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Nudge or Sludge? An In-Class Experimental Auction Illustrating How Misunderstood Scientific Information Can Change Consumer Behavior

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Abstract
Scientific information can be used to help people understand and describe the world. For example, consumers regularly seek out information about their food and drink to help inform their purchasing decisions. Sometimes, however, consumers can respond negatively to this information, even when the information did not intend to convey a negative signal. These negative responses can be the result of misunderstandings or strong, visceral, emotional behavior, that can be challenging to foresee and once arisen, difficult (and expensive) to mitigate. In this paper, we show how educators can use an in-class economic experiment to introduce the power of a sludge—a small behavioral intervention that leads to worse outcomes. We provide a step-by-step guide to take students through a demand revealing design using a second-price, willingness-to-accept (WTA) auction that tests preferences for tap water and bottled water when students receive total dissolved solids (TDS) information. Additional classroom discussion topics are presented, including comparing nudges and sludges, the public response to the treatment of tap water, and the role of safety information in consumer response.

1 Introduction and Background

Consumers regularly seek out scientific information about their food and drink to help inform their decisions and preferences. While this search is generally viewed as a positive process, in some instances consumers respond to scientific information in unintended ways. Consumer responses can be difficult to foresee and, once they occur, hard (and sometimes expensive) to mitigate. On the other hand, firms can misuse this information via product labels by stigmatizing other products, thus profiting from consumer confusion and strong, visceral responses to products that pose no risk to them—Thaler (2018) called this "nudging for evil."

Information provided by labels have often been seen as a type of "nudge" popularized by behavioral economics. A nudge is "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler and Sunstein 2008, p. 6). Nudges are low-cost interventions made at the point of a decision, and they can have large effects on behavior, but they have been referred to as "sludges" when they end up misleading people by making it more difficult for individuals to make decisions that reflect their preferences (Thaler 2018; Sunstein 2020). Nudges—and their dark side, sludges, can be used in a variety of ways. People, perhaps unknowingly, frequently experience them in marketing and policies. Nudges are an important avenue through which students can learn about behavioral economics. The objective of this paper is to illustrate the power of behavioral economics through experiential learning with an in-class experiment using a second-price, willingness-to-accept (WTA) auction that measures the impact of an information treatment, a nudge. Specifically, students submit their WTA as an auction bid for performing the task of drinking water after receiving information about the total dissolved solids (TDS) in different water types. Learning about behavioral economics and the impact of information could be particularly pertinent for undergraduate students in environmental economics, agricultural economics,

environmental and resource economics, or public policy classes, among other audiences.

The in-class experiment developed here explores potential for information to evoke stigma and make a task (somewhat) controversial. Disgust (or disutility) is evaluated through changes in WTA elicited using a second price auction, an incentive compatible economic mechanism. Measuring students' WTA to perform a task, as opposed to measuring the more common willingness-to-pay (WTP) to avoid the task, is easier to operationalize in the classroom setting. The key difference between WTA (the minimum amount of compensation a participant will accept for performing a task) and WTP (the maximum amount of money a participant is willing to pay to not perform a task) is one of framing. WTA is more straightforward in the classroom setting to deal with a potentially unpleasant task for several reasons, including that it avoids the possibly problematic scenario of asking students to pay something in a class activity, or the expensive scenario of sufficiently endowing every student before the activity.

Behavioral economics is relevant in many courses, from core microeconomics to specialized courses in marketing and consumer behavior. We include suggestions for linking the experiment to real-world issues, specifically, the impacts of a sludge on the public's demand for tap water versus bottled water. Additional topics include, for example, food labeling for GMOs, rbST-free, or organic-produced items. One could also imagine using this approach in other food contexts that could invoke a negative consumer response such as new meat-free products or the use of insects as a novel protein (perhaps in powdered form). Embedded in this activity's discussion is the stigmatization of safe and cost-effective public drinking water, such as recycled water. Recycled water involves the treatment of wastewater for immediate and direct human consumption. This water, once treated, is as safe as any other treated water (Chen et al. 2013). Consumers have been shown to largely reject recycled water as its potentially contaminated origins are too salient (Savchenko et al. 2019). Nonetheless, recycled water may be a cost-effective way to provide clean and safe drinking water to many areas dealing with water scarcity now and in the future. Removing TDS from drinking water can significantly increase consumer acceptability, even though the low initial levels of TDS do not present any risk to consumers. TDS is a measure of the small amounts of organic matter present in water that are generally harmless for human or environmental health. Understanding consumers' behavioral response to different framings of information thus offers pathways for firms to use sludges to stigmatize competitors' products. For example, the company ZeroWater promotes their treated bottled water as containing zero TDS, even though there is no scientific information that suggests that TDS should not be present in drinking water. This suggests the question, does information on TDS in drinking water impact consumer choice? Likely the answer is yes—and the experiment discussed here will show students how impactful sludges can be.

Given the importance of nudges and sludges in different contexts, there is the additional value to extend the conversation to further lessons from behavioral economics on the role of safety and environmental information in decision and policy making. In fact, the impacts of information on decision making provides an important foundation for broader and policy-relevant classroom discussion. Nudges are a great way to engage students in interesting and entertaining real-world scenarios, for example, improving airport bathroom cleanliness by putting an image of a fly in a urinal to improve aim, and therefore, cleanliness. Although appealing due to their simplicity and low cost, nudges can fail by inducing the "wrong" behavior, or by having no effect at all (Sunstein 2017; Bicchieri and Dimant 2019). In a meta-analysis of 100 experiments using nudges, Hummel and Maedche find that two thirds of the effects are statistically significant and the median effect size is 21 percent (Hummel and Maedche 2019). In other words, not only are nudges occasionally ineffective, but they sometimes harm decision makers by enabling firms to appear to protect consumers while in fact doing the opposite (with a sludge; Willis 2013).

Comprehension of the potential for nudges and sludges to influence behavior is important for students in applied and agricultural economics, and agribusiness undergraduate and graduate programs,

both as decision makers and future choice architects.[1] Science communication skills are in high demand across sectors, so it is important that students should be able to distinguish what is a nudge and what is a sludge. This in-class experimental game can facilitate the discussion of the impact of information on WTA.

2 In-Class Experiment to Demonstrate the Impact of Scientific Information

This is a versatile in-class experiment that can be made locally relevant by using tap water. After completing this activity, we anticipate several learning outcomes:

1. Students will be able to critically examine when information provided is a positive nudge or negative sludge.
2. Students will be able to discuss the role of information in decision making as it relates to different public policy contexts, such as treated drinking water.
3. Students will understand and be able to define WTA.
4. Students will be able to participate in and understand a second price auction by stating their WTA for completing a task.
5. Students will be able to compare the distributions of WTA before and after receiving new scientific information.
6. Students will be able to think critically about the proper regulatory response to a situation where the public's assessment of a risk is different than the scientific/expert assessment.

The materials required to run this experiment include printed handouts with instructions and information about the water sources, a labeled jug containing treated tap water, bottled water, a TDS meter, envelope, cash to be used for payoffs, and small paper cups. The method to evoke stigma regarding water quality is to illustrate the TDS in tap and bottled water using a TDS meter.[2] TDS typically does not pose any human health risks. However, the measurements can provide participants with a visible difference between the tap water and bottled water, influencing their WTA for drinking each. Instructors should plan for about 75 minutes to complete the experiment and discussion afterward.

The design of the experiment depends on the class size. For larger classes, the experiment will have a between-subject design—that is, one group will receive the TDS information and one group will not receive the TDS information. For smaller classes (i.e., fewer than 24 students), the experiment should have a within-subject design, where the second-price auction will be conducted twice, first before the TDS information treatment is received and then again after the treatment. The remainder of this paper will describe a larger class setup (the Appendix includes options for smaller classes).

The classroom experiment consists of three parts. First, the instructor explains the second-price auction mechanism and provides students with an opportunity to participate in a practice round of a second price auction using a simple task, such as drawing a picture. Second, one half of the students (treatment group) use a TDS meter to measure the TDS content in both the tap water and bottled water. The other half of the students (control group) receives no additional information. Third, an auction is conducted using the task of drinking two ounces of tap water and drinking two ounces of bottled water. The difference in the distribution of WTA from the treatment and control auctions for the two types of water is a measure of the impact of the information provided. Graphically comparing a histogram of WTA

[1] Thaler and Sunstein (2008) coined the term choice architect to describe those who design policies or marketing. Whether a student pursues a career in government or industry, it is likely that they will at some point have the opportunity to design a choice framework for others. In this context, it is usually difficult to be neutral, and there are profit or welfare incentives to nudge a decision maker in one direction without limiting the independence of their choice.

[2] At time of writing, TDS meters are available on amazon.com for less than $20. For example, https://www.amazon.com/HM-Digital-TDS-4-Measurement-Resolution/dp/B0002T6L5M.

in each treatment group for the two types of water will give visual information about the similarities or differences in distribution of WTA. Depending on the level of the class, instructors may test the null hypothesis if the difference in WTA between tap and bottled water is the same across treatment groups.[3] Alternatively, in a simpler framing, the instructor could just present the count of people who would have performed the task of consuming each water at a single price point.[4] This experiment can either be conducted using pen and paper (templates included in Appendix), or electronically through a system such as Google Forms, Qualtrics, or Poll Everywhere.

2.1 Introduction to the Activity and Second-Price Auctions

Second-price auctions are a useful tool to reveal demand because they induce participants to bid their true value. Further, participating in an auction can be a fun and interactive experience for students.

To begin, the instructor provides important notices for the experiment:

1. Each participant will receive written instructions (see Appendix). These instructions will describe several tasks (e.g., draw a picture, drink two ounces of water), and students will be asked to indicate the minimum compensation amount (WTA) to do the task.
2. Student decisions may affect the amount of money they will earn (or alternatively extra credit points).
3. No deception is permitted in experimental economics.

The instructions include an introduction to the key concepts of the *offer* and the *payoff.* The offer is the minimum amount of money a participant requires (WTA) to perform a given task. The payoff is the amount of money earned. In these auctions, participants will write down (or submit electronically) their offer, being sure to keep it private from their classmates. The participant with the lowest offer[5] wins the auction, and their payoff is the amount in the second-lowest offer. Offers must be between $0.00 and $9.99.[6] If a student refuses to perform a specified task for any amount less than or equal to $9.99, the student may offer $10.00, and they will not need to perform the task, no matter what. In the case of a tie for the lowest offer, the winner will be chosen randomly among the lowest offers, and that winner will be paid the lowest offer.

Instructors may also wish to implement a maximum compensation, particularly in the case of a small class size to eliminate the possibility of students colluding at $9.99, or in the case that everyone makes high offers. If so, include the following instructions:

> However, there is a limit on the maximum compensation to be paid. This value is determined by the instructor before the start of the session. This limit may be as high as $9.99 and is chosen randomly for each part of the experiment. The maximum possible compensation is written on a piece of paper in the sealed envelope labeled with today's date at the front of the room. We will ask one of you to draw an envelope and show the limit to everyone at the end of this part of the experiment.

The use of the second-lowest offer to determine the payment creates incentive compatibility. Instructors may present the following example to class to emphasize this: suppose the task is to eat a

[3] Of course, because class sizes are often relatively small, a nonsignificant outcome from a test, or a failure to reject the null is weak evidence for the null hypothesis versus the alternative hypothesis.
[4] Another simple starting point would be to first ask participants, which of the two products they want, then one could use the auction to try to measure this preference with greater precision.
[5] In the case of a tie, the instructor may choose to allow multiple winners, or could use a random number generator (i.e., https://www.random.org/) to select one winner.
[6] The example presented here is based on the $0–$10 interval. However, instructors are free to use any interval that makes sense to them or helps them to stay within a certain budget.

piece of broccoli. Offers must be $0.00–$9.99. Student A would be willing to eat the broccoli for $0.00 but wants to try to game the system to earn money *and* eat the broccoli, so they offer $1.00. Student B offers their true value of $0.10. The sealed envelope (if included) is revealed to be $7.50. Student B wins the auction, eats the broccoli, and earns $1.00 (the second price, and lower than the sealed envelope). Student A lost utility because they did not get to eat the broccoli, even though the price was more than their WTA. Student A therefore has the incentive to submit their true value of $0.00. The incentive compatibility feature of a second-price auction is in contrast with a first-price auction, in which the winner receives the winner's offer. So, in the example above, there is no dominant strategy to offer truthfully because both Student A and Student B may receive some positive gain if they offer a slightly higher amount than their true value.

After introducing the concepts, instructors can move on to practice auctions using practice tasks, such as "draw a picture." Figure 1 provides an example sheet that may be used to complete these auctions. Data may be manually entered in a spreadsheet by the instructor. Alternatively, students may submit bids electronically. The use of pen and paper versus electronic submissions will likely depend on class size—for small class sizes, for example, fewer than 24 students, pen and paper works well.

To help improve student comprehension, the offers can be ordered from lowest to highest and written on the board. Then, the lowest offer can be identified, the task implemented, and the payment made to the individual. Students can be encouraged to ask questions at any point of this process. After ensuring comprehension of the auction mechanism and its incentive compatibility with the illustration below and an example auction, the instructor proceeds with the remainder of the activity.

2.2 Measuring the Impact of the Sludge

The main part of the classroom experiment proceeds with second price auctions for drinking tap and bottled water. For the treatment group (half of the class) the instructor delivers information that is factually true, harmless, but may be stigma evoking. The information is provided by conducting a TDS test to measure the TDS level in the tap and bottled water. The control group (remaining half of the class) receives no additional information. There are several different approaches for the instructor to provide TDS information to one half of the class but not the other. For example, the experiment could be conducted in teaching assistant sections that are already subdivided. Or an instructor could leave half of the students out of the room. Alternatively, in the context of remote learning, breakout rooms could be used if the class would reconvene later. After the information is conveyed, the instructor conducts the

What is the least amount of money you are willing to accept to perform the tasks below?

- Offers must be $0.00–$9.99.
- Person with the lowest offer is the winner and will receive second lowest offer.*
- If you are absolutely not willing to perform the task for less than $10, you may offer $10, and you will not have to perform the task.

Draw a Picture
Offer: $

*Or the predetermined maximum amount, to be revealed at the end of the experiment.

Figure 1. Training Activity: Second-Price Auction

auction to measure the auction results for the two groups. Figure 2 illustrates an example form to administer the second-price auction for two types of water.

There are several methods to provide accurate scientific information that is likely to evoke stigma (or "sludge") against the treated public tap water. The TDS test is a good option because it provides easily comparable measures of the types of water and can be verified by the students. If taking a TDS measure is not an option, a simple information-only intervention can potentially also elicit stigma. We take advantage of a disgust response from the reminder that drinking water may have once been in contact with noxious substances. Figure 3 illustrates results from this activity when conducted at a public university. After providing information on TDS content of tap and bottled water, WTA offers for drinking bottled water decreased while the WTA offers for drinking tap water increased, indicating a move away from the stigmatized public tap water.

Figure 3 shows differences observed before and after providing undergraduate students with information about TDS content of two water types (tap and bottle). These results come from the authors' in-class experiments using the design described in this paper.

3 Discussion Suggestions and Conclusions

To facilitate classroom discussion, the instructor should present the students with the summaries of their offers in the auctions for a view of what happened during the activity. The instructor should describe what are TDS and how they generally present no human health risk. In the authors' experience, average WTA for bottled water from the group that received the information about TDS tends to be lower than the group that did not (in other words, the level of concern is lower with the information about TDS). Then, the instructor should move on to define nudges (and sludges) and give examples of nudges in policy and marketing. A sludge is a nudge that makes it more difficult for individuals to make wise decisions that reflect their preferences. In the authors' experience, the TDS measure increases the class mean WTA of drinking the more sustainable and economical tap water, despite the harmlessness of TDS. Students at this point should understand how the TDS information could be a sludge that impedes the treatment groups' valuation. This discussion should take place after the experiment and could include a

What is the least amount of money you are willing to accept to drink 2 ounces of the following water sources?

- Offers must be \$0.00–\$9.99.
- Lowest offer is winner, will receive second lowest offer.*
- If you are absolutely not willing to perform the task for less than \$10, you may offer \$10 and you will not have to perform the task.

Bottled Water	Tap Water
Offer: \$	Offer: \$

Figure 2. Second-Price Auction for Drinking Water

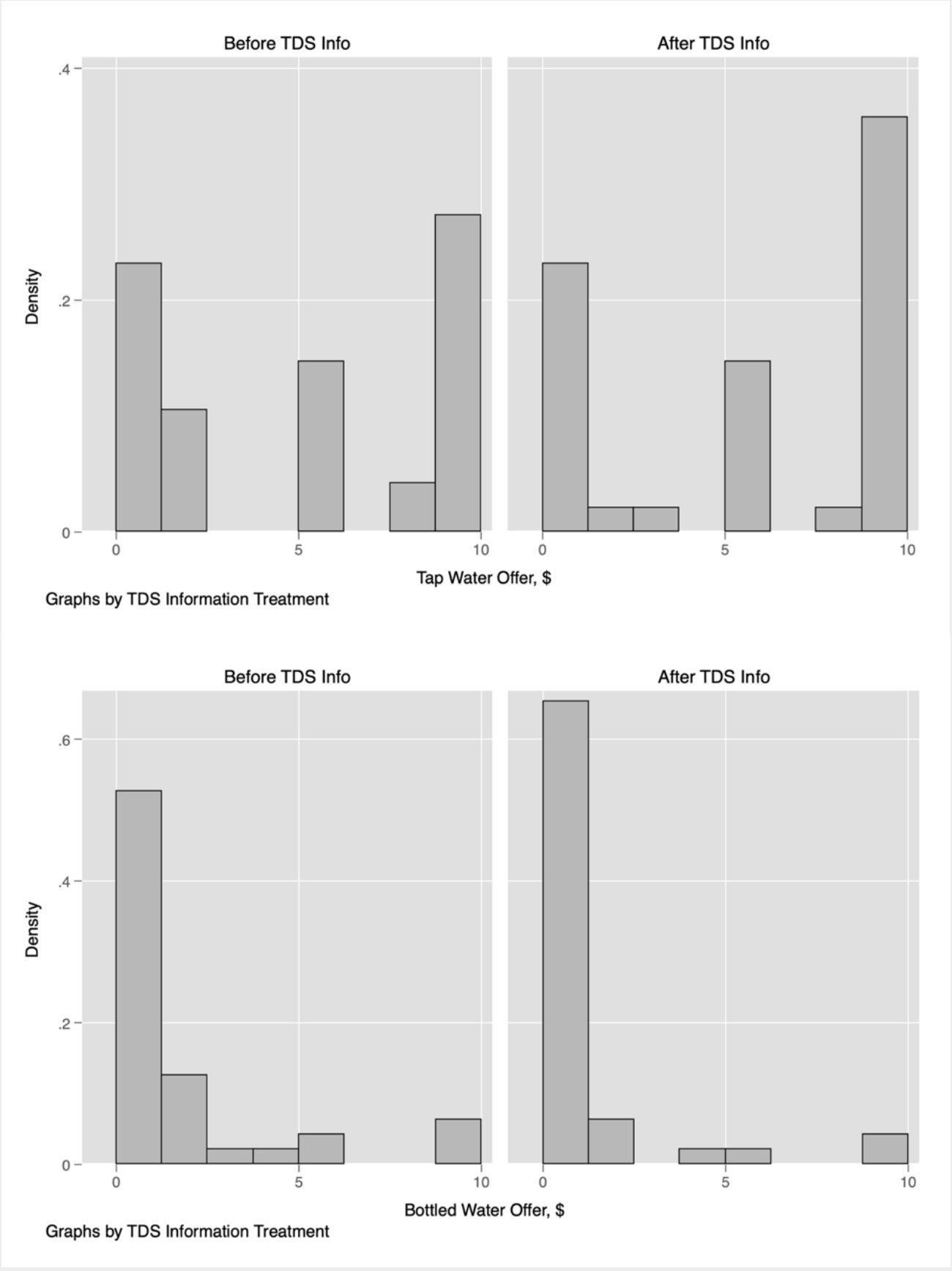

Figure 3. Experimental WTA Results from 39 Undergraduate Student Participants

simple survey or interactive question-and-answer between the students and instructor to see how the TDS measure was perceived.

At this point, students should have a better understanding of the potential for lessons from behavioral economics to influence policy and behavior. The instructor may also want to present the results shown in the manuscript (Kecinski and Messer 2018). This activity can relate to many different topics that can be selected based on the course;[7] in this section, we propose four potential discussion topics.

1. Nudges and sludges: Discuss examples from other contexts where informational nudging is or is not effective.
2. Response to recycled water: Discuss the issues involved in consumer response to different types of drinking water, specifically recycled or reused water.
3. Scientific labels and fear: Discuss the role of science and consumer fears in policy making (e.g., TDS concentrations in water, labeling for GMOs, rbST, organic production).
4. Policy: Discuss the proper regulatory response to a situation where the public's assessment of a risk is different than the scientific/experiment assessment.

Thaler's (2018) *Science* article describes "nudging for evil" as a sludge—interventions that make it more difficult for individuals to make wise decisions that reflect their preferences. While helpful nudges continue to be a major aspect of choice architecture, examples of intentionally malevolent use of nudges by profit-seeking firms abound: the difficulty of receiving promised rebates or cancelling a subscription because of the power of the default or status quo of continuing to pay for the subscription. Public sector examples include the difficulty of voter registration and immigration processes, student financial aid applications, and health care enrollment—processes that already have notoriously high transaction costs. Sunstein (2020) proposed a *sludge audit* for both the private and public sectors. In-class discussion could include what sludges the students experience, for example, the hurdle of complicated financial aid forms (Dynarski et al. 2018) or the difficulty of unsubscribing from paid services. In the context of this in-class activity, the TDS measure is providing additional information to muck up the students' value of the drinking water. TDS is generally not harmful, and some mineral water will necessarily have high levels. The added information at the time of the decision made it more difficult for students to evaluate their choices.

Different communities will have different water-related issues that can be highlighted in class, including the balance of surface and groundwater, the presence of natural contaminants, or elevated risk of water shortages due to drought. Instructors are encouraged to do their own research on local drinking water supplies, such as source and potential pollution issues. Generally, larger cities may rely more on surface water whereas rural areas may be more reliant on ground water (this will also depend on geographic location). Similarly, certain geographic locations may present with their own unique challenges. For example, there are various locations in several Asian countries (including China, Bangladesh, and India) that have naturally occurring arsenic in ground water. Other water issues, such as eutrophication, impact surface waters around the world. Additionally, discussion could include news coverage of policies that resulted in large scale lead contamination in Flint, Michigan, United States. Moreover, regardless of the specific water issue and geographic location, it is likely that climate change will intensify threats to water availability and quality (IPCC 2021), and so we suggest to including important information concerning the impacts of climate change on the water cycle.

A discussion about water shortages, either local or global, and the role of public opposition to water recycling development would represent an important, policy-relevant extension of the exercise.

[7] For a class that focuses on experimental methods, there are several additional relevant topics, including a discussion on auctions as a method for eliciting value and measuring the impact of a nudge.

For example, instructors can engage students in a discussion about the importance of the source of recycled water by introducing research on consumer acceptance of recycled water for drinking, recreation, and irrigation uses. This discussion can be enriched with examples of large-scale water reuse projects, including those that failed due to consumer concerns, such as East Valley Water Recycled Project in Los Angeles, California, and those that successfully operate today, such as the Groundwater Replenishment System facility in Orange County, California. Instructors can further motivate students to think about how consumers' experience with drought can shape their perceptions of recycled water. For example, consumers who have experienced a higher frequency of drought might be more willing to purchase products produced with groundwater drawn from an aquifer recharged with recycled water.

In addition, instructors can discuss the policy implications of consumer stigmatization of produce grown with recycled water or the impact of information about benefits and risks associated with recycled irrigation water on consumer preferences. A class could further discuss how product branding and processing, social preferences, and public decision making can help alleviate stigma. Further, there is a broad experimental literature that can be incorporated in class discussions. This paper describes using only local tap water and bottled water; however, this experiment can also be conducted using filtered water. Filtering the tap water using the ZeroWater home water filter, which reduced the TDS levels similar to Penta ultra-purified bottled water, mitigated the stigma of the tap water. These results suggest that the tap water was stigmatized due to the presence of TDS, which were removed in the filtering process.

The abundant (and sometimes contradictory) scientific information available to consumers about food and drink requires careful consideration to sift through it all. Labeling to communicate specific processing aspects and origins has become commonplace, and not always with good outcomes. Ask students what labels they look for on food and beverage products and whether they believe there to be a scientific backing for those labels. Discuss what their reaction might have been if bottled water was labeled "TDS Free" or "Contains TDS." Labeling can be a nudge with good outcomes by providing important scientific information about the health and safety of a product. However, labeling can easily become a sludge—complicating a consumer's decision with unhelpful information.

Finally, instructors are encouraged to have a discussion on what is the proper regulatory response to a situation where the public's assessment of a risk is different than the scientific or expert assessment. To help stimulate the discussion, students may be encouraged to read "Regulations in Happyville" by (Salanié and Treich 2009), who discuss the welfare impacts of a situation where regulators invest taxpayer money in water cleanup technology in response to the public's incorrect belief that their drinking water supply is contaminated.

In conclusion, behavioral economics is a powerful framework for understanding decision making in many contexts, and nudges (or sludges) provide an important introduction to it. This paper describes an in-class experiment to illustrate the role of scientific information in the context of valuing different types of drinking water. These concepts are relevant to a range of economics courses taught in applied and agricultural economics or agribusiness programs.

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