.0048	.5124
Regular tap water uses[c]		
Drinking	.7423	.4376
Ice for other beverages	.8190	.3852
Washing foods	.9703	.1697
Cooking	.9560	.2051
Baths and showers	.9918	.0901
Bottled water compared to tap is:		
Safer	.3194	.4665
Tastes better	.4335	.4958
More convenient	.3690	.4828
Safer only	.0298	.1700
Tastes better only	.0843	.2780
More convenient only	.1508	.3580
Safer and tastes better	.1478	.3551
Safer and more convenient	.0169	.1288
Tastes better and more convenient	.0764	.2658
Safer, tastes better, and more convenient	.1250	.3309
None of (safer, tastes better, more convenient)	.3690	.4828
Bottled water use		
At work	.2718	.4451
When exercising	.2143	.4105
In the car	.3710	.4833
At home	.4067	.4915
Experiences with tap water:		
Tap water with bad taste	.3294	.4702
Tap water with bad smell	.2569	.4372
Tap water with bad taste and bad smell	.2113	.4084
Population exposed to municipal water risk	.3929	.2589
Risk data missing	.0982	.2978
Demographics		
Income/$10,000	6.1241	4.2473
Top income category	.0228	.1494
Years of education	13.7758	2.5677
Age/10 years	4.9663	1.6088
Female	.5129	.5001
Race: Black	.1190	.3240
Race data missing	.0089	.0941
Ethnicity: Hispanic	.1359	.3429
Environmentalist	.4355	.4961
Env. data missing	.0139	.1171
Well water user	.1954	.3967

[a] $N = 1{,}008$.
[b] Sample size for change in consumption questions is 839 except for bottled use up, tap use down versus last year, which is 814.
[c] Sample size for tap water uses questions is 978.

Suppose that a consumer's utility function for water can be separated into three additive components: (1) the utility of the characteristics of the product net of price, (2) the expected adverse health effect, and (3) the time and convenience costs. Most adverse effects of water, gastrointestinal illnesses for instance, are temporary and therefore do not alter the utility function structure, so the assumption of health costs entering in an additively separable manner is reasonable.[7] Drinking bottled water is a form of self-protection if it enables the consumer to reduce the risk of illness and other adverse effects. The utility function for bottled water is $v\,(y\text{-}w,x)$ and for tap water is $u\,(y,x)$.

Thus, both bottled water and tap water are accompanied by two potential costs pertaining to safety and convenience. A water-related illness imposes a cost s with probability $p(x)$ for tap water and $q(x)$ for bottled water. The perceived risk of illness is a conditional probability based on past experiences and information, where this experience and information is captured by x. Tap water imposes a convenience time cost c, and bottled water has a time cost b, each of which is multiplied by income y to determine the economic value of these costs.

Drinking bottled water is preferable to drinking tap water if

$$v\,(y-w,\ x)-q\,(x)\,s-by > u\,(y,\ x)-p\,(x)\,s-cy,$$

or

$$v\,(y-w,\ x)-u\,(y,\ x)+\left[p\,(x)-q\,(x)\right]s+[c-b]\,y\ >\ 0.$$

This formulation leads to a series of testable empirical hypotheses:

1. Perception that bottled water offers greater safety (i.e., $[p(x) - q(x)] > 0$) increases the probability that the individual will prefer bottled water.
2. Adverse experiences or adverse information x about tap water increases the perception that bottled water is safer by increasing $q(x)$, making bottled water more attractive.
3. Adverse experiences with tap water taste make bottled water more attractive by increasing the gap $v(y - w, x) - u(y, x)$. Adverse tap water taste may also boost the value of $q(x)$ if consumers view taste as being correlated with safety.
4. Greater convenience of bottled water (i.e., $c > b$), increases the probability that the individual will prefer bottled water.
5. Higher income levels y raise the importance of convenience to bottled water choice.
6. Higher income decreases the utility loss from the price of bottled water (i.e.,$(\partial^2 v/\partial y\partial w > 0)$, making bottled water more attractive.

Examination of these issues is facilitated by the use of a unique database on whether the person perceives bottled water as being safer (i.e., $p(x) > q(x)$), more convenient (i.e., $c > b$), or having superior taste x. The model is in terms of the beliefs regarding bottled water, relative to the beliefs for tap water. The survey questions likewise elicit information of the relative beliefs concerning safety, taste, and convenience, and are consequently matched to the model structure. Note that reasonable consumer responses to subjective perceptions of product attributes imply consistency, but not necessarily rationality if the perceptions are not well founded. We explore the underlying basis for these perceptions linking them to past water quality experiences and objective water quality measures. The data also permit the assessment of the influence of income y and a diverse set of personal characteristics and experiences x.

III. PERCEPTIONS OF RISK, TASTE, AND CONVENIENCE

Table 3 provides summary statistics on the perceptions of bottled water attributes, indicating the extent to which beliefs about properties of bottled water differ between bottled water drinkers and non-drinkers. Over two-fifths of the sample believes that bottled water tastes better than tap water,[8] and almost one-third of all respondents believe that bottled water is safer than tap water. A slightly lower percentage believes that bottled water is more convenient than tap water.

These perceptions of the advantages of bottled water closely correspond with the decision to drink bottled water. Compared to tap water only drinkers, bottled water drinkers are 71 percentage points more likely to believe that bottled water tastes better, 65 percentage points more

7. That temporary health effects of consumer product risks do not alter the structure of utility functions and can be treated as an additively separable component is consistent with empirical evidence in Evans and Viscusi (1991).

8. Abrahams et al. (2000) found taste, color, and smell to be significant determinants in the decision to choose bottled water in a survey of Georgia residents.

TABLE 3
Percentage Who Perceive Advantages of Bottled Water for Users and Nonusers[a]

Bottled Water Compared to Tap Is:	All Respondents %	Drink Water only from Bottles %	Drink Water from Both Bottles and Tap %	Drink Water only from Tap %	Drink Neither Tap nor Bottled Water %
Safer	31.9	73.6	27.6	8.4	26.8
Tastes better	43.4	84.5	42.4	13.8	46.3
More convenient	36.9	49.1	53.3	6.7	9.8
Safer only	3.0	3.6	3.6	1.0	7.3
Tastes better only	8.4	9.5	7.6	6.4	26.8
More convenient only	15.1	5.9	27.8	4.7	0
Safer and tastes better	14.8	34.5	11.6	5.7	9.8
Safer and more convenient	1.7	2.7	2.2	.3	0
Tastes better and more convenient	7.6	7.7	13.1	.3	0
Safer, tastes better, and more convenient	12.5	32.7	10.2	1.3	9.8
No bottled aspect better than tap	36.9	3.2	24.0	80.1	46.3
Percentage in category	100.0	21.8	44.6	29.5	4.1

[a]$N = 1{,}008$.

likely to believe that it is safer, and 42 percentage points more likely to see bottled water as more convenient. These differences are less pronounced when bottled water drinkers are compared to those who drink both tap water and bottled water, but are still striking relative to those who do not drink any bottled water. Differences between bottled water only drinkers and tap water only drinkers in the perceptions of bottled water safety and better taste, which are the attributes that have come under the most criticism as being based on alleged consumer misperceptions, are more pronounced than are differences in the assessments of convenience.

To analyze whether consumer perceptions of the characteristics of bottled water have a sound basis in water quality measures and personal experiences, we consider each of the three key product quality dimensions and factors that influence consumer perceptions of these characteristics—safety, taste, and convenience. We link these beliefs to personal experience and a measure of water quality violations, which we then link to both levels and changes in bottled water consumption.

Table 3 also summarizes results for nonoverlapping categories of product attributes, such as whether the consumer regards bottled water as being safer but does not taste better and is not more convenient. The three largest categories of respondents are those who believe that bottled water is not superior on any of these three dimensions (36.9%), bottled water is more convenient but does not taste better and is not safer (15.1%), and bottled water is safer and tastes better (14.8%). To simplify the discussion, we focus below on overall consumer perceptions regarding safety, taste, and convenience, and the regressions below often do distinguish the complete set of different non-overlapping groups.

A. Perceptions of Safety

Different governmental agencies monitor the safety of bottled and tap water. EPA regulates tap water quality under the Safe Drinking Water Act, while the Food and Drug Administration (FDA) regulates bottled water as a food product under the Federal Food, Drug, and Cosmetics Act. EPA regulates the safety of tap water with an extensive set of standards and testing requirements, including prompt reporting requirements for dangerous contaminants. The FDA must adopt the same safety requirements that apply to tap water for bottled water unless it can demonstrate a reason for the deviation.[9] In addition, the major brands report extensive test results and have a strong financial incentive to avoid adverse publicity such

9. National Resources Defense Council, "Bottled Water: Pure Drink or Pure Hype?" 1999, at http://www.nrdc.org/water/drinking/bw/bwinx.asp. For a recent review, see "Bottled Doesn't Mean Better," *Consumer Reports,* September, 2011, p. 7. The EPA monitoring and reporting requirements for tap water are more rigorous than the FDA requirements for bottled water, which do not require firms to report tests indicating the presence of contaminants except for those posing a serious health risk, such as E. coli. Jane Zhang, "More Scrutiny Urged for Bottled Water," *Wall Street Journal*, July 13, 2009. Olga Naidenko et al., "Bottled Water Quality Investigation: 10 Major Brands, 38 Pollutants," Environmental Working Group, http://www.ewg.org/book/export/html/27010.

as that associated with the benzene in Perrier crisis in 1990.[10]

Notwithstanding the claims that bottled water drinkers have nothing to fear from tap water, the safety of tap water is a potentially legitimate consumer concern. Approximately 1 in 20 Americans annually suffer from gastrointestinal illnesses due to contaminated water.[11] Particularly susceptible individuals, such as the very young, the elderly, and those with weakened immune systems, face more severe risks. Seeking to reduce morbidity risks by drinking bottled water is often a reasonable consumer response.

There are some situations in which bottled water is clearly safer. EPA recommends that people with compromised immune systems use bottled water that has undergone additional treatment unless their tap water has been boiled or filtered.[12] Moreover, bottled water serves as an emergency source of drinking water when the public water system becomes contaminated. Under the Safe Drinking Water Act, the utility must notify residents of such contamination so that they can switch to bottled water or purify their tap water (Innes and Cory 2001).

Here we analyze the determinants of the attribute that has been at the center of the bottled water controversy—safety. While consumers generally believe that bottled water is safer than tap water, do they have any rational basis for that belief and are these beliefs linked to these factors in a meaningful way? In addition to analyzing the role of individual experiences and objective risk measures, we also consider the role of demographic factors correlated with lower quality water as well as whether the respondent is on well water.

The survey included the following questions regarding experience with tap water that the respondent had gotten from the faucet—whether it ever had an unpleasant taste (Tap Water with Bad Taste) and whether it ever had an unpleasant smell (Tap Water with Bad Smell), each of which is coded as a 0–1 variable. Generally, a high percentage of respondents reported using tap water for drinking (74%), ice for beverages (82%), washing and cooking food (97% and 96%, respectively), and bathing (99%). Those who report bottled water to be safer or tastier than tap water are between 35 and 40 percentage points less likely to use tap water for drinking and 10 percentage points less likely to use tap water for ice compared to respondents who do not consider there to be taste or safety differences between tap water and bottled water.

We matched respondents to an objective risk measure that would appropriately affect risk beliefs. That measure is the percentage of the state's population exposed to municipal water in excess of EPA water quality limits at least once over the 2004–2009 period.[13] In particular, this variable reflects the fraction of the state's population exposed one or more times to tap water with one or more contaminants above the legal limits.[14] Overall, the mean value of this violation rate across the sample is .44 among respondents in states for which data are available.[15] Thus, for the states reporting data there is a .44 probability that the respondent was exposed to at least one municipal water quality violation over the 2004–2009 period. The 6-year violation

10. Anne Christiansen Bullers, "Bottled Water: Better Than the Tap?" U.S. Food and Drug Administration, *FDA Consumer Magazine*, July-August, 2002, http://www.fda.gov/FDAC/features/2002/402_h20.html. Examples of detailed water quality reports are the report for Pepsi-Cola's Aquafina brand of purified water, http://www.aquafina.com/RequiredStatementsUnderCaliforniaLaw_English.pdf, and the extensive report for Poland Spring, http://www.nestle-watersna.com/pdf/PS_BWQR.pdf, which is similar to that of other Nestlé Water North America bottled water, such as Arrowhead and Deer Park.

11. Colford et al. (2006) estimate that the total number of acute gastrointestinal illness cases annually in the United States is 4.26–11.69 million, which corresponds to a risk range of 1.4%–3.4%. Messner et al. (2006) estimate a mean number of acute gastrointestinal illness cases of 16.4 million, which corresponds to an annual risk of 6%, with an estimated range from 2%–12%. More generally, see Reynolds, Mena, and Gerba (2008).

12. These treatments include reverse osmosis, distillation, exposure to ultraviolet light, and filtration. U.S. Environmental Protection Agency, Water Health Series: Bottled Water Basics, EPA 816-K-05-003 (2005). For example, Dasani Water, which is sold by the Coca-Cola Company, is filtered through a reverse osmosis process. Arrowhead Mountain Spring Water is exposed to ultraviolet light/ozone filtration and micro-filtration.

13. The regional study by Rahman et al. (2010) found that large, publicly owned systems are especially likely to be in noncompliance.

14. These data came from a study done by the Environmental Working Group and can be found at http://www.ewg.org/tap-water/executive-summary. The study included 20 million tests on 316 contaminants affecting 250 million Americans in 45 states. In particular, this variable reflects measures among 114 contaminants for which there are legal limits set by EPA. The data cover the 6-year period ending in 2009, while the survey was administered beginning in October, 2009.

15. The 11% of the sample where this variable is missing is coded as zero and a dummy variable (Exposed to Risk Missing) is added to the regression to account for these missing observations. As a result, the mean value of the violation rate variable reported in Table 1 is somewhat less than the mean value for states reporting violation data. State data are used because that is the most detailed geographic information collected for the survey.

TABLE 4

Probits and Seemingly Unrelated Linear Probability Regressions. Predicting Perceptions of Bottled Water Based on Respondent Characteristics[a]

	Probit Regressions		Seemingly Unrelated Linear Probability Regressions	
Variable	**Safer**	**Tastes Better**	**Safer**	**Tastes Better**
Experienced tap water				
With bad taste	.2803***	.4729***	.2691***	.4560***
	(.0481)	(.0457)	(.0441)	(.0448)
With bad smell	.2040***	.2280***	.1832***	.2068***
	(.0759)	(.0749)	(.0664)	(.0675)
With bad taste and smell	−.1748**	−.2591***	−.1844**	−.2497***
	(.0692)	(.0813)	(.0834)	(.0847)
Population exposed to municipal water risk	.2391***	.1724**	.2203***	.1451**
	(.0688)	(.0763)	(.0624)	(.0634)
Demographics				
Income/$10,000	.0015	−.0019	.0012	−.0015
	(.0043)	(.0048)	(.0039)	(.0039)
Years of education	−.0103	−.0099	−.0095	−.0083
	(.0064)	(.0072)	(.0058)	(.0059)
Age/10 years	−.0306***	−.0381***	−.0279***	−.0316***
	(.0100)	(.0111)	(.0090)	(.0091)
Female	−.0013	.0024	.0020	.0024
	(.0306)	(.0340)	(.0278)	(.0282)
Race: Black	.1946***	.1313**	.1780***	.1075**
	(.0521)	(.0544)	(.0438)	(.0445)
Ethnicity: Hispanic	.1418***	.0446	.1335***	.0387
	(.0478)	(.0506)	(.0411)	(.0417)
Environmentalist	.0277	−.0373	.0249	−.0302
	(.0316)	(.0349)	(.0285)	(.0290)
Well water user	−.0004	−.0861**	.0015	−.0708**
	(.0395)	(.0424)	(.0355)	(.0361)
Intercept	.2803***	.4729***	.3402***	.5092***
	(.0481)	(.0457)	(.0967)	(.0983)

Notes: Probit coefficients have been transformed to equal marginal effects. Standard errors are in parentheses. Equations also include a variable for top coded income, as well as dummy variables for missing values for risk data, race, and environmentalist.

[a]$N = 1{,}008$.

Significance levels: *.10, **.05, and ***.01.

probability among utilities for the sample is .29, which is similar to the national average of .28 for 44,219 utilities from the Environmental Working Group data.

The relatively high percentage of detected contaminants is consistent with the substantial media attention that has been devoted to the prevalence of water quality violations. One press estimate highlighted the gaps in enforcement of the Safe Drinking Water Act, with "more than 20 percent of the nation's water treatment systems" violating key regulatory requirements.[16] This media attention in turn publicizes the water quality violations, making the public more aware of the hazards and leading to reductions in subsequent water quality violations (Bennear and Olmstead, 2008). While bottled water may not be safer than tap water that is in compliance with water quality standards, water quality violations reduce consumers' confidence that tap water is equally safe.[17] Concern with water quality and gaps in the coverage of current water quality standards has also prompted efforts to strengthen EPA regulations for various chemical exposures.[18]

Table 4 reports two sets of regression estimates for perceptions of the relative safety and

16. Charles Duhigg, "Clean Water Laws Are Neglected, at a Cost in Suffering," *New York Times*, September 13, 2009, and Charles Duhigg, "Millions in U.S. Drink Dirty Water, Records Show," *New York Times*, December 8, 2009. This press figure is for a year period and is similar to the figure of 26% for utilities in our sample.

17. Camerer and Kunreuther (1989) suggest that experience with an adverse event may increase a person's response to the risk of such an event beyond what might otherwise be strictly rational given the event's probability of occurring.

18. Charles Duhigg, "That Tap Water Is Legal but May Be Unhealthy," *New York Times*, December 17, 2009, and Charles Duhigg, "U.S. Bolsters Chemical Restrictions for Water," *New York Times*, March 22, 2010.

better taste of bottled water as compared to tap water. The first two columns report the probit estimates, where the coefficients have been transformed to correspond to marginal probabilities. The final two columns are linear probability models estimated using seemingly unrelated regressions to account for the potential correlation of the errors in these perceptional equations. The results are quite similar for each estimation approach so for concreteness we focus on the probit results.

The Table 4 probit regression for perceptions of the relative safety of bottled water indicates that the perception that bottled water is safer than tap water reflects a consistent pattern of beliefs. Previous experience with bad tasting water is the most influential tap water drinking experience variable, increasing the perception of bottled water being safer by .28, while tap water experiences with a bad smell has a positive effect of .20. The interaction of these variables is negative, as experiences with bad smell and bad taste provide somewhat overlapping information regarding water quality. Thus, there is a diminished but still positive effect if the respondent has experienced tap water with bad taste and tap water with bad smell. These personal experiences in turn are consistent with the effect of the objective water quality variable on perceptions of bottled water safety. Based on the estimated coefficient for municipal water risk violations, the effect on safety perceptions of the mean percentage of the population exposed to water in violation of water quality standards is to increase the probability that the respondent believes that bottled water is safer than tap water by .09.[19] Older respondents are less likely to consider bottled water to be safer, which is consistent with generational differences in bottled water drinking. Blacks and Hispanics view bottled water as safer than tap water. The influence of these indicators of minority status has a consistent influence throughout the analysis and is examined further below.

B. Perceptions of Taste

The results in Table 4 assess whether the determinants of a consumer's belief that bottled water has a better taste than tap water is similar to their perceptions of safety. The variable for whether the respondent had a previous experience with bad tasting tap water raises the probability that the respondent believes that bottled water tastes better by .47, and bad smelling water has a .23 positive effect. However, water with both a bad taste and a bad smell has a .26 negative effect so that, on balance, bad smelling water has no additional effect on perceptions of bad taste if the respondent has already had a bad taste experience. The percentage of the population exposed to water in violation of EPA standards has a positive effect on belief that bottled water tastes better so that perceptions of taste differences are also based on underlying water quality, with an effect of the mean level of water quality violations for states reporting violation data on the probability that bottled water is believed to taste better equal to .07.

Several demographic characteristics are also influential. Respondents who are Black are .13 more likely to rate bottled water as tasting better, but the effect for Hispanics is not statistically significant. As in the case of safety perceptions, older respondents are less likely to view bottled water as tasting better than tap water. Well water drinkers appear to be satisfied with the taste of their water relative to bottled.

C. Perceptions of Convenience

Probit regressions for the final comparative attribute—whether the respondent finds bottled water more convenient than tap water—appear in Table 5. Convenience is a quite different attribute than the safety and taste measures, as it relates primarily to ease of use of the product and, more specifically, emphasizing its package and distribution over the characteristics of the water itself. To capture this different set of considerations, we introduce variables related to product usage. We report two sets of probit regressions—the first set including indicators of different types of bottled water usage and a second including only the demographic factors,

Several usage variables included in the probit regressions in Table 5 are influential. The specific locales where the respondent reports drinking bottled water have a differential effect on perceptions of convenience. The indicator variables for use of bottled water at work, while in the car, or at home all increase perceptions of convenience. Notably, that effect is not seen among respondents who report bottled water use while

19. The full effect of the variable, if a respondent were to move from a state with no violations to the one with the most prevalent fraction of the population affected by water quality violations (.883) would be to a .21 change in the probability that the respondent believes bottled water to be safer than tap water.

TABLE 5
Probit Regressions for Whether Perceive Bottled Water as More Convenient than Tap Water[a]

Variable	Convenient	Convenient
Bottled water use		
At work	.0938**	
	(.0415)	
When exercising	.0507	
	(.0459)	
In the car	.1965***	
	(.0379)	
At home	.1898***	
	(.0369)	
Population exposed to municipal water risk	−.0285	.0342
	(.0740)	(.0707)
Demographics		
Income/$10,000	.0115**	.0152***
	(.0045)	(.0043)
Years of education	−.0054	−.0103
	(.0068)	(.0065)
Age/10 years	−.0215**	−.0286***
	(.0107)	(.0100)
Female	.0745**	.0847***
	(.0322)	(.0310)
Race: Black	.0496	.1290**
	(.0525)	(.0510)
Ethnicity: Hispanic	−.0291	.0062
	(.0462)	(.0459)
Environmentalist	−.0763**	−.0823***
	(.0328)	(.0316)
Well water user	.0159	.0196
	(.0421)	(.0403)

Notes: Probit coefficients have been transformed to equal marginal effects. Standard errors are in parentheses. Equations also include a variable for top coded income, as well as dummy variables for missing values for risk data, race, and environmentalist.

[a]$N = 1{,}008$.

Significance levels: *.10, **.05, and ***.01.

exercising, possibly because water is already provided in places where people exercise, and carrying bottled water can be difficult to do when exercising.

Higher income respondents, who also likely have a higher value of time, also view bottled water as being more convenient. In contrast, income does not have a significant effect on perceptions that bottled water is safer or tastes better. Female respondents, who are principal consumers of bottled water, also view bottled water as more convenient. Female respondents did not have higher perceptions of greater safety or superior taste of bottled water, as convenience is the main attribute for which they have different beliefs. This greater convenience belief could be attributed to something as simple as the fact females often carry purses or bags that can easily hold bottled water.

The racial and ethnicity effects also differ from the previous results. In particular, whether a respondent is Black does not influence perceptions of convenience if the uses variables are included, but does have a significant positive effect if they are not. Being Hispanic is not significantly associated with perceptions of convenience. Different demographic characteristics come into play for different aspects of the bottled water market, with safety being the greatest matter of common concern to Blacks and Hispanics.

There are two demographic groups who are clearly less enamored of the convenience aspect of bottled water. Older respondents do not find bottled water more convenient, which reflects the rise in use of bottled water among younger cohorts. Environmentalists also are less likely to regard bottled water as more convenient. However, environmentalists do not differ from others in their perceptions of the relative safety or taste of bottled water. This is a somewhat surprising emphasis as environmentalist critiques of bottled water have focused principally on questioning the safety and taste attributes of bottled water relative to tap water rather than its convenience.[20]

IV. CONSUMPTION OF BOTTLED WATER

To analyze how these perceptions of product attributes and other individual characteristics influence bottled water consumption, we begin with an analysis of three discrete water consumption decisions and the effect of the three product attributes on these decisions. This analysis distinguishes the influence of the eight different non-overlapping product attribute categories, where the omitted category is that bottled water is not viewed as being safer, having a better taste, or being more convenient. Table 6 presents the probit regressions for whether the respondent only drinks bottled water, drinks both bottled water and tap water, drinks tap water only, or spends more than $10 per month on bottled water. The categories involving perceptions of greater safety and better taste are more influential than the convenience aspect of bottled water as determinants of drinking water only from bottles and spending more than $10 per month on bottled water. Notably, the variable for safer, tastes better, and more convenient has an effect very similar to that for safer and tastes better. The combined effect of safer and tastes better is

20. Additionally, since environmentalism is significantly correlated with more frequent plastic bottle recycling (see Viscusi et al., 2013), that behavior may reduce the sense of convenience associated with bottled water.

TABLE 6

Perceived Advantages of Bottled Water for Users and Nonusers, Probit Regressions[a]

Bottled Water Compared to Tap Is:	Drink Water only from Bottles	Drink Water from Both Bottles and Tap	Drink Water only from Tap	More than $10 on Bottled per Month
Safer only	.4982***	.2459***	−.2243***	.6155***
	(.1047)	(.0849)	(.0188)	(.0831)
Tastes better only	.4610***	.1189*	−.2115***	.4090***
	(.0745)	(.0607)	(.0211)	(.0763)
More convenient only	.1977***	.5065***	−.2870***	.3085***
	(.0663)	(.0327)	(.0206)	(.0650)
Safer and tastes better	.6786***	.0654	−.2751***	.6483***
	(.0476)	(.0502)	(.0206)	(.0488)
Safer and more convenient	.5885***	.2929***	−.2244***	.6266***
	(.1140)	(.1028)	(.0181)	(.1007)
Tastes better and more convenient	.4307***	.4426***	−.2803***	.6088***
	(.0790)	(.0417)	(.0178)	(.0622)
Safer, tastes better, and more convenient	.7275***	.0826	−.3051***	.6426***
	(.0446)	(.0530)	(.0196)	(.0514)

Notes: Probit coefficients have been transformed to equal marginal effects. Standard errors are in parentheses. Excluded independent variable is belief that bottled water is superior in none of these ways (41.6%).

[a]$N = 1{,}008$.

Significance levels: *.10, **.05, and ***.01.

larger than the effect of safer alone for the effect on whether the respondent drinks bottled water, but there is no additional role of better taste for bottled water expenditures. For the intermediate case in which people drink both bottled and tap water, the categories involving greater convenience are the principal drivers of joint consumption except when bottled water is viewed as being superior on all three dimensions. For the decision to drink only tap water, the effects of bottled water beliefs are appropriately reversed. The effects in the third column of Table 6 are in the opposite direction from the coefficients in the first column and are statistically significant for each of the seven belief categories.

To explore the determinants of these decisions more fully, Table 7 expands the probit regressions in the first two columns of Table 6, adding a broad range of experience and demographic factors. Because the seven bottled water attribute perception categories included in the regression are the mechanisms by which some of the demographic and experience variables exert their influence, we also include a second semi-reduced form equation omitting these variables for each dependent variable. The seven attribute variables remain statistically significant with positive effects as in Table 6. Experience with bad tasting tap water increases the probability that the respondent consumes only bottled water. Omission of the attribute category variables boosts the influence of taste experiences and also leads the bad smell experience variable to have significant positive effects on drinking bottled water. However, if the respondent has experienced both a bad taste and a bad smell experience, the interactive effect of this combination largely counteracts the effect of the bad smell experience. The directions and significance of the other variables in the first two columns of Table 7 are unaffected, except age, which takes on a significant negative effect and Black which now has a significant positive effect.

The effect at the mean value of the population exposed to risky municipal water is to increase the probability of drinking bottled water by .07 after accounting for the indirect effect of this variable on the attribute beliefs and a full effect of .11 in the absence of the belief variables. More affluent respondents are more likely to drink bottled water, which is not surprising as it is a normal consumer good. Females, who may be drawn to the low calorie aspect of bottled water, are more likely to drink bottled water than males.

The race and ethnicity variables have effects that reinforce the types of patterns exhibited in the attribute equations. Controlling for perception of bottled water attributes, Hispanics are more likely to drink bottled water. The full effect of these variables is to increase the probability of drinking bottled water by .14 for both Blacks and Hispanics.

The next two probit regressions in Table 7 analyze determinants of the mixed consumption

TABLE 7
Predicting Respondent Water Use, Probit Regressions[a]

Variable	Consume Only Bottled Water		Tap and Bottled Water	
Bottled water compared to tap is:				
Safer only	.4550***		.2644***	
	(.1118)		(.0852)	
Tastes better only	.4505***		.1382**	
	(.0803)		(.0633)	
More convenient only	.1809***		.5076***	
	(.0660)		(.0336)	
Safer and tastes better	.6475***		.0896*	
	(.0553)		(.0544)	
Safer and more convenient	.5496***		.2841***	
	(.1241)		(.1053)	
Tastes better and more convenient	.3731***		.4462***	
	(.0841)		(.0431)	
Safer, tastes better, and more convenient	.6793***		.0988*	
	(.0546)		(.0577)	
Experienced tap water				
With bad taste	.0654*	.2435***	−.0900	−.0701
	(.0366)	(.0440)	(.0557)	(.0507)
With bad smell	.0833	.1924***	−.0406	.0215
	(.0582)	(.0704)	(.0817)	(.0764)
With bad taste and smell	−.0806*	−.1661***	.1508	.0708
	(.0430)	(.0449)	(.1020)	(.0968)
Population exposed to municipal water risk	.1667***	.2730***	−.2566***	−.2300***
	(.0522)	(.0585)	(.0772)	(.0725)
Demographics				
Income/$10,000	.0082***	.0087**	.0093*	.0146***
	(.0031)	(.0036)	(.0048)	(.0045)
Years of education	−.0053	−.0098*	.0022	.0037
	(.0048)	(.0054)	(.0071)	(.0067)
Age/10 years	−.0033	−.0139*	−.0096	−.0132
	(.0073)	(.0083)	(.0111)	(.0104)
Female	.0540**	.0616**	.0182	.0336
	(.0224)	(.0258)	(.0340)	(.0321)
Race: Black	.0577	.1354***	.0696	.0741
	(.0395)	(.0482)	(.0537)	(.0510)
Ethnicity: Hispanic	.0900**	.1421***	−.0240	−.0422
	(.0409)	(.0443)	(.0500)	(.0469)
Environmentalist	−.0200	−.0232	.0062	−.0279
	(.0229)	(.0264)	(.0351)	(.0330)
Well water user	.0054	−.0082	.0061	.0009
	(.0308)	(.0336)	(.0439)	(.0410)

Notes: Probit coefficients have been transformed to equal marginal effects. Standard errors are in parentheses. Equations also include a variable for top coded income, as well as dummy variables for missing values for risk data, race, and environmentalist.

[a]$N = 1{,}008$.

Significance levels: *.10, **.05, and ***.01.

group of those who drink both tap and bottled water. The convenience of bottled water is a larger driver of being a joint consumer relative to the estimates from bottled-only drinkers, as the more convenient only categories and tastes better and is more convenient have the largest effect. If a respondent also believes that bottled water is safer than tap water, not just more convenient and tastier, then there is a much diminished effect on drinking both tap water and bottled water as safety concerns dampen the desirability of consuming both. Consistent with this effect of safety perceptions is that in areas in which there is a higher portion of the population exposed to documented EPA water quality violations, a person is less likely to drink tap water as well as bottled water. As with the reverse results in the first two columns of estimates in Table 7, this effect is quite strong even when the many water quality perception variables are included.

Table 8 further explores these predictions of water-drinking habits with ordered probit regressions. The ordered probit estimates present the consumption decision as a continuum

TABLE 8
Predicting Respondent Water Use, Ordered Probit Regressions[a]

Variable	Ordered Water Use	Ordered Water Use
Bottled water compared to tap is:		
Safer only	1.6042***	
	(.2382)	
Tastes better only	1.3754***	
	(.1588)	
More convenient only	1.2762***	
	(.1215)	
Safer and tastes better	2.0456***	
	(.1380)	
Safer and more convenient	1.7757***	
	(.2955)	
Tastes better and more convenient	1.6321***	
	(.1603)	
Safer, tastes better, and more convenient	2.3071***	
	(.1508)	
Experienced tap water with		
Bad taste	.1659	.6949***
	(.1307)	(.1188)
With bad smell	.2185	.5647***
	(.1864)	(.1740)
With bad taste and smell	−.1467	−.5566**
	(.2347)	(.2202)
Population exposed to municipal water risk	.3466*	.5836***
	(.1837)	(.1708)
Demographics		
Income/$10,000	.0531***	.0502***
	(.0111)	(.0104)
Years of education	−.0202	−.0275 *
	(.0168)	(.0156)
Age/10 years	−.0168	−.0735***
	(.0260)	(.0242)
Female	.2558***	.2301***
	(.0800)	(.0747)
Race: Black	.3103**	.5021***
	(.1243)	(.1164)
Ethnicity: Hispanic	.3300***	.3481***
	(.1178)	(.1093)
Environmentalist	−.0450	−.1019
	(.0819)	(.0762)
Well water user	.0607	−.0318
	(.1026)	(.0953)

Notes: Dependent variable coding is drink bottled water only = 3, drink bottled water and tap water = 2, drink tap water only = 1. Standard errors are in parentheses. Equations include a variable for top coded income, as well as dummy variables for missing values for risk data, race, and environmentalist.

[a]$N = 967$ (41 respondents reported drinking neither tap nor bottled water).

Significance levels: **.05, and ***.01.

from bottled water only at the highest extreme, tap and bottled water in the intermediate case, and tap water only at the lowest extreme. The estimates perform in much the same ways as the separate probit regressions, with similar effects of controlling for beliefs about bottled water, income, age, and gender. The seven perceptional category variables and the three water experience variables all have effects that closely follow the patterns in Table 7. The ordered probit estimates, however, significantly predict a higher outcome on the tap/bottled continuum for respondents who are Black regardless of whether the regression controls for beliefs about bottled water relative to tap. As in Table 7, the effect for Hispanic respondents toward greater bottled water use persists with and without the perception variables in the ordered probit regressions.

Table 9 presents two pairs of analyses of the determinants of the total amount spent on bottled water. In each pair, we first report results including the full set of variables and then consider an equation omitting the seven categories of water quality perceptions. The first two columns

TABLE 9

Regressions Predicting Whether Respondent Spends over $10 per Month on Bottled Water and Monthly Expenditure[a]

Variable	Over $10 Bottled Water (Probit Regressions)		Amount Spent on Bottled Water (Interval Regressions)	
Bottled water compared to tap is:				
Safer only	.5888***		6.9760***	
	(.0912)		(1.5042)	
Tastes better only	.4212***		4.3026***	
	(.0821)		(.9583)	
More convenient only	.2923***		4.8832***	
	(.0680)		(.7503)	
Safer and tastes better	.6289***		10.7990***	
	(.0560)		(.8145)	
Safer and more convenient	.5870***		8.8918***	
	(.1155)		(1.9778)	
Tastes better and more convenient	.5905***		9.9214***	
	(.0703)		(1.0131)	
Safer, tastes better, and more convenient	.6004***		10.2693***	
	(.0611)		(.8705)	
Experienced tap water				
With bad taste	.0072	.1552***	.0485	3.6015***
	(.0348)	(.0441)	(.8292)	(.8931)
With bad smell	.0702	.1894***	.9501	3.4885***
	(.0590)	(.0701)	(1.2055)	(1.3464)
With bad taste and smell	−.0360	−.1279**	−.3854	−3.0864*
	(.0558)	(.0541)	(1.5098)	(1.6919)
Population exposed to municipal water risk	.1113**	.1940***	3.1368***	4.8575***
	(.0531)	(.0596)	(1.1172)	(1.2557)
Demographics				
Income/$10,000	.0113***	.0137***	.2943***	.3633***
	(.0032)	(.0036)	(.0698)	(.0782)
Years of education	−.0067	−.0097 *	−.1268	−.2041 *
	(.0049)	(.0055)	(.1033)	(.1164)
Age/10 years	−.0182**	−.0299***	−.2366	−.5714***
	(.0076)	(.0087)	(.1607)	(.1803)
Female	.0007	.0070	.1209	.2968
	(.0231)	(.0264)	(.4962)	(.5586)
Race: Black	.1264***	.2019***	3.3887***	4.8822***
	(.0469)	(.0507)	(.7973)	(.8901)
Ethnicity: Hispanic	.0985**	.1406***	1.5020**	2.1659***
	(.0415)	(.0445)	(.7477)	(.8354)
Environmentalist	.0235	.0104	.0545	−.3097
	(.0243)	(.0272)	(.5120)	(.5747)
Well water user	−.0003	−.0099	.4789	.1461
	(.0315)	(.0346)	(.6355)	(.7142)
Intercept			−.0968	5.1262***
			(1.7604)	(1.9487)

Notes: Probit coefficients have been transformed to equal marginal effects. Standard errors are in parentheses. Equations also include a variable for top coded income, as well as dummy variables for missing values for risk data, race, and environmentalist.

[a]$N = 1{,}008$.

Significance levels: *.10, **.05, and ***.01.

of Table 9 consist of two probit regressions for whether the household spends at least $10 per month on bottled water, while the final two columns report two interval regressions for the amount that the household spends per month on bottled water. These interval regressions analyze the amount that the household spends per month on bottled water, and in doing so addresses econometric issues both with respect to responses that are truncated both at $1 or less and at over $40 per month, and the intermediate responses, which can lie within one of four discrete intervals.[21]

There are many strong parallels of the estimates for the two different variables capturing the amount of bottled water consumption. All

21. Respondents choose between more than $1 up to $5, more than $5 up to $10, more than $10 up to $25, or more than $25 up to $40 in addition to the two extremes.

seven of the attribute categories have a significant positive effect relative to the group who believe that bottled water is not superior in terms of safety, taste, or convenience. Perception that bottled water is only safer or only tastier than tap water increases the probability that the household spends at least $10 per month on bottled water by more than do perceptions of greater convenience alone. Based on the interval regressions, perceptions that bottled water is safer and tastes better raises the amount spent on bottled water by about $10.80 per month, with the additional perception of convenience associated with a somewhat smaller point estimate of $10.27. Experience with water that has a bad taste or smell increases the amount spent on water after omitting the set of water quality perception variables, but the combined influence of bad taste and bad smell is not much different than either of them individually. Exposure to municipal water quality violations increases the likelihood that a household spends at least $10 per month on bottled water as well as the total amount spent in all regressions.

The most notable personal characteristics that influence consumption of bottled water are income, which is consistent with water being a normal good, and being Black or Hispanic. For the final equation that omits the water quality perception variables, which are significantly correlated with race and ethnicity, Black households spend an additional $4.88 per month on bottled water while Hispanic households spend an additional $2.17 per month as compared to other minority group and White households and non-Hispanic households, respectively.

A. Risks to Blacks and Hispanics

As shown throughout, Black and Hispanic respondents consistently indicate a preference for bottled water. For Hispanics there is a greater belief in bottled water safety but not the other attributes, while for Blacks there is a belief that bottled water is safer and tastes better and, only if one excludes the influence of uses of bottled water, is safer as well. Thus, the preferences of these minority groups are not driven by concerns about convenience but rather perceptions about water quality. Is there a legitimate basis for these preferences or are erroneous beliefs correlated with these demographic characteristics?

Race and ethnic identifiers are included in many analyses that include demographic factors. This is not done because of a belief that there is something intrinsically different due to race or ethnic background, but because race and ethnicity are often correlated with observed and unobserved cultural, historical, and social factors. Because these correlations can often be multifaceted and subtle, race and ethnicity variables help to account for the effects. Variables accounting for interactions between race or ethnicity with other demographic variables did not provide statistically significant explanations for the differences in perception and consumption behavior in regressions.[22]

Blacks and Hispanics are of particular interest because of their greater exposure to unsafe water from their primary water source.[23] These minorities are disadvantaged with respect to tap water quality in two ways nationally. First, within their housing type, minorities are exposed to water that is not safe to drink at a rate that is at least as high or higher than the population at large. For owner-occupied units, the percentage of housing units with unsafe drinking water from their primary source is 6% for the population overall, 9% for Blacks, and 16% for Hispanics. For renter-occupied units, the corresponding percentages are even higher—11% overall, 11% for Blacks, and 21% for Hispanics. Being in a rental unit roughly doubles the chance that the primary water source is believed to be unsafe, while within unit types Hispanics in particular face greater risks. Second, because the safety of the primary water source is lower in rental units, these minorities face magnified water quality risks due to their housing location. Black households occupy 9% of owner-occupied units and 21% of renter-occupied units. Similarly, Hispanics occupy 8% of owner-occupied units and 18% of renter-occupied units. The overall population risks from the primary drinking water source are almost twice as great for rental units, and Black and Hispanic households have more than twice as large a share of the rental units as owner-occupied units. The strong result that our

22. We do know that for our nationally representative sample, Black respondents have lower income than others ($t = 5.58$) and are less likely to own their home ($t = 5.48$), that Hispanic respondents are more likely to live in a state with higher water violations ($t = -4.61$), and each group is more likely to use municipal water relative to wells ($t = 3.81$ for Blacks, $t = 2.50$ for Hispanics).

23. These calculations and other calculations in this paragraph are based on data in Tables 3-4 and 4-4 of the U.S. Department of Housing and Urban Development (2011). See also Wescoat, Headington, and Theobald (2007) for the relation of water quality to poverty.

TABLE 10
Probit Regressions of Changes in Bottled Water Drinking

Variable	Greatly Increased Bottled Use vs. Last Year	Bottled Use Up, Tap Use Down vs. Last Year
Panel A: basic probit regressions[a]		
Population exposed to municipal water risk	.0579*	.0822**
	(.0321)	(.0367)
Risk data missing	.0163	.0465
	(.0362)	(.0465)
Panel B: detailed probit regressions[b]		
Population exposed to municipal water risk	.0566**	.0748**
	(.0264)	(.0315)
Demographics		
Income/$10,000	−.0032*	−.0020
	(.0017)	(.0020)
Years of education	−.0027	−.0037
	(.0025)	(.0029)
Age/10 years	−.0069*	−.0043
	(.0035)	(.0043)
Female	.0014	.0031
	(.0115)	(.0137)
Race: Black	.0578**	.0969***
	(.0291)	(.0367)
Ethnicity: Hispanic	−.0104	.0122
	(.0143)	(.0226)
Environmentalist	.0087	.0137
	(.0119)	(.0143)
Well water user	−.0140	−.0187
	(.0130)	(.0156)

[a] $N = 814$. Coefficients have been transformed to equal marginal effects. Standard errors are in parentheses. Significance levels: *.10, **.05, and ***.01.

[b] $N = 814$. Probit coefficients have been transformed to equal marginal effects. Standard errors are in parentheses. Significance levels: *.10, **.05, and ***.01. Nine observations excluded from the regression because no respondents with missing environmentalist data had greatly increased bottle use or bottle use up with tap use down. Equations also include a variable for top coded income, as well as dummy variables for missing values for risk data, race, and environmentalist.

empirical analysis found for Blacks and Hispanics is quite consistent with their housing location and risk exposures and need not be the result of flawed beliefs, as some have suggested.[24] In addition, the older water systems for Black households may contribute to their assessment that the taste of bottled water is better than that of tap water.

It is quite reasonable that minorities also have different safety perceptions. Respondents who are Black or Hispanic are more likely to perceive bottled water as safer, which is consistent with their relative preference for bottled water and relative aversion to tap water in the earlier results. Their minority status boosts bottled water usage both directly as well as indirectly through the effect on perceptions of bottled water safety.

24. "Minorities See Bottled Water as Safer, Buy More," FoxNews.com, June 8, 2011: "Poor minority parents are spending a sizeable chunk of their income on bottled water based on unfounded beliefs that it's safer, researchers say." See also Gorelick et al. (2011).

V. WATER QUALITY VIOLATIONS AND CHANGES IN BEHAVIOR

We have shown that state water quality violations are associated with greater bottled water use. Next we provide stronger causal evidence with an examination of the relationship between water quality violations and risk beliefs. Using grocery store level data from Northern California and Nevada, Zivin, Neidell and Schlenker (2011) found a positive relationship between water quality violations and aggregate measures of bottled water consumption. Our analysis suggests that a reasonable perceptional mechanism is driving such a relationship. Past water quality violations over the 2003–2009 period increase perceptions of the relative safety of bottled water over time, which in turn do affect bottled water consumption. Although these violation data are not available on an annual basis to test for short term responses, it is likely that the low probability nature of the events couples with delays in information dissemination, consumer learning,

and adaptation so that the long-term performance will be pertinent to consumer choice.[25]

We add to these results with a natural experiment of how changes in bottled water consumption respond to water quality violations using our individual household data. Our survey included questions pertaining to the change over one year ago in the number of weekly servings of different beverages. If people are responding to water quality violations, a high percentage of the state's population served by systems in violation of EPA standards should, over time, increase bottled water consumption. Our data also provide additional insight by being able to specifically address whether people substitute bottled water for tap water when there have been past water quality violations.

The probit regression estimates in Table 10 consider two different measures of change in bottled water consumption: whether bottled water consumption increased substantially and whether bottled water consumption increased while tap water consumption decreased.[26] Table 10 reports two panels of results. The first set of estimates in Panel A does not include the full set of demographic and regional variables, while the second set in Panel B does. In the parsimonious specifications, water quality violations always have a positive and statistically significant effect on great increases in bottled water consumption and on the substitution of bottled water for tap water. The main additional result from adding the full set of variables is the positive effect of being Black, consistent with our earlier results on the race effect.

VI. CONCLUSION

We provide data showing that consumers have a coherent set of beliefs and behaviors with respect to bottled water, resulting in a favorable assessment of the private rationality of the consumer choices that lead to bottled water consumption. The attractiveness of key product attributes influences consumer choices with respect to whether and how much bottled water they consume. Product characteristics that boost bottled water consumption are those that enhance the attractiveness of bottled water and decrease the attractiveness of the tap water alternative. Perceived greater safety and better taste make bottled water more attractive and, relative to tap water, the greater convenience of bottled water makes bottled water attractive as well.

While the greater convenience of bottled water is not controversial, many critics have questioned whether bottled water offers superior taste and greater safety. Analysis of the determinants of these perceptions indicates that these beliefs are appropriately related to the individual's personal experiences with tap water and objective measures of tap water quality. Having had tap water with a bad taste is particularly influential in boosting perceptions that bottled water is safer and tastes better. Respondents who live in states in which water quality standard violations are more common rate bottled water higher both with respect to safety and taste. Water quality violations are also positively linked to consumption of bottled water, switching to bottled water to tap water, and increases in bottled water consumption. These linkages suggest that consumer decisions are not only internally consistent but also are responsive to both their past experiences and objective measures of the risk.

The role of demographic characteristics is particularly intriguing in terms of the competing effects at work. More affluent respondents place a greater value on convenience and, reflecting the overall positive income elasticity of demand for bottled water, are more likely to drink bottled water and to spend more on bottled water. A quite different mechanism is operative for minority groups drinking bottled over tap water given their greater risk exposure to water that can make them sick. These findings for Black and Hispanic respondents are consistent with their being more likely to prefer bottled water to tap water and view bottled water as offering greater levels of safety and better taste.

The empirical results provide a consistent and favorable assessment of consumer behavior. Consumers have a strong basis for their water quality perceptions based on available information. These perceptions in turn influence consumer behavior in the expected manner.

25. For much the same reasons, studies of wage compensation for worker fatality rates generally utilize a multi-year average of the fatality rate variable as a measure of the risk even though annual data are readily available in this context.

26. The response categories are increased substantially, increased somewhat, about same, decreased somewhat, and decreased substantially. We recoded the responses as 0–1 indicator variables.

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