Selection Effects and Heterogeneous Demand Responses to the Berkeley Soda Tax Vote

This manuscript has been published by the American Journal of Agricultural Economics. Debnam, Jakina. 2017. "Selection Effects and Heterogeneous Demand Responses to the Berkeley Soda Tax Vote." *American Journal of Agricultural Economics* 99 (5): 1172–87. doi:10.1093/ajae/aax056.

Abstract

Early evidence from household-level surveys suggests that the one-cent-per-ounce tax on sugar-sweetened beverages which took effect March 1, 2015 in Berkeley, California decreased consumption of sugar-sweetened beverages dramatically. Even if these findings are robust, the public policy implications of expanding the Berkeley soda tax policy to a national level are complicated by selection effects inherent in the populations of both voters and consumers. We find consumption responses related to the tax interact nontrivially with consumer heterogeneity. Some of these responses directly counter the public policy goals of a soda tax: first, high-consuming households are less price sensitive and therefore less responsive to price changes following a tax; and, second, "reactance" among high-consuming populations led to increases in soda consumption immediately following the passage of the tax, partially mitigating reductions in soda consumption.

Key Words: Behavioral economics, public policy, sugar-sweetened beverage tax, reactance

JEL codes: I18, D12, H00

The consumption of sugar-sweetened beverages (SSBs), defined as drinks which contain added sugar (e.g. soda, soft drinks, sports drinks, and some fruit drinks) has been associated with increased risks of diabetes, obesity, and heart disease (Brownell *et al.*

2009). In response to these public health concerns, policymakers have become increasingly interested in adopting measures to discourage SSB consumption. Proposed and implemented measures include anti-soda advertising campaigns, soda bans, warning labels, and soda taxes – which are the focus of this paper. At the time of this writing, the American cities of Albany, CA, Berkeley, CA, Boulder, CO, Oakland, CA, Philadelphia, PA, and San Francisco, CA have passed similar one- or two-cent-per-ounce excise taxes on soda and sugar-sweetened beverages since November of 2014. Outside of the United States, targeted SSB taxes have been implemented in Barbados, Chile, Dominica, Finland, France, Hungary, and Mexico (Nakhimovsky 2016). Such taxes are currently being promoted by the World Health Organization, and national SSB taxes are actively under consideration by policymakers in a number of countries including South Africa, Thailand, and Vietnam as well as by local policymakers in several cities in the United States (World Health Organization 2016).

While the economic logic of increasing the price of a good to decrease its consumption is clear, the welfare implications of a soda tax in the presence of heterogeneous consumers is less so. Differing elasticities of demand may cause high-SSB-consuming households, arguably the target of soda taxes, to under-adjust their consumption relative to low-SSB-consuming households. Meanwhile, consumers may also respond to the *invasiveness* of a soda tax – or the extent to which it represents a negative sanction – in addition to its explicit price incentives. If these responses to invasiveness counter the policymaker's goal of mitigating SSB-associated health risks, they have real welfare consequence.

Using the implementation of a one-cent-per-ounce excise tax on SSBs[1] in the city of Berkeley, California during November of 2014, this paper provides empirical evidence

regarding consumption responses to the passage of a "soda tax", with a focus on whether these responses differ between high-SSB-consuming populations and low-SSB-consuming populations. We anticipate that in the face of a well-publicized tax on soda, some high-SSB-consuming households may be motivated to consume more soda than they otherwise would as a form of protest. This type of consumption is a result of *psychological reactance*. Originated by Brehm in 1966, the notion of psychological reactance captures the idea that when an individual is facing a restriction on her behavior, she may be motivated to take some action to restore or affirm that behavior.

We use a large dataset of 77,976,307 of household purchases made in the Nielsen Homescan Consumer Panel between 2010 and 2015 and identify two welfare-relevant effects of the Berkeley SSB excise tax on high-SSB-consuming households. First, we estimate an Almost Ideal Demand System for eight non-alcoholic beverages. From this, we separately estimate elasticities of demand for both high-SSB-consuming and low-SSB-consuming households[2]. We find that high-SSB-consuming households (own-price elasticity for full-calorie soda = -1.318; own-price elasticity for non-carbonated SSBs = -1.149) are less price sensitive than low-SSB-consuming households (own-price elasticity for full-calorie soda = -1.400; own-price elasticity for non-carbonated SSBs = -1.154). This implies that the incidence of any SSB excise tax falls disproportionately on high-consuming households. This occurs not only because these households consume more SSBs, but because they reduce their consumption less in response to price changes. Second, we test for *reactance* effects and find that following the passage of the referendum instituting the Berkeley tax on SSBs, high-consuming households living in the surrounding area increased their weekly consumption of sugar-sweetened beverages

by 7.41 ounces (or roughly two-thirds of a can of soda) – the consumption of these households shifted in the opposite direction of that intended by policymakers, in a response we characterize as *psychological reactance*. We demonstrate that this effect cannot be explained by co-occurring beverage consumption trends or by rebounding consumption after pre-vote advertising campaigns. It must be stressed that this reactance occurs after the vote, but prior to the implementation of the tax. Thus, it likely represents a short-term response to the policy.

We conclude with a comment that we should not expect consumption changes following the implementation of the tax in Berkeley to be generalizable to the population of the United States; both the population which voted for the tax and the consumers impacted by it are atypical of the rest of the United States. Thus, studies of the Berkeley SSB tax provide something of a cautionary tale for natural experiment type studies of policies that are implemented by ballot measure and for which the appeal is somewhat correlated with outlier status in general.

Background

The health risks targeted by soda taxes are concentrated among high-SSB consumers. In a large correlational study of 1.66 million adults living in New York City, Rehm *et al.* (2008) find that frequent soda consumption is most prevalent among the obese and overweight. In a public health study based on a survey of adults living in rural communities in the American West, Liebman *et al.* (2003) present evidence that being overweight or obese is strongly associated with being a frequent consumer of SSBs. Using both survey and biometric indicators from a large set of adults, Ma *et al.* (2016) find that, after adjusting for age, sex, and other confounders, being a frequent consumer

of SSBs is associated with an approximately 46% higher risk of developing prediabetes than the risk faced by the lowest-SSB-consuming group of participants. The authors also find that being a high-consumer of SSBs is also associated with developing insulin resistance and with increasing body mass index.

In the face of a soda tax, high-SSB-consuming households may adjust their consumption differently than low-SSB-consuming households. Using a large set of household-level panel data from Australian households, Etilé and Sharma (2015) compare the impact of a proposed SSB tax on moderate-SSB-consumers and high-SSB-consumers and estimate that SSB price elasticities decrease with the frequency of consumption. Gustavsen and Rickertsen (2011) use quantile regression to consider high-consuming and low-consuming households separately while estimating the effects of an increase in the value-added tax (VAT) on sugar-sweetened carbonated soft drinks in Norway. The authors' elasticity estimates suggest that high-consuming households are less responsive to price changes than low- and moderate-consuming households. Where elasticities of demand for soda vary by household consumption-type, studies which quantify average consumption changes will obfuscate the impact of a tax on the at-risk population – high-SSB consumers.

Beyond heterogenous responses driven by differences in the price sensitivity of high- and low-SSB consuming household-types, we consider additional variation due to individuals' propensities to restore or affirm threated behaviors, known as *psychological reactance* (Brehm 1966). Empirical work in psychology finds evidence of reactance behaviors in increased desires to engage in a threatened or restricted behavior (Pennebaker & Sanders 1976) and in increased preference for a threatened or restricted

good (Mazis, Settle & Leslie 1973; Cacioppo & Petty 1979; Calder & Sternthal 1980; Petty & Cacioppo 1986). If true, the latter reactance mechanism is problematic for would-be regulators – if individuals respond to choice set restrictions with stronger preferences for restricted items, the price incentives created by excise taxes will also generate countervailing reactance effects.

Under the theory of reactance, individuals act out of a desire to restore a restricted freedom; individuals who feel most threatened by a policy will also be the most likely to change their behavior to resist the threat. In our case, psychological reactance suggests that SSB-consuming households facing an SSB-tax should be likely to increase their consumption of these beverages in the short term. Among these households, high-SSB-consumers should be the most likely to increase their consumption as more of the goods which they currently purchase will be subject to increased taxation. Consumers in areas without an imminent SSB-tax should not display reactance-motivated increases in SSB consumption.

Reactance behaviors in response to excise taxes have been previously proposed and formalized by Just and Hanks (2015). Consistent with reactance, Debnam and Just (2017) find that after viewing an anti-soda advertisement, laboratory participants consumed *more* soda while performing an unrelated task than participants who had been shown a neutral non-soda-related advertisement. To our knowledge, we are the first to empirically examine responses to the Berkeley soda tax through the framework of reactance.

Existing analyses of the Berkeley SSB tax include much-discussed work by Falbe *et al.* (2016) which finds that 47% of the Berkeley excise tax was passed through to consumers in the form of higher prices. Further, the authors find a large decrease in self-reported

soda consumption following the implementation of the tax – a 21% decrease in consumption of SSBs. Taylor, Kaplan, Villas-Boas, and Jung (2016) use panel data of purchases from campus retailers in Berkeley, California to estimate the consumption effects of the well-funded advertising campaign which preceded the Berkeley soda tax vote. The authors find a small and insignificant drop in soda sales before the election and a large drop in soda consumption following the election.

Data Description

Data for our empirical analyses comes from the Nielsen Homescan Consumer Panel, a longitudinal panel dataset of participants from across the United States, which documents the set of household purchases made by each of roughly 60,000 households annually. We accessed this panel through the Kilts Center for Marketing at the University of Chicago. This panel has been widely used for demand estimation for goods including sugar-sweetened beverages (Zhen, Finkelstein, Nonnemaker, Karns & Todd 2013; Sharma *et al.* 2014) and snack foods (Kuchler, Tegene & Harris 2005). The Homescan Consumer Panel sample is balanced along categories of household size, income, age of head, education of head, occupation of head, presence of children, race, and Hispanic origin. Data is available from Nielsen with a two-year lag; for our estimations we use purchasing data from 2010 through 2015. For each household item purchased, a customer scans the UPC code of the item or manually enters the name of the item purchased, and further indicates the quantity of the item purchased, the date of the purchase, the location of the purchase, and whether or not the item was purchased as part of a store promotion. Nielsen receives point of sale data directly from some retailers and for items purchased at these retailers, Nielsen assigns to the purchase the average weekly price paid for that

UPC at the retailer. For purchases made at retailers where Nielsen does not receive point of sale data, the panelist manually enters the expenditure made on the purchase. We also observe the purchase brand and information for a set of purchase characteristics. We additionally observe household-level demographic and socio-economic characteristics. Participation in the panel is incentivized by a system of reward points and eligibility for sweepstakes and monthly prize drawings; points increase both in the number of items purchased and in the household's length of participation. With an average of 20 percent of households in the panel exiting each year, the panel is not fully balanced.

Several recent studies have used data from the Nielsen Homescan Consumer Panel to make advances in knowledge of the impact of SSB taxes on consumer behavior. Using data from years 1998-2003, Dharmasena and Capps (2012) estimate a variation of a Quadratic Almost Ideal System (AIDS) model to study the effects of an SSB tax on consumption, calorie intake, and weight changes. Because of the substitutability between non-alcoholic beverages, the authors emphasize the importance of considering a demand system when estimating the welfare impact of a tax on SSBs. Sharma, Hauck, Hollingsworth, and Siciliani (2014) estimate an AIDS model using data from 2011 to compare the effects of an SSB tax on tax burden, consumption, and weight, considering separately low-income, middle-income and high-income consumers. In work closely related to ours, Finkelstein *et al*. (2013) use 2006 data to model the effect of an SSB tax by modeling the demand for nutrients and the impact of substitution and complementarity on other beverage and food categories. The authors use quantile regressions to explore how the effects of an SSB tax vary by household SSB-consumption-type by modeling

household demand for nutrients. The authors find the highest consumers of SSBs have a lower price elasticity of demand than other types of consumers.

Despite its common use for this purpose, there are some concerns with using this dataset to explore consumption responses. First, there may be concerns about the credibility of self-reported purchasing data which is both detailed and time consuming to report. By cross-referencing Nielsen reported purchases with store records, Einav, Liebtag, and Nevo (2008) find evidence of household underreporting of shopping trips, and underreporting of the purchases made during these trips, with roughly 20 percent of the purchases reported by stores unobserved in the Nielsen reported purchases. For quantity information, the authors find that 94 percent of quantities reported by households match the quantities reported by stores. This measurement error is likely uncorrelated with the timing of the Berkeley soda tax vote. We may, however, be concerned that underreporting and measurement error could be correlated with household-SSB-consumption-type. It could also be the case that consumers are less likely to self-report small, infrequent purchases such as a single soda. While we cannot estimate the extent to which this may be the case, we note that because of possible stigma, high-SSB-consuming households are likely to underreport rather than to overreport their consumption of soda. If it exists, such underreporting will lead us to underestimate the extent to which these households consume soda, biasing us toward the null in our estimation of consumption shifts. Even if underreporting is increasing during the period before the vote because of increasing stigma, our consumption shift estimates will remain biased toward the null unless (implausibly) underreporting lessens in the period

immediately following the vote. The impact of such possible underreporting on our elasticity estimates is ambiguous.

Advantages to using this data include our ability to precisely identify purchases which would be subject to an SSB tax, and our ability to match them to the characteristics of purchasing households. The panel nature of this data allows us to robustly control for the effects of household-level characteristics in estimating price sensitivity and household consumption shifts.

For tractability, we draw a random sample of 20 percent of the households in the dataset, maintaining the full set of households in the areas surrounding Berkeley, California (Alameda and San Mateo Counties) for a sample of over 2,399,897 million household-purchasing weeks. With an average household income of $63,881.08 our resulting sample is wealthier and better educated than the average household in the United States. The average expenditure on an item purchased is $3.77. On average, households in our sample purchase 4.38 household items per week in which household purchases are observed. A table of aggregated household summary statistics is given in table A1 of the supplementary online appendix.

Estimating Elasticities of Demand by Household-Type

We begin by investigating whether price responses differ by household consumption-type. For our analysis, we define a *high-SSB-consuming household* to be a household whose median weekly sugar-sweetened beverage consumption is greater than the median weekly consumption across the sample. We refer to all other households as *low-SSB-consuming households*. We define a *high-soda-consuming household* to be a household

whose median weekly consumption of soda (defined as a carbonated soft drink) is greater than the median weekly consumption across the sample. We refer to all other households as *low-soda-consuming* households. Summary statistics by household-SSB-consumption-type are given in table 1. For summary statistics by household-soda-consumption-type, see online appendix table A2.

[Insert table 1 here]

High-SSB-consuming and low-SSB-consuming households in our sample are demographically similar to one another. One notable difference is that fewer low-SSB-consuming households have a male household head present than do high-SSB-consuming households. This is consistent with the demographic trends described in Rehm *et al*. (2008) where men are more likely to be frequent soda consumers.

To estimate the price elasticities of demand for SSBs, we estimate an AIDS model for non-alcoholic beverage purchases (Deaton & Muellbauer 1980) which has been adapted to control for household demographic characteristics. AIDS models have been used frequently in the literature to estimate price elasticities, including for the elasticity of demand for soda and sugar-sweetened beverages (Colchero, Salgado, Unar-Munguía, Hernández-Ávila, & Rivera-Dommarco 2015; Guerroro-Lopéz, Unar-Munguía & Colchero 2017; Zhen, Wohlgenant, Karns, and Kaufman 2011). To provide suggestive evidence about the way the elasticities of demand may differ between high-SSB- and low-SSB- consuming populations, we estimate this model separately for subsamples of high-SSB- and low-SSB- consumption-types.

[Insert table 2 here]

We aggregate the quarterly purchases for each household in our panel for a total of 296,467 quarterly observations across the 22,544 households in the sample. For each household-quarter, we then aggregate consumption for each non-alcoholic beverage category to standardized units of ounces per household-quarter for each of eight beverage categories of non-alcoholic drinks. The beverage categories of non-alcoholic beverages are: 1) tea and other infusions; 2) coffee; 3) milk; 4) no-sugar-added fruit juice; 5) bottled water; 6) non-carbonated SSBs; 7) full-calorie carbonated SSBs; 8) low-calorie carbonated SSBs. For each purchase, quantities are standardized in ounces and unit prices are calculated by dividing the expenditure for that purchase net of any coupons by the total number of ounces purchased. For each beverage category, household quarterly budget shares are calculated as the ratio of total expenditure on beverages in that category to the total household quarterly spending across all non-alcoholic beverage categories.

We estimate a standard AIDS model (Deaton and Muellbauer 1980) for budget share w_{hj} for beverage group *j* consumed by household *h* at time *t*:

$$w_{hjt} = \alpha_{i0} + \sum_{j=1}^{J} \gamma_{ij} \ln p_{hjt} + \beta_j [\ln x_{ht} - \ln a(p_{ht})] + u_{hjt} \quad (1)$$

With *j* = 1, …, 8 beverages, *h* = 1,…,H households and *t* = 1,…,24 quarters.

Where $\ln a(p_{ht})$ is the transcendental logarithm function, x_{ht} is the household's total expenditure on non-alcoholic beverages in quarter *t*, and we set α_{i0} at ten, approximately the natural log of the lowest income in the dataset following the rule of thumb used by Deaton and Muellbauer (1980). β_j and γ_{ij} are the parameters of interest. We calculate uncompensated own-price elasticities for each non-alcoholic beverage, performing

separate demand estimations for high-SSB- and low-SSB-consuming households (table 3).

[Insert table 3 here]

We examine the own-price elasticities for SSBs (non-carbonated SSBs, full-calorie carbonated SSBs, and low-calorie carbonated SSBs) separately for high-SSB- and low-SSB-consuming households. From the AIDS estimations, we find that own-price elasticities of demand for full-calorie soda and low-calorie soda are higher for low-SSB-consuming households (own-price elasticities are -1.400 and -1.749 respectively) than for high-SSB-consuming households (own-price elasticities are -1.318 and -1.378 respectively). We also find that own-price elasticities for non-carbonated SSBs are higher among low-SSB households (own-price elasticity = -1.154) than among high-SSB households (own-price elasticity = -1.149). These estimates suggest that high-SSB consuming households will adjust their consumption less than low-SSB consuming households in the face of a tax on SSBs.

Estimating Demand Shifts Following Berkeley Soda-Tax Vote

Next, to investigate possible heterogenous *reactance* responses to the Berkeley soda tax, we use a quasi-experimental "fuzzy" regression discontinuity design. This specification is akin to a difference in differences estimation where we assume that household purchasing decisions are as good as randomly distributed about the date of the soda tax vote. The key point of departure is that the probability of treatment need not jump from zero to one at the date of the soda tax vote, but rather from zero to some probability between zero and one. This is key as the effect in which we are interested is one of exposure – not all

residents may have been aware of the vote and therefore not all residents may not have been treated. This design identifies changes in aggregate consumption of soda and sugar-sweetened beverages by residents in the county containing Berkeley, California following the soda tax referendum vote. Simple graphical evidence shown by plotting household consumption of county residents over time (shown in figure 1) is consistent with shifting consumption around the time in which the vote was passed.

[Insert figure 1 here]

The finest level of geographic information in the Nielsen Homescan Consumer Panel dataset is the Federal Information Processing Standards (FIPS) county code of the household or retailer. This means that we cannot disentangle the consumption shifts of Berkeley residents from those of residents of other households within the same county. With 112,580 residents, Berkeley is the fourth most populous city in Alameda County, and since the passage of Measure D in Berkeley, two additional cities in this county, Oakland and Albany, have passed taxes on sugar-sweetened beverages. Therefore, it is plausible that the passage of Measure D signaled potential changes in future soda consumption to a greater set of households in Alameda County than simply Berkeley residents. Nonetheless, any consumption shifts we observe will be dampened by the consumption responses of non-Berkeley residents of the same county.

We compare the consumption shifts in Alameda County following the passage of the tax with the shifts made by households in the United States, as well as with households in neighboring San Mateo County (where no SSB tax was proposed). Our estimation procedure provides information about shifts in consumption which co-occur with the date of the referendum vote, controlling for underlying time trends and household-level

sociodemographic characteristics. We are interested in the effect of exposure on consumption. Absent any purely exogenous shocks, an important concern for our empirical strategy is whether any effect we observe may be due to unrelated co-occurring events which may or may not be related to the policy of interest. While we cannot eliminate these concerns, we address them through a series of robustness checks. First, we estimate the same specification for no-sugar-added fruit juice, a product which would not have been subject to the SSB tax and therefore for which we should not observe reactance consumption responses. Second, instead of estimating the specification for Alameda County, we estimate the specification for the county of San Mateo, which faced no SSB tax vote. Finally, we re-estimate our main specification using a placebo policy date one year before the actual vote.

Given the pre-vote drop in SSB consumption in Berkeley identified by Taylor *et al.* (2016), an additional concern is that the shift we observe following the SSB tax vote is simply a return to normal consumption levels. We therefore re-estimate all specifications including a dummy for the heavy-advertisement pre-vote period – our results are robust to the inclusion of this variable and across almost all regressions its coefficient is directionally consistent with the findings of Taylor *et al*. (2016) (these estimations are available in the online appendix tables C1- C7).

We limit our sample to the set of households who have purchased some positive quantity of any beverage from 2010 to 2015, for a total of 2,399,897 household-purchase-weeks. Our main specification is a household-level fixed effects regression, clustering standard errors at the household level:

$$(2) \quad y_{ht} = \alpha + \gamma_1 D_{AfterVote} + \gamma_2 Time + \gamma_3\left(Time \cdot D_{AfterVote}\right) + \gamma_4\left(D_{Berkeley} \cdot D_{AfterVote}\right) + \gamma_5\left(D_{Hi-type} \cdot D_{AfterVote}\right) + \gamma_6\left(D_{Berkeley} \cdot D_{AfterVote} \cdot D_{Hi-type}\right) + \gamma_7 Month + \varepsilon_{ht}$$

Where y_{ht} is the dependent variable of interest, ounces of either soda (defined as carbonated soft drinks) or sugar-sweetened beverages (defined as all beverages which contain added sugar) consumed by household *h* in week *t*. We also include month fixed effects to address seasonal variation in soda demand. For geographic residence dummies, a household is defined as living in Berkeley, California ($D_{Berkeley} = 1$) if the Federal Information Processing Standard (FIPS) state and county codes associated with its address identifies Alameda County, California. We define a household to be a *high-SSB-consuming household* ($D_{Hi-type} = 1$) if household median weekly sugar-sweetened beverage consumption is greater than the median weekly consumption across the sample. We refer to all other households as *low-SSB-consuming households*. We define a household to be a *high-soda-consuming household* ($D_{Hi-type} = 1$) if household median weekly consumption of soda (defined as a carbonated soft drink) is greater than the median weekly consumption across the sample. We refer to all other households as *low-soda-consuming* households. Throughout, the estimation of the main specification in the sub-sample of only Alameda and San Mateo Counties is given in the right two columns; the estimation of the main specification in the whole sample is given in the left two columns.

The estimation of the main specification for the volume of all sugar-sweetened beverages is given in table 4. From columns one and two, we find statistically significant evidence that, consistent with reactance, households in Alameda County increased their

consumption of sugar-sweetened beverages by 8.89 ounces relative to other U.S. households following the soda tax vote. We estimate the impact of the soda tax vote on high-consuming households living in Alameda County to be an increase in weekly consumption of 7.41 ounces (or roughly two-thirds of a can of soda). This shift represents a 3.68% increase in the average weekly SSB consumption of high-consuming households. While small, these results are consistent with the notion that reactance behavior is compounded by being a high-consumption-type household. Columns three and four of table 4 replicate the analyses, limiting the sample to households living in San Mateo or Alameda Counties. We do not find significant evidence of a positive consumption shift among households living in Alameda County after the soda tax vote relative to households living in San Mateo County. When we replicate the analyses in columns one through four of table 4 for San Mateo County households, rather than Alameda County households, we do not find evidence of any such consumption shifts (see online appendix tables M1 and M2).

The estimation of the main specification for the volume of soda (or carbonated soft drink) purchased is given in table 5. Here we observe consumption shifts following the vote consistent with reactance among all households living in Alameda of 26.56 ounces relative to the United States population, and 37.15 ounces relative to the population of San Mateo, but we do not observe any additional statistically significant consumption shifts associated with being a high-soda consumer. Again, when we replicate the analyses in columns one through four of table 5 for San Mateo County, households for whom the Berkeley SSB tax vote represented no threat, we do not find evidence of any such consumption shifts (see online appendix tables M1-M2).

Using household-level data, we find evidence of consumption shifts following the vote for a sugar-sweetened beverage tax that run counter to the public policy goals of the tax. While these results are significant, our data capture short-term impacts of the vote—prior to actual implementation of the tax. Indeed, this shift may just be the first-stages of longer-term consumption adjustments, which would likely include declines following implementation of the tax.

[Insert table 4 here]

[Insert table 5 here]

Robustness

One potential concern is that the consumption shifts we observe represent intertemporal substitution in anticipation of higher prices, particularly given the finding of Wang, Rojas, and Colantuoni (2016), that obese consumers are more likely to purchase large amounts of soda when it is on sale. If consumers are purchasing beverages before a soda tax takes effect and storing them for future consumption, then the increase in purchasing we observe does not imply increased consumption, only rational consumption smoothing. To investigate, we re-estimate the main specification for purchases which are unlikely to represent purchases made with the intent of storage for later use and consumption – purchases in which a single soda or SSB was purchased at a time, and in a volume of 16 ounces or less. These estimations are found in online appendix tables A6 and A7. We do not observe reactance consumption shifts for this small subset of purchases, leaving open the possibility that intertemporal substitution by consumers may explain some of the observed shifts in consumption.

In the absence of data on household beverage inventories or actual consumption, we address this possibility using testable implications from consumer inventory models (for an example of a recent model see Hendel & Nevo 2006). In an inventory model, consumers facing price uncertainty optimize by storing some of the purchased good for future consumption. There are two key predictions of these models that have been used to empirically investigate potential *stockpiling* – or purchasing and storing goods for later consumption (see the applications of Hendel & Nevo 2006; Boizot, Robin & Visser 2001). First, if a household has purchased and stored beverages, it may choose to consume product on hand rather than to purchase new products. This means that, all else being equal, after stockpiling consumers will wait longer than they usually do to purchase more of the beverage. The second testable prediction is that the quantity of beverages purchased should decrease when consumers face relatively higher prices (like after the implementation of a tax). Therefore to investigate potential stockpiling for households in Alameda County we compare the first beverage-purchasing trip made after the implementation of the tax with the average beverage-purchasing trip made by households. If household purchasing volume relatively decreases in the trip immediately following tax implementation, this is evidence of consumer stockpiling in the previous periods. If households wait longer than usual to make their next purchase following the implementation of the tax, this is evidence of stockpiling. In table 6, we summarize the household purchasing patterns of households living in Alameda county around the time in which the tax was implemented. As seen in table 6, we do not find evidence consistent with either testable prediction of stockpiling following the vote for Measure D in Berkeley.

[Insert table 6 here]

First, for Alameda households' purchases of both SSBs and soda, we cannot reject the null hypothesis that the mean length of time that elapses between households' last pre-tax purchase and their first taxable purchase is equal to the mean length of time between beverage purchases. This is inconsistent with the first testable implication of household stockpiling – that households will wait longer to make new purchases following the tax as they substitute to inventory-based consumption. We also do not find evidence that following the implementation of the tax households decreased the volume of their purchases in favor of consuming stored beverages. For SSBs, we cannot reject the null hypothesis that households' average purchasing volume is equal to the average volume of soda purchased during households' first trip following the tax. For soda, we find that the average volume purchased on households' first shopping trip following the implementation of the tax is statistically significantly *greater* (p-value = 0.017) than households' average purchasing volume. This is inconsistent with the second testable prediction of consumer inventory models.

We may also be concerned that promotional behavior on the part of stores is driving the observed consumption shifts, rather than a household-level consumer response. To investigate potential supply-side effects, we estimate the main specification for purchases of soda and SSBs which were made as part of a store promotion (online appendix tables A4 and A5). We do see consumption shifts in these purchases associated with living in Alameda County after the vote (significant increases of 4.11 ounces of SSBs and 3.53 ounces of soda), but of a smaller magnitude than that of the overall consumption shifts following the vote. Further, the proportion of soda and SSB purchases made as part of a

promotion does not interact with household consumption-type, nor does it shift substantially before and after the soda tax vote (the percentage of soda purchases made as part of a promotion shifts from 9.01% before the tax to 8.65% after the tax; the percentage of SSB purchases made as part of a promotion shifts from 17.10% before the tax to 16.09% after the tax).

An additional concern is that the shifts we observed would have occurred regardless of the soda tax vote, or may represent some general trend in beverage consumption. Therefore, we re-estimate the main specification for no-sugar-added juice (see table 7), a beverage which would not have been subject to the tax, supposing that if this were the case, we would likely observe similar effects in the purchase of these goods.

[Insert table 7 here]

We find no evidence of consumption shifts following the soda tax vote in juice purchases. Thus, the impact appears to be unique to soda and SSB purchases, consistent with the tax driving reactance based purchases.

Finally, we may be concerned that the consumption shifts we observe following the soda tax vote capture the effect of some co-occurring seasonal event. As an additional robustness check, we re-estimate the main specification for both SSBs and soda using a placebo date exactly one year earlier than the date of the Measure D vote - November 13th, 2013. Since no event related to SSB consumption occurred on this date, we should not expect to see reactance-motivated shifts in consumption. Indeed, despite being extremely well-powered we find no statistically significant evidence of increases in consumption of either beverage category by households in Alameda County following

the placebo date, nor do we find evidence of interactions between the placebo date and being a high-consuming household. The results of these estimations can be found in online appendix tables A8 and A9.

A Comment on the Selection Inherent in the Berkeley Soda Tax

Along many dimensions, the population of Berkeley, California is atypical of the United States (hence the nickname "The People's Republic of Berkeley"). Demographic summary statistics from the Census Bureau for the cities of Berkeley, CA, San Mateo, CA, and the United States are shown in table 8. Related demographic summary statistics from our sampled Nielsen households in Alameda County, San Mateo County, and the United States are available in table A3 of the online appendix. The demographic characteristics most likely to predict soda consumption – low-income status, male gender, and being African-American (Rehm *et al.* 2008) – are under-represented in Berkeley relative to the broader population of the United States. In addition, the modal household in both Alameda and San Mateo Counties drinks zero ounces of soda in a month. The modal household across the United States, in contrast, consumes 67.6 ounces of soda in a month in our sample. Likewise, the modal households in Alameda and San Mateo Counties consume 32.0 ounces and 8.4 ounces of sugar-sweetened beverages respectively. In the entire sample, this statistic is 131.6 ounces.

These summary statistics illustrate a simple point – since laws enacted through referenda reflect the majority view of local voters, we are likely to observe sugar-sweetened beverage excise taxes voted into law in places where the demand for these beverages is already low.

If the impetus for such taxes is to address the public health concerns associated with high levels of sugar-sweetened beverage consumption, local excise taxes are likely to be an ineffective tool with which to accomplish this goal. First, implementing the tax requires a voting base that is willing to implement the tax; this is unlikely to occur in populations that are heavy users of SSBs. Second, the impact of the tax on consumption is primarily concentrated among those who are relatively light consumers of SSBs. Thus, it would be unwise to extrapolate any local effect of the Berkeley soda tax to the general population when considering public health goals.

[Insert table 8 here]

Conclusion

Using a nationally representative sample of 77,976,307 household purchases, we find evidence that immediately after the passage of Measure D – an excise tax on sugar-sweetened beverage (SSB) purchases in the city of Berkeley, California – some local households *increased* the volume of their soda and sugar-sweetened beverage consumption. We find statistically significant evidence that immediately following the tax, households living in Alameda County increased their consumption of sugar-sweetened beverages by 8.89 ounces relative to other households in the United States. Estimating the same specification for soda, we find that households living in Alameda County increased their consumption of soda by 26.56 ounces relative to the United States population and by 37.15 ounces relative to residents of San Mateo, a neighboring county. Consistent with reactance, we find statistically significant evidence that being a high-SSB-consuming-household positively interacts with the consumption shift in sugar-sweetened beverages.

While we cannot exclude a role for intertemporal substitution, these effects are not fully explained by store promotions, are not consistent with the testable predictions of consumer inventory models, do not occur following a placebo date, and they do not occur in San Mateo County, a neighboring county in which no SSB-tax vote was held (where we should therefore not expect to observe reactance). We also do not observe these shifts for no-sugar-added juice, a related beverage which is not subject to the tax and for which we should not observe reactance-driven consumption increases. Finally, these results are not affected by the inclusion of a campaign dummy, which is defined for the advertisement-intensive period preceding the tax.

When paired with our finding that, consistent with Sharma *et al*. (2014), Finkelstein *et al*. (2013), and Gustavsen and Rickertsen (2011), high SSB-consuming households are less price sensitive than low-SSB-consuming households; our results suggest that high-SSB-consuming populations may disproportionately bear the tax burden from an excise tax on SSBs (though this may be offset by health benefits gained). Elasticity asymmetries between high-SSB- and low-SSB-consumers present retailers with an opportunity for price discrimination. An important question for future work is to explore the dynamic response of retailers to a soda tax in the presence of heterogeneous consumers.

Our work differs from the work of others exploring the Berkeley tax on SSBs along two key dimensions. The first point of difference is methodological. Unlike previous studies of the impact of the Berkeley SSB tax on consumption that use in-person cross-sectional survey methods (Falbe *et al.* 2016) and retailer-level data (Taylor *et al.* 2016; Cawley & Frisvold 2016), our use of a large set of household-level panel data allows us to explore the role of heterogenous consumption-types on responses to the soda tax vote. Since we

find evidence of differing elasticities and consumption responses by consumption-type, this distinction is an important one. The second point of difference is one of scope. We estimate consumption shifts which occur after the vote, but prior to the implementation of the tax and are therefore likely to be short-term effects. This contrasts with the work of Falbe *et al*. who study the impact of the tax on consumption patterns following the implementation of the tax itself, and with the work of Taylor *et al*. who explore the impact of the advertising campaign preceding the Measure D vote on consumption.

The policymaker's ultimate goal of decreasing the incidence of SSB-related health risks may be addressed through any of a menu of policy tools, each with different degrees of invasiveness. This toolkit includes nudges, anti-soda advertising campaigns, soda bans, and warning labels among other policies. When addressing SSB-related health risks, we encourage policymakers to consider the invasiveness of the policy tool itself in addition to the explicit price incentives it provides.

References

Andreyeva, T., M.W. Long, and K.D. Brownell. 2010. "The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food." *American Journal of Public Health* 100 (2): 216–22.

Boizot, C., J.-M. Robin, and M. Visser. 2001. "The Demand for Food Products: An Analysis of Interpurchase Times and Purchased Quantities." *The Economic Journal* 111 (470): 391–419.

Brownell, K.D., T. Farley, W.C. Willett, B.M. Popkin, F.J. Chaloupka, J.W. Thompson, and D.S. Ludwig. 2009. "The Public Health and Economic Benefits of Taxing Sugar-Sweetened Beverages." *New England Journal of Medicine* 361 (16): 1599–1605.

Cacioppo, J.T., and R.E. Petty. 1979. “Effects of Message Repetition and Position on Cognitive Response, Recall, and Persuasion.” *Journal of Personality and Social Psychology* 37 (1): 97–109.

Calder, B.J., and B. Sternthal. 1980. “Television Commercial Wearout: An Information Processing View.” *Journal of Marketing Research* 17 (2): 173–86.

Colchero, M.A., J. C. Salgado, M. Unar-Munguia, M. Hernandez-Avila, and J. A. Rivera-Dommarco. "Price elasticity of the demand for sugar sweetened beverages and soft drinks in Mexico." *Economics & Human Biology* 19 (2015): 129-137.

Deaton, A. 1988. “Quality, Quantity, and Spatial Variation of Price.” *The American Economic Review* 78 (3): 418–30.

Deaton, A., and J. Muellbauer. 1980. “An Almost Ideal Demand System.” *The American Economic Review* 70 (3): 312–26.

Debnam, J., and D.R. Just. 2017. “Endogenous Responses to Paternalism: Examining Psychological Reactance in the Lab and the Field.” *Working Paper.*

Dharmasena, S., and O. Capps. 2012. “Intended and Unintended Consequences of a Proposed National Tax on Sugar-Sweetened Beverages to Combat the U.S. Obesity Problem.” *Health Economics* 21 (6): 669–94.

Einav, L., Leibtag E., and A. Nevo. 2008. “On the Accuracy of Nielsen Homescan Data.” *ERR-69, U.S. Dept. of Agriculture, Economic Research Service*.

Etilé, F., and A. Sharma. 2015. “Do High Consumers of Sugar-Sweetened Beverages Respond Differently to Price Changes? A Finite Mixture IV-Tobit Approach.” *Health Economics* 24 (9): 1147–63.

Falbe, J., H.R. Thompson, C.M. Becker, N. Rojas, C.E. McCulloch, and K.A. Madsen. 2016. "Impact of the Berkeley Excise Tax on Sugar-Sweetened Beverage Consumption." *American Journal of Public Health* 106 (10): 1865–71.

Finkelstein, E.A., C. Zhen, M. Bilger, J. Nonnemaker, A.M. Farooqui, and J.E. Todd. 2013. "Implications of a Sugar-Sweetened Beverage (SSB) Tax When Substitutions to Non-Beverage Items Are Considered." *Journal of Health Economics* 32 (1): 219–39.

Fletcher, J.M., D.E. Frisvold, and N. Tefft. 2010. "The Effects of Soft Drink Taxes on Child and Adolescent Consumption and Weight Outcomes." *Journal of Public Economics* 94 (11–12): 967–74.

Guerrero-López, C.M., M. Unar-Munguía, and M.A. Colchero. 2017. "Price Elasticity of the Demand for Soft Drinks, Other Sugar-Sweetened Beverages and Energy Dense Food in Chile." *BMC Public Health* 17: 180.

Gustavsen, G.W., and K. Rickertsen. 2011. "The Effects of Taxes on Purchases of Sugar-Sweetened Carbonated Soft Drinks: A Quantile Regression Approach." *Applied Economics* 43 (6): 707–16.

Heien, D., and C.R. Wessells. 1990. "Demand Systems Estimation with Microdata: A Censored Regression Approach." *Journal of Business & Economic Statistics* 8 (3): 365–71.

Hendel, I., and A. Nevo. 2006. "Sales and Consumer Inventory." *The RAND Journal of Economics* 37 (3): 543–61.

Just, D.R., and A.S. Hanks. 2015. "The Hidden Cost of Regulation: Emotional Responses to Command and Control." *American Journal of Agricultural Economics* 97 (5): 1385–99.

Kuchler, F., A. Tegene, and J.M. Harris. 2005. "Taxing Snack Foods: Manipulating Diet Quality or Financing Information Programs?" *Review of Agricultural Economics* 27 (1): 4–20.

Liebman, M., S. Pelican, S.A. Moore, B. Holmes, M.K. Wardlaw, L.M. Melcher, A.C. Liddil, L.C. Paul, T. Dunnagan, and G.W. Haynes. 2003. "Dietary Intake, Eating Behavior, and Physical Activity-Related Determinants of High Body Mass Index in Rural Communities in Wyoming, Montana, and Idaho." *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity* 27 (6): 684–92.

Ma, J., P.F. Jacques, J.B. Meigs, C.S. Fox, G.T. Rogers, C.E. Smith, A. Hruby, E. Saltzman, and N.M. McKeown. 2016. "Sugar-Sweetened Beverage but Not Diet Soda Consumption Is Positively Associated with Progression of Insulin Resistance and Prediabetes." *The Journal of Nutrition* 146 (12): 2544–50.

Mazis, M.B., R.B. Settle, and D.C. Leslie. 1973. "Elimination of Phosphate Detergents and Psychological Reactance." *Journal of Marketing Research* 10 (4): 390–95.

Nakhimovsky, S.S., A.B. Feigl, C. Avila, G. O'Sullivan, E. Macgregor-Skinner, and M. Spranca. 2016. "Taxes on Sugar-Sweetened Beverages to Reduce Overweight and Obesity in Middle-Income Countries: A Systematic Review." *PLOS ONE* 11 (9): e0163358.

Pennebaker, J.W., and D.Y. Sanders. 1976. "American Graffiti: Effects of Authority and Reactance Arousal." *Personality and Social Psychology Bulletin* 2 (3): 264–67.

Petty, R.E., J.T. Cacioppo, and D. Schumann. 1983. "Central and Peripheral Routes to Advertising Effectiveness: The Moderating Role of Involvement." *Journal of Consumer Research* 10 (2): 135–46.

Rehm, C.D., T.D. Matte, G. Van Wye, C. Young, and T.R. Frieden. 2008. "Demographic and Behavioral Factors Associated with Daily Sugar-Sweetened Soda Consumption in New York City Adults." *Journal of Urban Health: Bulletin of the New York Academy of Medicine* 85 (3): 375–85.

Sharma, A., K. Hauck, B. Hollingsworth, and L. Siciliani. 2014. "The Effects of Taxing Sugar-Sweetened Beverages Across Different Income Groups." *Health Economics* 23 (9): 1159–84.

Taylor, R., S. Kaplan, S.B. Villas-Boas, and K. Jung. 2016. "Soda Wars: Effect of a Soda Tax Election on Soda Purchases." *eScholarship*, December. http://escholarship.org/uc/item/0q18s7b7.

U.S. Census Bureau. "Population Estimates, July 1, 2015, (V2015)." http://www.census.gov/quickfacts/table/PST045215/0606000 (accessed November 13, 2016).

Wang, E., C. Rojas, and F. Colantuoni. 2017. "Heterogeneous Behavior, Obesity, and Storability in the Demand for Soft Drinks." *American Journal of Agricultural Economics* 99 (1): 18–33.

World Health Organization. *Report of the Commission on Ending Childhood Obesity*. Geneva: World Health Organization, 2010.

Zhen, C., E.A. Finkelstein, J.M. Nonnemaker, S.A. Karns, and J.E. Todd. 2014. "Predicting the Effects of Sugar-Sweetened Beverage Taxes on Food and Beverage Demand in a Large Demand System." *American Journal of Agricultural Economics* 96 (1): 1–25.

Zhen, C., M.K. Wohlgenant, S. Karns, and P. Kaufman. 2011. "Habit Formation and Demand for Sugar-Sweetened Beverages." *American Journal of Agricultural Economics* 93 (1): 175–93.

Zheng, Y., E.W. McLaughlin, and H.M. Kaiser. 2013. "Taxing Food and Beverages: Theory, Evidence, and Policy." *American Journal of Agricultural Economics* 95 (3): 705–23.

Table 1. Summary Statistics of Households by Household Consumption-Type

	High-SSB-Households	Low-SSB-Households
Number of Household-Purchasing Weeks	889,362	1,510,535
Household Size	2.596 (.001)	2.476 (.001)
Income	$63,609.62 (559.011)	$63,971.99 (324.922)
No Male Household Head	1,206 (21.32%)	4,397 (26.04%)
Male Household Head Less than High School	254 (4.49%)	559 (3.31%)
Male Household Head High School	1,225 (21.66%)	3,036 (17.98%)
Male Household Head Some College	1,304 (23.06%)	3,626 (21.47%)
Male Household Head College	1,208 (21.36%)	3,706 (21.94%)
Male Household Head Graduate School	459 (8.12%)	1,564 (9.26%)
No Female Household Head	566 (10.01%)	1,533 (9.08%)
Female Household Head Less than High School	133 (2.35%)	379 (2.24%)
Female Household Head High School	1,298 (22.95%)	3,299 (19.53%)
Female Household Head Some College	1,539 (27.21%)	4,877 (28.88%)
Female Household Head College	1,572 (27.79%)	4,925 (29.16%)

Female Household Head	548 (9.69%)	1,875 (11.10%)
Graduate School		
Married	3,705 (65.51%)	10,371 (61.41%)
Widowed	259 (4.58%)	1,126 (6.67%)
Divorced/Separated	777 (13.74%)	2,652 (15.70%)
Single	915 (16.18%)	2,739 (16.22%)
White/Caucasian	4,709 (83.26%)	13,618 (80.64%)
Black/African American	550 (9.72%)	1,761 (10.43%)
Asian	115 (2.03%)	653 (3.87%)
Other	282 (4.99%)	856 (5.07%)
Hispanic	348 (6.15%)	1,089 (6.45%)
Non-Hispanic	5,308 (93.85%)	15,799 (93.55%)

Note: For income and household size, standard errors are given in parentheses. Nielsen records household income as categorical ranges. We recode these as continuous variables by defining each household's income as the median of the income range which they report, save for the lower ($0 - $5,000) and upper bound ($100,000 +) categories which we recode as $5,000 and $150,000 respectively.

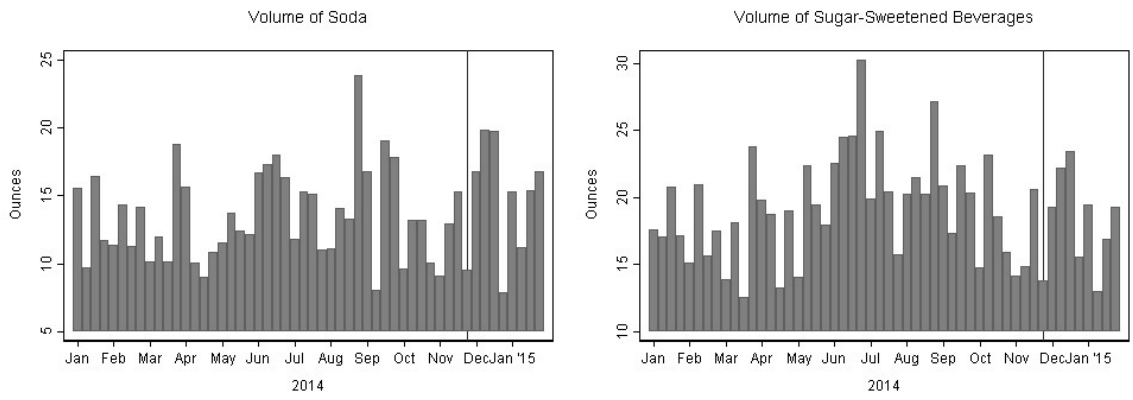
Table 2. Consumption Summary Statistics by Household Consumption-Type

Variables	Low-SSB Households	High-SSB Households	All Households
Consumption (ounces/quarter)			
All SSBs	557.24	1450.35	889.96
Low-Calorie Carbonated SSBs	*152.12*	*462.51*	*267.75*
Full-Calorie Carbonated SSBS	*195.71*	*519.21*	*316.22*
Non-Carbonated SSBs	*209.42*	*468.64*	*305.99*
Tea & Other Infusions	62.35	109.30	79.84
Coffee	24.77	30.44	26.88
Milk	485.09	641.68	543.43
No-Sugar-Added Fruit Juice	128.49	161.33	140.72
Bottled Water	296.68	490.00	368.70
Budget Share			
All SSBs	.334	.504	.398
Low-Calorie Carbonated SSBs	*.094*	*.180*	*.126*
Full-Calorie Carbonated SSBS	*.118*	*.185*	*.143*
Non-Carbonated SSBs	*.122*	*.139*	*.129*
Tea & Other Infusions	.045	.043	.045
Coffee	.134	.092	.119
Milk	.283	.207	.254

No-Sugar-Added Fruit Juice	.123	.086	.109
Bottled Water	.080	.067	.075
Number of Household Quarters	186,023	110,444	296,467

Table 3. Uncompensated Price Elasticities by Household-Type

	Low-SSB Household	High-SSB Household
All SSBs		
Low-Calorie Carbonated SSBs	-1.749	-1.378
Full-Calorie Carbonated SSBS	-1.400	-1.318
Non-Carbonated SSBs	-1.154	-1.149
Tea & Other Infusions	-.950	-.952
Coffee	-1.149	-1.220
Milk	-1.176	-1.166
No-Sugar-Added Fruit Juice	-1.172	-1.232
Bottled Water	-1.232	-1.226



Note: The vertical line indicates the date of the passage by referendum of Measure D – an excise tax on sugar-sweetened beverages in the city of Berkeley, California.

Figure 1: Mean Household Consumption of Soda and Sugar-Sweetened Beverages by Residents of Alameda County during 2014

Table 4. Estimation of Main Specification for All Sugar-Sweetened Beverages (oz.)

	U.S. Households		Alameda and San Mateo County Households	
	(1)	(2)	(3)	(4)
After Vote	17.626***	25.544****	3.290	8.450
	(5.492)	(5.525)	(32.831)	(32.821)
Time Trend X	-0.079****	-0.082****	-0.072	-0.071
After Vote	(0.020)	(0.020)	(0.118)	(0.117)
Alameda County X	8.892**	-1.246	8.145	1.020
After Vote	(4.045)	(4.231)	(8.303)	(8.880)
Time Trend X After Vote		-15.038****		-16.889
X Hi-SSB-Household		(1.509)		(17.591)
Alameda County X		23.694**		21.773
After Vote X Hi-SSB-Household		(9.273)		(19.603)
Constant	148.001****	147.571****	103.332****	103.318****
	(1.258)	(1.249)	(7.322)	(7.316)
Time Trend/Seasonal Controls	YES/YES	YES/YES	YES/YES	YES/YES

Observations	2399897	2399897	60577	60577

Note: Standard errors given in parentheses. Double asterisk (**), triple asterisk (***), and quadruple asterisk (****) denote variables significant at 5%, 1% and .1% respectively.

Table 5. Estimation of Main Specification for All Soda Purchases (oz.)

	U.S. Households		Alameda and San Mateo County Households	
	(1)	(2)	(3)	(4)
After Vote	16.225	23.964**	-29.329	-16.912
	(11.271)	(11.333)	(62.795)	(61.699)
Time Trend X	-0.070	-0.072	-0.000	-0.005
After Vote	(0.041)	(0.041)	(0.223)	(0.222)
Alameda County X	26.556****	17.081**	37.149**	25.884
After Vote	(7.584)	(7.707)	(16.676)	(16.629)
Time Trend X After Vote		-19.742****		-61.579
X Hi-Soda-Household		(3.711)		(50.357)
Alameda County X		27.355		62.384
After Vote X Hi-Soda-Household		(19.441)		(52.418)
Constant	251.204****	250.936****	169.649****	169.405****
	(2.748)	(2.736)	(14.120)	(14.065)
Time Trend/Seasonal	YES/YES	YES/YES	YES/YES	YES/YES

Controls				
Observations	1822692	1822692	57118	57118

Note: Standard errors given in parentheses. Double asterisk (**), triple asterisk (***), and quadruple asterisk (****) denote variables significant at 5%, 1% and .1% respectively.

Table 6. Purchasing Patterns of Alameda County Households Following Regular Purchases, Promotional Purchases, and Purchases Made During the Week of Soda Tax Vote

	Sugar-Sweetened Beverages			Soda		
	Any Purchase	Sale Purchase	First Purchase Following Tax Implementation	Any Purchase	Sale Purchase	First Purchase Following Tax Implementation
Average Quantity of Purchase (oz.)	104.797	96.708	120.836	89.173	103.302	137.936
	(6.080)	(4.420)	(38.653)	(4.375)	(5.325)	(43.923)
Average Days Since Previous SSB Purchase	61.772	53.722	62.754	81.071	70.100	65.857
	(5.385)	(6.016)	(4.881)	(6.489)	(6.070)	(5.638)

Note: Standard errors given in parentheses. "Sale" purchases are those indicated by Nielsen respondents as having been made as part of a store promotion. A purchase is defined as "First Purchase Following Tax Implementation" if it is the household's first SSB purchase since the tax was implemented on March 1, 2015. For regular price purchases and sale price purchases, "Average Days Since Previous SSB Purchase" indicates the average number of days, across households, that a household waits after making an SSB purchase of any kind until making the indicated type of SSB purchase. For the columns "First Purchase Following Tax Implementation", this indicates the average number of days that have elapsed between

households' first purchase following the tax implementation and their most recent SSB purchase before the implementation of the tax.

Table 7. Estimation of Main Specification for Fruit Juice Purchases (oz.)

	U.S. Households		Alameda and San Mateo County Households	
	(1)	(2)	(3)	(4)
After Vote	3.680	5.018**	-11.417	-11.312
	(2.098)	(2.116)	(10.495)	(10.278)
Time Trend X	-0.017**	-0.018**	0.036	0.037
After Vote	(0.008)	(0.008)	(0.038)	(0.038)
Alameda County X	-3.407	-5.828**	-1.546	-3.138
After Vote	(1.765)	(2.273)	(3.457)	(3.746)
Time Trend X After Vote		-2.545****		-0.764
X Hi-Soda-Household		(0.571)		(7.494)
Alameda County X		5.970		4.503
After Vote X Hi-Soda-Household		(3.583)		(8.291)
Constant	53.106****	53.029****	50.972****	50.999****
	(0.458)	(0.457)	(2.758)	(2.756)

Time Trend/Seasonal Controls	YES/YES	YES/YES	YES/YES	YES/YES
Observations	2399897	2399897	60577	60577

Note: Standard errors given in parentheses. Double asterisk (**), triple asterisk (***), and quadruple asterisk (****) denote variables significant at 5%, 1% and .1% respectively.

Table 8. Berkeley Household, California Household and Other Household Summary Statistics

	City of Berkeley, California	City of San Mateo, California	United States
Race and Hispanic Origin			
White	59.5%	57.8%	72.4%
Black or African American	10.0%	2.4%	12.6%
Asian	19.3%	18.9%	4.8%
Hispanic or Latino	10.8%	26.6%	16.3%
Female	51.1%	51.2%	50.8%
Education			
High school graduate or higher	95.5%	88.9%	86.3%
Bachelor's degree or higher	70.2%	45.4%	29.3%
Income			
Median value of owner-occupied housing	$719,500	$736,600	$175,700
Median household income (in 2014 dollars)	$65,283	$90,087	$53,482
Per capita annual income (in 2014 dollars)	$42,406	$46,782	$28,555
Population	120,972	103,536	321,418,820

Note: United States Census Bureau Estimates retrieved from QuickFacts in November of 2016. The demographic trends across these geographic regions are preserved in the Nielsen Homescan data set used for the empirical analysis, but the Nielsen sample is consistently better educated and wealthier.

[1] Sugar-sweetened infant formula, drinks for medical or weight-loss use, and drinks containing milk as the primary ingredient or alcohol are exempt from the tax.

[2] As a robustness check, we replicate the demand analyses for high-soda-consuming and low-soda-consuming households. Our main findings hold.