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THE INCIDENCE OF TAXES ON SUGAR-SWEETENED BEVERAGES: THE CASE OF BERKELEY, CALIFORNIA

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ABSTRACT

One of the most commonly-proposed policies to address the high prevalence of obesity is a tax on energy-dense foods, in particular sugar-sweetened beverages (SSBs). This is based on the assumption that such taxes are largely passed through to consumers in the form of higher retail prices, leading to reduced consumption. However, relatively little is known about the extent to which taxes on SSBs are in fact passed through to consumers.

We estimate the pass-through of the first city-level tax on SSBs in the U.S., which was enacted by the voters of Berkeley, California in November, 2014. We collected the prices of various brands and sizes of SSBs and other beverages before and after the implementation of the tax from a near-census of convenience stores and supermarkets in Berkeley, California. We also collected prices from stores in a control city: San Francisco, where in 2014 a similar voter referendum failed despite majority support.

Estimates from difference-in-differences and other models consistently indicate that there was relatively little pass through of the Berkeley SSB tax to consumers; across brands and sizes, we estimate that retail prices rose by less than half of the amount of the tax. This is in contrast to much of the previous literature on the pass-through of taxes, which tended to find full or even overshifting of taxes.

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Introduction

This paper estimates the extent to which taxes on sugar-sweetened beverages (SSBs) are passed through to consumers in the form of higher prices. We examine data from Berkeley, California, where voters passed a ballot measure instituting such a tax in November, 2014, and compare it to data from the city of San Francisco, which is a suitable control because it is geographically proximate and had a similar ballot measure in 2014 that also had majority support but failed to reach the two-thirds supermajority needed to pass. Advocates of the Berkeley tax argued that it would be fully passed on to consumers in the form of higher prices, thereby reducing consumption.[2]

The incidence or shifting of excise and sales taxes is a classic topic in public finance. Although policymakers and the media often emphasize the party on whom the tax is levied, economists have long recognized that in a perfectly competitive market who actually pays the tax is determined by the relative elasticities of supply and demand (see, e.g. Weyl and Fabinger, 2013; Fullerton and Metcalf, 2002; Anderson et al., 2001). In a competitive market, if the supply curve is upward sloping and the demand curve is downward sloping (the standard Marshallian cross), then the tax is undershifted; price rises by less than the tax. The more inelastic the demand, the greater the extent to which taxes are passed through to prices. At the extreme, if demand is perfectly inelastic (or supply is perfectly elastic), then the tax will be fully shifted to consumers; see Kotlikoff and Summers (1987). If the market is imperfectly competitive, then taxes could be undershifted, perfectly shifted, or even overshifted (i.e. the retail price could increase by an amount greater than the tax). Bonnet and Requillart (2013) argue that oligopolists

[2] The webpage of the group "Berkeley vs. Big Soda" argues that the tax would reduce consumption, citing as evidence Wang et al. (2012), which assumes that a penny-per-ounce tax on SSBs would be fully passed on to consumers. Even after the tax was implemented advocates have stated that it was largely or fully passed through to consumers (e.g. Brownell, 2015).

may undertake strategic pricing changes in response to a tax that result in it being overshifted to consumers.

Previous empirical research on the pass-through of sales and excise taxes has tended to find that such taxes are fully shifted to consumers, if not overshifted (DeCicca et al., 2013; Alm et al., 2009; Kenkel, 2005; Besley and Rosen, 1999; Poterba, 1996). A few studies have found that taxes are less than fully shifted, in the range of 45-85% (Harris et al., 2015; Harding et al., 2012; Doyle and Samphantharak, 2008).

There are few studies of the pass-through of taxes on SSBs in particular (as opposed to general sales taxes that also apply to SSBs).[3] Three working papers estimate the pass-through of taxes on SSBs in Mexico, France, and Denmark. Grogger (2015) examines how retail prices responded to a nationwide one-peso-per-liter tax on SSBs that was implemented in Mexico in 2014. He examines data on prices from 46 cities that were used to calculate the Mexico Consumer Price Index; only city-level average prices were available. Lacking a geographic control group, Grogger (2015) estimates the change in prices within Mexico before and after the tax and concludes that the tax was overshifted; the tax of roughly 9 percent raised the price of caloric soda by 12 percent.

Berardi et al. (2012) estimate the impact of the French tax on soda of 7.16 euros per hectoliter (or roughly 11 euro cents per 1.5 liters) that took effect January 1, 2012. They use detailed data from 800 supermarkets that participated in a novel form of shopping in which customers order their groceries through the internet but then go in person to pick up their items; although fewer items may be available, they are sold at the same price as in the supermarket.

[3] A growing literature estimates the price elasticity of demand for SSBs (see, e.g., the review in Cabrera Escobar et al., 2013). When speculating on the impact of taxes on consumption or weight, these studies typically assume that the tax is fully shifted to consumers. Fletcher, Frisvold, and Tefft (2010a) directly estimate the impact of state taxes on soft drink consumption and find that they reduce youth consumption. These estimates imply that the taxes were at least partly shifted to consumers, but the pass-through rate was not directly estimated.

They examine data from August 2011 to July 2012, using only the most frequently-observed price in each month for each product in each store. They estimate difference-in-differences models, estimating the change before and after the tax in the price of beverages subject to the tax and exempt from the tax. They find that, for soda, the tax was fully shifted to prices by the fourth month of the tax.

Bergman and Hansen (2012) estimate the pass-through that resulted from three tax changes to SSBs in Denmark: tax hikes in 1998 (of 0.2 DKK per liter) and 2001 (of 0.65 DKK per liter) and a tax cut in 2003 (of 0.50 DKK per liter). The authors examine micro price data at the item-chain level that are used by Statistics Denmark to create the Danish Consumer Price Index. Lacking a geographic control group, they estimate the change in prices over time in Denmark and estimate that both tax hikes were over-shifted to consumers; their estimates indicate a pass-through of at least 200%. The tax cut, however, was undershifted to consumers.

Although Besley and Rosen (1999) examine the shifting of sales taxes, not excise taxes on SSBs in particular, one of the 12 commodities they examined was a one-liter bottle of Coca-Cola. They estimate that sales taxes were overshifted for that item, which they interpret as consistent with imperfectly competitive retail grocery markets.

Another consistent finding from the previous literature is that the shifting of taxes to consumers happens quickly. Grogger (2015) finds that prices responded to the soda tax in the month that the tax took effect, Berardi et al. (2012) found that the French tax was fully shifted by the fourth month, Besley and Rosen (1999) find the shifting of sales taxes occurred by the next quarter (the frequency of their data), and Alm et al. (2009) find that gasoline excise taxes are shifted to consumers “almost instantly” (Ibid, p. 118).

The category of products we examine – sugar-sweetened beverages (SSBs) – is of particular interest because there have been many calls for taxes on such products in response to the high prevalence of obesity and related diseases such as Type II diabetes and heart disease (see, e.g. World Health Organization, 2015; U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2015; British Medical Association, 2015; Institute of Medicine, 2009; Brownell and Frieden, 2009, and Jacobson and Brownell, 2000). As a result, taxes on SSBs have been implemented in Australia (2000), Fiji (2006), Nauru (2007), Finland (2011), Hungary (2011), France (2012), and Mexico (2014); see e.g. World Health Organization (2015) and Thow et al. (2011). In the U.S. as of January 1, 2014, 34 states and the District of Columbia apply sales taxes to SSBs sold in stores (Chriqui et al., 2014).[4] Public health officials recognize that the success of such taxes in reducing consumption of SSBs depends on the tax being passed through to consumers in the form of higher prices (Sassi et al., 2013).

We examine the first and only tax on SSBs by a city in the United States. This tax, in Berkeley, California[5], is levied in the amount of one cent per ounce on sweetened beverages, which includes soda, energy drinks, and presweetened tea, but specifically excludes infant formula, alcoholic beverages and milk products.[6] The tax is levied on distributors.

The tax in Berkeley passed by public referendum (it is sometimes still referred to as "Measure D" based on its placement on the ballot) on November 4, 2014. It passed with 76.17%

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[4] In 20 states, the sales tax on SSBs sold through food stores were higher than the sales tax on food generally. Interestingly, states tax diet soda at the same rate as caloric soda (Chriqui et al., 2014); historically, the primary purpose of these taxes has been to raise revenue, not incentivize healthy diets or internalize externalities (Fletcher, Frisvold, and Tefft, 2010b).

[5] Berkeley, California is a city in Northern California, located northeast of San Francisco. Its population, which was 116,768 in 2013, is 59.5% white, 10.0% African-American, and 19.3% Asian, with 10.8% Hispanic or Latino (who could be of white or African-American race); see U.S. Census (2015). Its area is 10.47 square miles (Ibid).

[6] The exact wording was: Shall an ordinance imposing a 1¢ per ounce general tax on the distribution of high-calorie, sugary drinks (e.g., sodas, energy drinks, presweetened teas) and sweeteners used to sweeten such drinks, but exempting: (1) sweeteners (e.g., sugar, honey, syrups) typically used by consumers and distributed to grocery stores; (2) drinks and sweeteners distributed to very small retailers; (3) diet drinks, milk products, 100% juice, baby formula, alcohol, or drinks taken for medical reasons, be adopted?

voting yes after a bitter election campaign, with an estimated $2.5 million spent by soda manufacturers to defeat it, and an estimated $1 million spent by supporters (Dugdale, 2015).[7] Its passage was seen as a major victory for public health activists and a litmus test for future SSB taxes in other localities (Gagliardi, 2014; Abcarian, 2014). The tax was initially announced to take effect on January 1, 2015, but because of delays in implementation the first month that the tax was collected was March, 2015. It is slated to expire on December 31, 2026.

Based on prices before the tax took effect, the tax of one cent per ounce represents an average of an 11.0% tax on 20-oz. bottles, 30.8% tax on 2-liter bottles, and a 25.0% tax on a 12-pack of 12-oz. cans.[8] The tax is relatively smaller for 20 oz. bottles because of bulk discounts - SSBs are more expensive when bought in small quantities, so the flat one cent per ounce tax is a smaller percentage of the pretax price for a 20 oz. bottle than for larger quantities.

This paper offers numerous contributions to the literature. First, we collected longitudinal price data from a near-census of grocery stores, supermarkets, convenience stores, and pharmacies with posted prices in the treatment city. Many previous studies observe only average prices at the city level (e.g., Grogger, 2015; Besley and Rosen, 1999), but there can be substantial variation in prices within markets (see the discussion in DeCicca et al., 2013). Having a near-census of stores ensures that we are accurately measuring the changes in prices. Second, we collected data for a nearby and similar control city, which allows us to control for any shocks to SSB prices in that vicinity around the time of the tax. This is a contribution to the literature because all of the previous literature on the pass-through of excise taxes on SSBs has lacked a geographic control group. A particular strength of our approach is that our control

[7] Former New York City mayor Michael Bloomberg spent $657,000 promoting Measure D in Berkeley, and also spent $10 million to promote the tax on SSBs that took effect in Mexico in 2014 (Dinkelspiel, 2014).
[8] Authors' calculation based on December 2014 prices in Berkeley of regular (i.e. full calorie) Coke, Pepsi, and Mountain Dew in those sizes.

community also gave majority support to the same policy (an SSB tax), but it did not pass because a supermajority was required. Third, we collected data on close substitute products that were not taxed (diet versions of the SSBs), which allows us to control for trends in prices for this category of products in the same store over time. Fourth, we examine perfectly homogenous products, at the level of brand-item-size; thus, we avoid any variation in prices that could be due to differences in brand, quality, or other characteristics. Fifth, we estimate the pass-through separately for several sizes and quantities of SSBs, which is relevant because research on the pass-through of cigarette taxes found that the pass-through was lower on higher-volume sales, i.e. cartons (DeCicca et al., 2013), perhaps because more price elastic consumers bought in volume. Finally, we estimate tax pass-through for a category of products, SSBs, for which there have been many calls for higher taxes. These results are the first estimates of the pass-through of a city-level excise tax on SSBs in the United States; thus, our results are very policy relevant.

Data

Data were collected by hand from grocery stores, pharmacies, and convenience stores (both stand-alone and those in gas stations) in Berkeley, and San Francisco, California.[9] A list of stores was drawn from ReferenceUSA, which is a database of approximately 24 million U.S. businesses that is updated monthly. We attempted to collect data from the universe of such establishments in Berkeley and a similarly sized sample of those in San Francisco.[10] Prior to the

[9] We thank our research assistants, Natalie Veldhouse and Marcus Cassidy, for collecting the price data.

[10] More specifically, we created a list of all grocery stores, pharmacies, convenience stores, and gas stations with SIC codes 514105, 514110, 541103, 541105, 541107, 541108, 541109, 549948, 554101, and 591205 in Berkeley (zip codes: 94702, 94703, and 94704), San Francisco (zip codes: 94102, 94103, 94104, 94105, 94107, 94108, 94109, 94110, 94111, 94112, 94114, 94115, 94116 , 94117, 94118, 94121, 94122, 94123, 94124, 94127, 94129, 94130, 94131, 94132, 94133, 94134, and 94158). In Berkeley, 81 stores met these criteria. Of these listings, 22 were pharmacies and gas stations that did not sell soft drink products, 3 only sold specialty soft drinks, 3 were duplicate locations, 5 were closed locations, and 18 did not list prices on the items. This left 30 stores with at least one price for the products in our data collection in December and June. We randomly selected 123 stores from the

tax taking effect, we collected data on December 22, 2014 in Berkeley and December 21-27, 2014 in San Francisco. After the tax took effect, we collected another round of data on June 1, 2015 in Berkeley and May 31-June 3, 2015 in San Francisco.[11]

Research assistants entered each store and recorded prices for a wide variety of products and sizes.[12] For Coke, Diet Coke, Pepsi, Diet Pepsi, and Mountain Dew, they recorded prices for 20 oz. bottles, 2-liter bottles, and a 12-pack of 12-oz. cans. In addition, they recorded prices for 20 oz. bottles of Gatorade and Dasani water. For Red Bull, they recorded prices for an 8.4 oz. can and a 4-pack of such cans. They also recorded the price of a 16 oz. bottle of Snapple Iced Tea.

Distributions to stores with less than $100,000 annual receipts are exempt from the Berkeley tax. Based on the revenue data available in the ReferenceUSA database, no stores in our sample are exempt. Further, discussions with advocates of the tax told us that they thought that *no* stores qualified for the exemption. Thus, we assume that all of the stores from which we collected data were subject to the tax.

The data contain a balanced panel of stores. Not every product was available in every store, so the sample size varies by product size. For example, for a 20 oz. bottle of Coke, we have data for 24 stores in Berkeley both before and after the tax, as well as from 45 stores in San

San Francisco population, of which 23 did not sell soft drink products, 2 were duplicate locations, 7 were closed locations, and 26 did not list prices on the items. This left 56 stores with at least one price for the products in our data collection in December and June.

[11] Under the assumption that the tax would be implemented on January 1, 2015, as stated in the law, we also collected a round of data January 11-14, 2015. However, Berkeley subsequently announced that the first month for which SSB distribution would be taxed would be March 2015. Because the January data are neither clearly pre-tax nor post-tax (distributors may have been unsure at the time whether taxes would actually be collected), we dropped the January wave of data from our analysis.

[12] A subset of stores (18 in Berkeley and 26 in San Francisco) did not have posted prices and we thus lack data for these. Comparing data from ReferenceUSA, the stores that did not post prices were much smaller, with significantly fewer employees (3.8 versus 29.7 in Berkeley) and less than one-quarter the revenue. To put our lack of data for these stores into perspective, even low-income households buy the vast majority (78%) of their groceries at larger grocery stores and supermarkets (Alcott et al., 2015). Thus, our data for larger stores still reflect the prices paid in most (but not all) cases by lower-income individuals.

Francisco. 4-packs of Red Bull was the item we examine that was carried by the fewest stores: 13 in Berkeley and 17 in San Francisco. Sample sizes by product and city are listed in Table 1.

Methods

We examine two outcomes: the price (in cents) of the product, and the price (in cents) per ounce of the product. To identify the effect of the tax on prices, one must make assumptions about the counterfactual: the change in prices that would have occurred in the absence of the tax. An advantage of our data is that we can examine three counterfactuals for the change in price of taxed SSBs in Berkeley: 1) the change in price of the same product in San Francisco; 2) the change in price of the diet version of the same product in Berkeley; 3) the change in the relative price of regular versus diet of the same brand in San Francisco (this is a counterfactual for the change in the relative price of regular versus diet of a given brand in Berkeley).

Difference-in-Differences (DD) Model: Berkeley compared to San Francisco

We first assume that prices of the taxed items in Berkeley would have followed the same trend as prices of the same items in San Francisco. We estimate a difference-in-differences (DD) model to measure the relative change in price for each product after the implementation of the tax compared to before the tax, in the treatment city (Berkeley) compared to the control city (San Francisco):

$$\mathrm{P}_{st} = \alpha + \beta_t \mathrm{Post}_t + \beta_{DD} \mathrm{Post}_t {*} \mathrm{Treat}_s + \beta_{day} \mathrm{Day} + \beta_s \mathrm{Store}_s + \varepsilon_{st} \qquad (1)$$

where P_{st} denotes the dependent variable (either the price or the price per ounce of the product) in store *s* and time *t*. Our coefficient of interest is the difference-in-differences estimator β_{DD}; it is the coefficient on the interaction term Post*Treat, which equals one if the store was in Berkeley (as opposed to San Francisco) and if the price was measured after the tax was implemented. This measures the effect of the tax on prices after controlling for the general time trend in prices for that product. The indicator variable Post equals one if the price is from after the tax as opposed to before the tax. Store indicator variables control for time-invariant heterogeneity associated with each store. We also control for indicator variables for day of week. Models are estimated separately by product (Coke, Diet Coke, Pepsi, Diet Pepsi, Mountain Dew, Gatorade, Dasani, Red Bull, and Snapple Iced Tea) and by size (20 oz. bottle, 2 liter bottle, and 12 pack of 12 oz. cans).

We assume that San Francisco is a suitable control for Berkeley. Specifically, we assume that, had the tax not been implemented in Berkeley, its prices would have followed the same trend as those in San Francisco. San Francisco is a logical candidate for a control city for Berkeley: it is geographically proximate and culturally and politically similar. Importantly, it too had an initiative on its November, 2014 ballot to tax soft drinks that had the support of a majority of voters.[13] However, it was not implemented because, although it got 55.6% of the vote, it needed two-thirds of the vote to pass.[14] In fact, the proposed tax in San Francisco was twice as large as that in Berkeley (two cents rather than one cent per ounce) yet it still got majority support. A strength of our approach is that the treatment and control cities each have majorities supporting the policy being evaluated; as such, the match between treatment and controls should be particularly close with fewer problems of policy endogeneity.

Difference-in-Differences (DD) Model: Diet Versions of the Same Product, in Berkeley

[13] Richmond and El Monte are two additional cities in California that introduced a similar tax on the ballot in recent years that did not pass. These cities are less likely to be suitable control cities because their demographics differ from those of Berkeley.

[14] The reason that the San Francisco ballot initiative needed two-thirds of the vote to pass, whereas that for Berkeley needed only a simple majority, is that the San Francisco initiative stated that tax revenues would be dedicated for a special fund, whereas those from Berkeley would only go to the city's general fund (Dinkelspiel, 2014). However, Berkeley plans to appropriate amounts equal to the tax revenue to fund related public health goals (Dugdale, 2015).

Despite these similarities, it is possible that the trend in prices for individual products would not have been the same in Berkeley as in San Francisco; perhaps Berkeley experienced location-specific shocks to the prices of SSBs that were not experienced by San Francisco. To address this possibility, we estimate models using another counterfactual: the price of diet version of the same product, in Berkeley.

$$\mathrm{P}_{pst} = \alpha + \beta_t \mathrm{Post}_t + \beta_p \mathrm{Sugar}_p + \beta_{DD} \mathrm{Post}_t {*} \mathrm{Sugar}_p + \beta_{day} \mathrm{Day} + \beta_s \mathrm{Store}_s + \varepsilon_{pst} \quad (2)$$

P_{pst} denotes the dependent variable (either the price or the price per ounce of the product) of product *p* in store *s* and time *t*. Our coefficient of interest is the difference-in-differences estimator β_{DD}; it is the coefficient on the interaction term Post*Sugar, which equals one if the price is for the regular (sweetened) version as opposed to the diet version, and if the price was measured after the tax was implemented. This measures the effect of the tax on prices after controlling for the general trend in prices for that brand of product in Berkeley. Models are estimated separately for Coke and Pepsi, which are the two brands for which we have prices for both regular and diet versions. Models are also estimated separately by size (20 oz. bottle, 2 liter bottle, and 12 pack of 12 oz. cans).

The diet version of the same brand of product may be a credible counterfactual, if shocks to the prices of caloric SSBs are common to the diet versions as well. It is a strength of this study that we have data for a close substitute for the taxed item that is not taxed. The previous literature on the pass-through of taxes on cigarettes, alcohol, and gasoline generally do not have data for close substitutes that are untaxed.

Difference-in-Difference-in-Differences (DDD) Model: Trend in Relative Prices of Regular versus Diet Versions of the Same Product, in San Francisco Relative to Berkeley

However, one might be concerned that there could be shocks to the prices of regular SSBs that were not shared by the diet versions of the same product. For example, one might be concerned that the campaigns surrounding the ballot measure gave consumers additional information about the health consequences of consuming caloric SSBs, which shifted the demand curve, lowering prices.

To address this possibility, we assume that the counterfactual for the relative prices of regular versus diet SSBs in Berkeley is the relative prices of those two products in San Francisco. (Recall that San Francisco also voted on a referendum to impose a tax on SSBs during the same election, suggesting that San Francisco consumers also experienced any information component of the campaigns. In addition, both cities are in the same media market, implying that the campaigns would have affected both populations similarly.) Specifically, for the two brands for which we have both diet and full-calorie versions of the beverage (Coke and Pepsi), we estimate difference-in-difference-in-differences (DDD) models that examine the change over time in the price of the taxed items relative to the change over time in the price of the untaxed items in the treatment city, while also controlling for the trend in the relative prices in the control city. For these models, prices for the diet and full-calorie versions are pooled, and we estimate the following models separately for Coke and Pepsi:

$$\begin{aligned} \mathrm{P}_{pst} &= \alpha + \beta_t \mathrm{Post}_t + \beta_u \mathrm{Sugar}_p + \beta_{ts} \mathrm{Post}_t{*}\mathrm{Treat}_s + \beta_{ut} \mathrm{Sugar}_p{*}\mathrm{Post}_t + \beta_{ut} \mathrm{Sugar}_p{*}\mathrm{Treat}_s \\ &+ \beta_{DDD} \mathrm{Post}_t{*}\mathrm{Treat}_s{*}\mathrm{Sugar}_p + \beta_{day} \mathrm{Day} + \beta_s \mathrm{Store}_s + \varepsilon_{pst} \end{aligned} \tag{3}$$

The indicator variable Sugar equals one if the product was not diet and thus was subject to the tax. β_{DDD} , the DDD estimate, is our coefficient of interest. For these models, the data are at the level of product *p*, store *s*, and time *t*. Models are estimated separately for Coke and Pepsi, separately by size (20 oz. bottle, 2 liter bottle, and 12 pack of 12 oz. cans).

In subsequent models, we seek additional statistical power by pooling observations. Specifically, we pool observations for: 1) Coke, all sizes; 2) Pepsi, all sizes; 3) 20-oz. bottles of both brands; 4) 2-liter bottles of both brands; 5) 12-packs of 12-oz cans of both brands; 6) all sizes of both brands. These models are similar to equation (3) except that we add to the set of regressors indicator variables for size and brand when relevant.

Number of Clusters, and Standard Errors

An important issue is that we have only two clusters (Berkeley and San Francisco), for one time period before and one time period after the policy; this has been called the two-by-two case of clustering (see, e.g. Donald and Lang, 2007). Cameron and Miller (2015) demonstrate that standard errors that do not account for this clustering can overstate precision unless the within-cluster correlation of errors is solely driven by a common shock process, which would be picked up by our store-level fixed effects. In the two-by-two case, clustering can lead to degenerate standard errors (Donald and Lang, 2007; Cameron and Miller, 2015). This is in fact what happens when we cluster by city or use the wild cluster bootstrap recommended by Cameron and Miller (2015): we find implausibly small standard errors (close to zero) and p values (of zero). We cluster standard errors by store in each of our models but acknowledge that these likely underestimate the true standard errors.

To put our limited number of clusters into context, the three previous studies of the pass-through of taxes on SSBs (Grogger, 2015; Berardi et al., 2012; Bergman and Hansen, 2012), as well as some studies of the pass-through of taxes on other goods (e.g. Kenkel, 2005), had only one cluster – data for the treated country or state, with no geographic control. Despite the serious limitations of having only two clusters, it represents an improvement relative to the existing literature.

Sampling error is reduced because: 1) we have not sampled one of many treated cities, but instead have data for the *only* treated city.[15] Moreover, what happened in that one city is of great interest because it is viewed as a litmus test for soda taxes in other jurisdictions. 2) Within that treatment city we have data for a near-census of supermarkets, grocery stores, and convenience stores with posted prices, so we have unusually good data for stores that were treated by this policy. Still, we acknowledge the limitations of our standard errors that arise from having two-by-two clusters.

Empirical Results

Summary Statistics

Table 1 lists the mean price in cents for each product and size, for each city (Berkeley, San Francisco) and time period (December which is pre-tax, and June which is post-tax). If there was 100% pass-through of the tax, and no other shocks to prices, one would expect the price of taxed items to rise by one cent per ounce (e.g. by 20 cents for a 20 oz. bottle). In Berkeley, the price of a 20-oz. bottle of Coke rose 8.3 cents, a 20-oz. bottle of Pepsi rose 10.3 cents, and a 20-oz. bottle of Mountain Dew rose 11.25 cents. However, these items may have risen in price even in the absence of the tax; for example, in San Francisco those same three items rose 0.2 cents, 2.4 cents, and 3.5 cents over that same period.

Also, it should be noted that prices vary considerably within cities in each time period. For example, in December, 2014 in Berkeley, the average price of a 2-liter of Coke was $2.15, but the standard error was 5 cents; prices ranged from $1.66 to $2.49 in that city. A range in price of 50% may be surprising because it is a perfectly homogenous good and within a single

[15] Our control city, on the other hand, is just one of many possible control cities, although it is an unusually good match in that its populace gave majority vote to the same policy at the same time as that in the treatment city.

city. The variance in price may reflect differing retail costs by neighborhood or differing elasticities of demand for each store's shoppers. It is also consistent with imperfect information, costly search, or difficulties to arbitrage. The range in prices is relevant because previous studies often used a city average in each time period that may have been based on a varying set of stores.

We also depict visually the basic, unconditional patterns in the data. Figures 1-3 depict the price per ounce for Coke, Diet Coke, Pepsi, and Diet Pepsi in three sizes: 20 oz. bottle (Figure 1), two liter bottle (Figure 2) and a 12-pack of 12 oz. cans (Figure 3), in both Berkeley and San Francisco, and in December (before the Berkeley tax) and June (after the Berkeley tax was implemented). These figures can be used to visually examine the unconditional DD and DDD. We expect the price per ounce for the diet and regular versions to be equal in Berkeley in December (before the tax) and in San Francisco in both periods. We also expect that, if the tax was fully passed through and there was no substitution among consumers from regular to diet products, there should be a difference in price of one cent per ounce between Coke and Diet Coke, and between Pepsi and Diet Pepsi, in Berkeley in June.

The three figures show a similar story across the three sizes. It is generally true that the diet and regular versions of each brand are quite similar in Berkeley before the tax, and in San Francisco in both periods. In Berkeley in June, there is indeed a difference in price between the regular and diet versions of each brand, but it is less than one cent; i.e. the figures suggest that the tax was only partially passed-through to consumers in the form of higher retail prices.

Difference-in-Difference (DD) Model: Berkeley Versus San Francisco

In order to estimate the relative change in price for the products after the implementation of the tax compared to before the tax, in the treatment city compared to the control city, we estimate our difference-in-differences model, equation (1). If the tax was 100% passed through to consumers, then prices for caloric drinks would rise one cent per ounce in Berkeley compared to San Francisco; this would amount to 20 cents for a 20 oz. bottle, 68 cents on a two-liter bottle, and $1.44 on a 12-pack of 12 oz. cans. Table 2, Panel A, presents the results for prices in cents for items subject to the tax. In Berkeley relative to San Francisco, the price of a 20 oz. bottle of Coke rose 8.2 cents and a two-liter of Coke rose 22.8 cents; both of these are significantly different from zero at the 5% level. The 95 percent confidence intervals are shown in Table 2 below the standard errors, and these exclude 20 cents for a 20 oz. bottle of Coke and 68 cents for a two liter of Coke. In other words, the confidence intervals rule out full pass-through of the tax. The price of a 12-pack of cans of Coke rose 19.8 cents, which was not statistically significant.

The prices of Pepsi rose by 9.2 cents for a 20 oz. bottle, 30.9 cents for a two-liter, and 46.5 cents for a 12-pack of cans, all of which are significantly different from zero. Likewise, the price of Mountain Dew rose 8.9 cents for a 20 oz. bottle, 34.2 cents for a 2-liter, and by 62.4 cents for a 12-pack of cans, all of which are statistically significant. The price of a 20 oz. bottle of Gatorade also rose significantly, by 8.7 cents. The prices of Red Bull and Snapple did not change significantly. Consistently, these results suggest that the tax was passed through to consumers, but less than fully – e.g. roughly 8 to 9 cents of the 20 cent tax on 20 oz. bottles was passed through in the form of higher prices. The confidence intervals rule out full pass-through of the tax for all 20 oz. bottles, 2-liter bottles, and 12-packs of 12 oz. cans in the data.

Table 2, Panel B, displays the estimates for untaxed products. For Diet Coke, the estimates for 20 oz. bottles are positive, but small in magnitude and imprecisely estimated; the estimate for a 12-pack of cans is negative and imprecisely estimated. The prices of Diet Pepsi rose by 6.5 cents for a 20 oz. bottle and 18.4 cents for a 2-liter bottle, both of which are significantly different from zero. The price of a 12-pack of Diet Pepsi cans rose by 26.5 cents, but this change was not statistically significant. The prices of a 20 oz. bottle of Dasani water fell by 3.1 cents, which was not statistically significant.

Table 3, which reports estimates from models of the price per ounce, show that the extent of pass-through of the tax, for 20-oz. bottles, ranged from 41.1% for Coke to 45.8% for Pepsi. In the 2-liter size, pass-through ranged from 33.8% for Coke to 50.6% for Mountain Dew. Pass-through of the tax in the 12-pack of cans was generally smaller: 13.7% (not statistically significant) for Coke to 43.3% (and significant) for Mountain Dew. For most estimates in Table 3, the 95% confidence interval excludes 1; i.e. we can reject the hypothesis of full cost shifting. The exceptions are Red Bull and Snapple, which are imprecisely estimated.

Difference-in-Difference (DD) Model: Regular Versus Diet in Berkeley

A limitation of the DD models described above is that prices in San Francisco may be an imperfect counterfactual for what prices in Berkeley would have been in the absence of the tax. For example, there may be shocks to prices of SSBs that are very geographically concentrated, affecting Berkeley but not San Francisco.

Conveniently, we can control for price shocks that were specific to Berkeley using a close substitute for Coke and Pepsi that was not taxed – the diet versions of those same products. Our assumption is that any non-tax shocks to the prices of Coke and Pepsi were experienced equally by their diet versions. Specifically, for Coke and Pepsi separately, we pool the data for the full-calorie versions with the data for the diet versions and estimate the DD model shown in equation (2). The results are presented in Table 4 (for prices in cents) and Table 5 (for prices in cents per ounce).

These results are also consistent with modest pass-through of the tax. The point estimates suggest that, of the 20-cent tax on 20-ounce bottles, 6.2 cents (30.8%) was passed through to consumer prices for Coke, and 2.1 cents (10.5%) was passed through for Pepsi; neither is significantly different from zero. Pass-through on 2-liter bottles is in the tight range of 17% to 18% and not statistically significant. The pass-through on 12-packs of cans is 24.4% and statistically significant for Coke, but 13.0% and not statistically significant for Pepsi. While the estimated pass-through is not significantly different from zero, we can rule out a pass-through of 100% for each product (in 5 out of 6 cases, we can rule out a pass-through of even 47%).

Difference-in-Difference-in-Differences (DDD) Model

One might be concerned that shocks to prices were not identical for diet and regular versions of SSBs. In order to control for the extent to which caloric and diet SSBs may have had different trends in price over time, we estimate difference-in-difference-in-differences (DDD) models. These models assume that the trend in the relative prices of regular and diet SSBs in Berkeley would have, in the absence of the tax, followed the trend in San Francisco. For Coke and Pepsi separately, we pool the data for the full-calorie versions with the data for the diet versions and estimate the DDD model shown in equation (3). The results are reported in Table 6 for prices in cents and Table 7 for prices in cents per ounce.

Once again, the pass-through is quite modest: 6.3 cents (31.5%) for a 20 oz. bottle of Coke, and 2.4 cents (12.0%) for a 20-oz. bottle of Pepsi, neither of which is statistically significant. Estimated pass-through on 2 liter bottles is 22.8% for Coke and 18.3% for Pepsi, both of which are statistically significant (see Table 7). Estimated pass-through on a 12-pack of cans is 27.9% for Coke (statistically significant) and 13.9% for Pepsi (not statistically significant). For every estimate in Table 7, the 95% confidence interval excludes 1; i.e. we can reject the hypothesis of full cost shifting.

In order to increase statistical power, we estimate DDD models for all sizes of Coke pooled and all sizes of Pepsi pooled. We also estimate models for each size, pooling both brands. Finally, we estimate a model for both sizes and all brands pooled. The results are shown in Tables 6 (for prices) and 7 (for prices per ounce). As shown in Table 7, pooling all sizes of Coke yields an estimated pass-through of 28.2%, which is statistically significant. For all sizes of Pepsi pooled, pass-through was 14.4%, which is statistically significant at the 10% level. For the three sizes examined (20 oz. bottles, 2 liter bottles, 12 packs of 12 oz. cans) the pass-through ranged narrowly from 21.0% to 22.4%. Pooling both brands and all sizes, estimated pass-through of the tax was 21.7%. For every estimate in Table 7, the 95% confidence interval excludes 1; i.e. we can reject the hypothesis of full cost shifting.

Extensions

One possibility is that supermarkets and convenience stores pass through the tax to a different extent. To investigate this possibility, we re-estimated our DD and DDD models using only the data for convenience stores (there are not enough supermarkets in Berkeley to estimate the model separately for them). The results, which are available upon request, are very similar to those for the entire sample discussed above.

We also collected data on whether each of these items was listed as “on sale” at each store. We did not control for this in the main model because we are interested in the transaction price for the product, not whether it is framed as a regular or sale price. However, one might be concerned that temporary sales could occur at different times in Berkeley and San Francisco, or for diet and regular versions, so we also estimated models that control for an indicator variable for whether the item was listed on sale. Results, which are available upon request, are very similar to those described above.

We also re-estimate each of the models without clustering standard errors by store. The standard errors without clustering are in some cases larger, and in other cases smaller, than those with clustering by store. They are, in particular, larger for the DDD models – these have the most observations per store. In all cases, however, the 95% confidence intervals easily rule out full pass-through of the tax.

A Closer Look at the Store-Level Data

Table 8 lists the number of stores that charged the same price for the regular and diet version of the same product (Coke or Pepsi, by size) by city and time period. The table is based on a balanced panel, so the exact same set of stores is represented for December as for June, although the number of stores varies by item because some stores do not carry every item. The table also lists the average difference in prices (regular minus diet) for the stores that charged different prices.

In Berkeley, before the tax was implemented, virtually all stores charged the same price for regular and diet versions of the same product. Every store in our sample in Berkeley in December 2014 charged the same price for the regular and diet versions of: 2 liter bottle of Coke (16 stores), 12 pack of 12 oz. cans of Coke (15 stores), 20 oz. bottle of Pepsi (19 stores), and 2 liter bottle of Pepsi (15 stores). In Berkeley in December, only one store (out of 23) charged a different price for a 20 oz. Coke than for its diet version, and only one store (out of 13) charged a different price for a 12-pack of cans of Pepsi than for its diet version; in both cases, the regular version was cheaper than the diet version.

In Berkeley after the tax was implemented (June, 2015), the majority of stores still charged the same price for the regular and diet versions, but a small number of stores began charging a higher price for regular than diet versions. For example, whereas no stores charged a different price for a regular and diet versions of 2 liter bottles of either Coke or Pepsi in December, 2014, in June, 2015, 4 stores charged a higher price for a 2 liter of regular Coke than diet Coke (the average difference in price was 46 cents), and 3 stores charged a higher price for a 2 liter of regular Pepsi than diet Pepsi (the average difference in price was 69 cents).

Across all sizes, the average difference in price between the regular and diet versions of Pepsi was almost exactly the amount of the tax: 20 cents for 20-oz. bottles, 69 cents for 2-liter bottles, and $1.44 for a 12-pack of 12 oz. cans. However, this is only for a handful of stores (2, 3, and 1 respectively)[16]; the vast majority of stores (12 to 17, depending on product) charged the same price for regular and diet Pepsi. For Pepsi, the vast majority of stores shifted none of the tax and a small handful shifted the tax fully to consumers.

For Coke products, the amount of the tax that was shifted is not as bimodal. Again, only a handful of stores charged a different price for regular than diet Coke in Berkeley in June: 3 out of 23 for 20-oz. bottles, 4 out of 16 for 2-liter bottles, and 5 out of 15 for a 12-pack of cans. In the stores with a price difference, the regular version was more expensive by 43 cents for a 20-oz. bottle, 46 cents for a 2-liter bottle, and $1.06 for a 12-pack of cans. Thus, this subset of stores overshifted the tax for a 20-oz. bottle of Coke, and undershifted it for 2-liter bottles and 12-packs of cans of Coke.

The columns for San Francisco show that even when there is no tax on caloric SSBs, there are some stores that charge a different price for the regular and diet versions. These are rare exceptions, though; the vast majority of stores charge identical prices for the regular and diet versions of the same product and size.

[16] The same three stores in Berkeley are passing through the tax 100% on all of the non-diet Pepsi products that they carry; however, they differ in how many of the different sizes they carry. Two of the three are also fully passing through the tax on all non-diet Coke products.

Conclusion

This paper estimates the extent to which the first city-level tax on sugar-sweetened beverages in the United States was passed on to consumers in the form of higher prices, a necessary step for the tax to reduce consumption. Strengths of the study include: longitudinal data at the store level, data from a near-census of stores with posted prices in the treatment community, data for a close substitute that was not taxed (diet versions of the same brand of SSB), and an unusually closely-matched control community in which a majority of residents also voted for the policy in question. This allows us to estimate a variety of difference-in-differences (DD) and difference-in-difference-in-differences (DDD) models to difference away any contemporaneous price shocks that were specific to the region or city and/or the category of beverages.

Across all of these models, we consistently find that, on average, less than half of the tax was passed on to consumers in the form of higher prices. Averaging all three sizes of Coke and Pepsi, our DDD models indicate that only 21.7% of the tax was passed through to consumers. Our findings are consistent with journalists' anecdotal reports of incomplete, or even zero, pass-through by certain stores in Berkeley (see, e.g., Johnson, 2015; Barnidge, 2015).

Our estimates are much lower than those from previous studies of the pass-through of nationwide taxes on SSBs in other countries (Grogger, 2015; Berardi et al., 2012; Bergman et al., 2010). Our estimates are also lower than most of the studies of the pass-through of taxes on other products in the U.S. such as cigarettes (DeCicca et al., 2013), alcohol (Kenkel, 2005), food (Besley and Rosen, 1999), and clothing (Poterba, 1996); these studies tended to find that taxes are fully shifted, or even overshifted, to consumer prices. Our results are more consistent with the subset of studies that found incomplete pass-through of taxes (ranging from 45% to 85%) on items such as tobacco and gasoline (e.g. Harris et al., 2015; Harding et al., 2012; Doyle and Samphantharak, 2008).[17]

There are several possible explanations for why the Berkeley tax on SSBs was passed through less than other taxes in other locations. One factor that is likely to be important is that this tax was implemented at the city level. Berkeley is just 10.5 square miles (U.S. Census Bureau, 2015), and thus the tax is relatively easy to evade through cross-border shopping. Previous research has found cross-border shopping in response to food taxes, even at the state level (e.g. Tosun and Skidmore, 2007; Fisher, 1980). In the U.S., the mean distance traveled to shop for groceries is 5.2 miles; even for households with income below $30,000 the average distance traveled to grocery shop is 4.8 miles (Alcott et al., 2015). In light of this, retailers may not try to shift the tax to consumers, fearing loss of sales. If true, taxes passed at the city level may be less effective at changing prices and consumption than taxes at higher levels of government that are harder to avoid through cross-border shopping. The previous literature on tax pass-through studied taxes at the level of the nation (e.g. Grogger, 2015; Berardi et al., 2012; Bergman et al., 2010) or U.S. state (e.g. DeCicca et al., 2013; Kenkel, 2005; Besley and Rosen, 1999), so that may in part explain why we find lower rates of pass-through. Cross-border shopping may be a more serious concern for larger sizes of SSBs – 12-packs and 2 liter bottles – but we find limited pass-through of taxes even for single-serving 20 ounce bottles.

[17] Research in the empirical industrial organization and international trade literatures consistently find that upstream cost changes are imperfectly passed-through to retail prices. For example, Nakamura and Zerom (2010) estimate a pass-through rate of 0.30 in the coffee market. Potential explanations for the less than complete pass-through include market power, nominal price rigidities, long-term contracts, nonlinear pricing, consumer search behavior, and strategic markup adjustments along the supply distribution chain (Nakamura and Zerom, 2010; Bonnet et al., 2013; Richards et al., 2014).

It is possible that stores in Berkeley were still in the process of adjusting their prices in June; however, previous studies have tended to find that taxes were passed through almost instantly, i.e. within a quarter, a month, or less (Grogger, 2015; Alm et al., 2009; Besley and Rosen, 1999). Our June data were collected more than three months after the tax took effect. It is possible that pass-through takes longer for a new tax than for an increase in an existing tax, but previous research on new SSB taxes finds that even new taxes are quickly passed through (e.g. Bergman and Hansen, 2012; Berardi et al., 2012; Grogger, 2015). For example, Berardi et al. (2012) found that the French tax on SSBs was 93% shifted to prices in the third month, and fully shifted in the fourth month, after implementation. Initially, the Berkeley tax was scheduled to be implemented on January 1. But, after initial confusion about the details of the tax and its collection, the effective date of the tax was delayed until March 1. The amount of revenue initially collected was well-advertised and our June data are three months after this revised date of implementation. Thus, it is unlikely that distributors and retail stores are unaware of the tax or that delays in implementation explain the lack of pass-through in Berkeley.

Another important consideration is that the demand of Berkeley consumers for SSBs may be price elastic (for reasons unrelated to cross-border shopping), so the tax is absorbed by manufacturers, distributors, or retailers. Previous research finds that the demand for SSBs and soft drinks is elastic (e.g., Dharmasena and Capps, 2012; Powell et al., 2013; Harding and Lovenheim, 2014).[18] The price elasticity of demand for SSBs also appears to be higher for higher-income individuals (Zhen et al., 2011; Lin et al., 2011), and Berkeley is a relatively high-income city (U.S. Census Bureau, 2015). If the demand for SSBs is elastic in Berkeley, one should expect the pass-through to be less than if demand was relatively inelastic. However, this

[18] A review of the literature finds that the mean estimate of the price elasticity of demand for SSBs overall was -1.21, that for regular carbonated soft drinks was -1.25, and that for sports drinks was -2.44 (Powell et al., 2013).

does not explain why some stores in our sample passed through the taxes fully, while others did not pass them through at all, unless there are dramatic differences in price elasticity between the shoppers at those stores. This seems unlikely, however, because stores that increased prices by exactly the amount of the tax are often located close to stores that did not change their prices at all. This suggests that differences across stores in pass-through may not be determined by either elasticity of customer demand or ease of cross-border shopping. In addition, the elasticity explanation cannot account for why previous studies estimated high pass-through of taxes on SSBs specifically, unless the elasticity of demand in Berkeley varies significantly from the elasticity in these other settings (Grogger, 2015; Berardi et al., 2012; Bergman et al., 2010; Besley and Rosen, 1999).

Another possible explanation is that we are able to do a better job of controlling for trends in prices, through the use of a control community that is a close match and a close substitute that was untaxed (diet versions of the same brand SSB). However, we estimate low rates of pass-through (under 50%) even when we do not difference out trends in the price of diet versions or control for trends in the control community. Another advantage of this study is that we have a balanced panel of store-level data, allowing us to estimate fixed effects models that eliminate time-invariant heterogeneity at the store level and eliminate the possibility of changes in which stores were sampled.[19] Like DeCicca et al. (2013), we find substantial variation in prices within cities, which underscores the importance of having data on a balanced panel of stores, as opposed to using average prices in a city. However, Kenkel (2005) collected store-level data from the same set of stores and still found that alcohol taxes in Alaska were overshifted.

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[19] The ACCRA data used in Besley and Rosen (1999) were not consistently drawn from the exact same stores, and data collectors are allowed to substitute a similar product if the requested one was not available; to some extent, the Besley and Rosen (1999) estimates may have been confounded by differences in stores or products over time.

We find that the prices of Diet Coke and Diet Pepsi also rose in Berkeley around the time of the tax. It is possible that they rose not because of a general underlying trend in Berkeley relative to San Francisco, but because people switched to the diet versions after the caloric versions were taxed, and this drove up the price of the diet versions.[20] Grogger (2015) also observed an increase in the price of diet soda after the tax on diet soda in Mexico. If the price of diet SSBs rose in Berkeley because of cross-price elasticity, then it would be inappropriate to use the price of diet SSBs as a counterfactual. Based on this, we think that the most conservative approach is to prefer the DD models that use the price of the same product in San Francisco as the counterfactual; these models indicate that the pass-through of the tax was less than 50%.

These results are relevant beyond the city of Berkeley. Simulations of the effect of proposed SSB taxes on consumption have often assumed that taxes will be fully passed through to consumers (e.g. Long et al., 2015; Zhen et al., 2014; Wang et al., 2012; Andreyeva et al., 2011). A recent study of the cost-effectiveness of taxing SSBs in the U.S. (Long et al., 2015) conducted a robustness exercise which assumed that tax pass-through would range between 50% to 150%; many of our estimates lie below even that lower bound, implying that the study overestimated the behavior change that would result from such a tax.

Existing taxes on SSBs are a fixed amount per unit volume, e.g. one cent per ounce in Berkeley, one peso per liter in Mexico, and 7.16 euros per hectoliter in France. However, we find that the extent of pass-through varies by size of the product; e.g. it is generally lower on a 12-pack of 12 oz. cans than for smaller sizes. Other research has also found smaller pass-through on bulk purchases (e.g. Harding et al., 2012, for cartons versus packs of cigarettes). This suggests that policymakers, if they wish to achieve the same reduction in consumption across

[20] If the motivation for the tax is to increase the relative price of caloric SSBs relative to non-caloric options, the fact that prices of diet versions may rise in response is very relevant.

quantities, or to avoid people substituting larger bulk purchases for numerous smaller purchases, may wish to levy different sized taxes on different quantities of SSBs. This would likely raise the administrative and enforcement costs of the tax, however.

To clarify, this paper does not argue that a tax on SSBs is unjustified. There is in fact a credible economic rationale for an SSB tax: to internalize the negative externalities associated with obesity and the chronic conditions associated with a poor diet (see, e.g., Cawley, 2015). Even if consumer prices do not rise much, and thus there is not much impact on consumption, such a tax may still raise revenue and internalize externalities (i.e. confront consumers with some of the marginal external costs of their actions).

This study has a number of limitations. The most important is that we have a two-by-two case of clusters, which makes it difficult to accurately calculate standard errors. However, this limitation is shared by the previous literature, which is further limited by a lack of a control community. Nevertheless, the results from the examination of the number of stores with the same prices for diet and regular SSBs in Berkeley and San Francisco before and after the implementation with the tax are consistent with the results from the regression models that the tax was not fully passed-through. Despite the clustering issue, this paper presents important information from the only city in the U.S. to enact a tax on SSBs, and is based on a near-census of grocery stores, supermarkets, and convenience stores in the treatment city.

The control city, San Francisco, may be an imperfect counterfactual for Berkeley, which would bias our estimates in the DD and DDD models. However, for our estimates of pass-through to be biased downwards, prices of full-calorie SSBs, but not their diet versions, would have to have been declining in Berkeley relative to San Francisco, which seems unlikely. Importantly, a majority of San Francisco voters voted for (yet did not get) a tax on SSBs, which suggests that San Francisco is an unusually well-matched control community for Berkeley in this context.

The outcomes we examine are limited to the prices of national brands that are most commonly sold in grocery stores, convenience stores, and pharmacies. Anecdotal reports suggest that distributors responded in other ways to the tax. For example, one distributor temporarily stopped selling his niche products (craft sodas and naturally sweetened beverages) in Berkeley out of confusion about the tax's implementation, and the two Dollar Tree stores in Berkeley stopped selling caloric SSBs altogether (Lee, 2015).

Finally, we do not observe prices charged by distributor to retailer, only the retail price to the consumer. Estimating the extent of pass-through from distributors to retailers would also be an interesting direction for future work.

Despite these limitations, this study provides important information on one of the most commonly-proposed anti-obesity policies: a tax on sugar-sweetened beverages. Specifically, we find that average pass-through was less than 50%, far from the full pass-through found in much of the previous literature and assumed in simulations of such taxes. These results imply that the Berkeley soda tax, because it is passed through to consumers to a lesser extent than anticipated, will result in less of a reduction in consumption, and thus less health improvement, than anticipated.

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Figure 1: Prices of Regular and Diet Versions of Coke and Pepsi, Berkeley and San Francisco, December 2014 and June 2015, 20 oz. Bottles

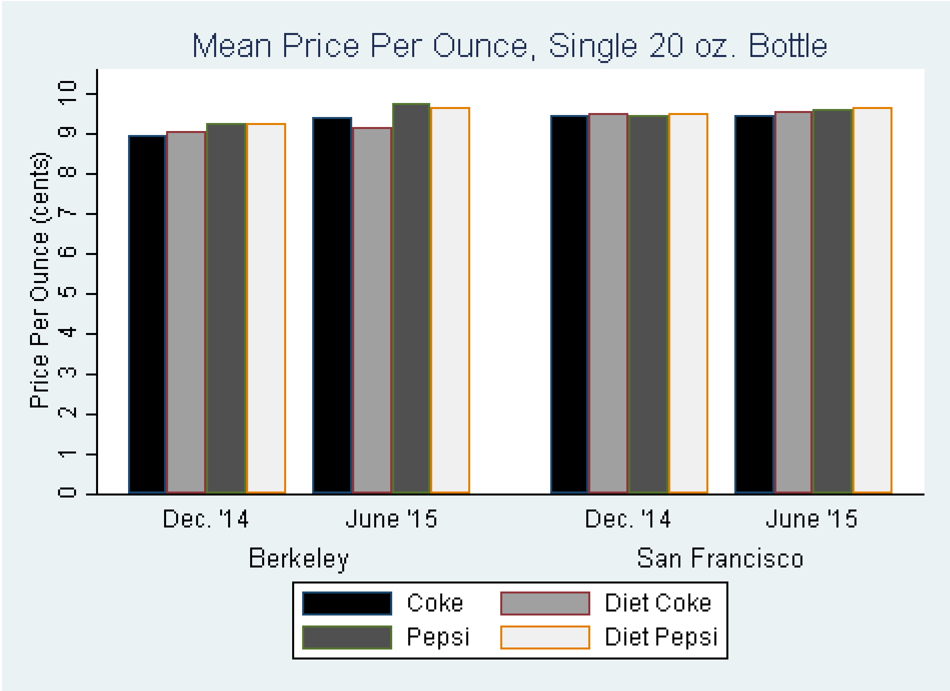

Figure 2: Prices of Regular and Diet Versions of Coke and Pepsi, Berkeley and San Francisco, December 2014 and June 2015, 2 Liter Bottles

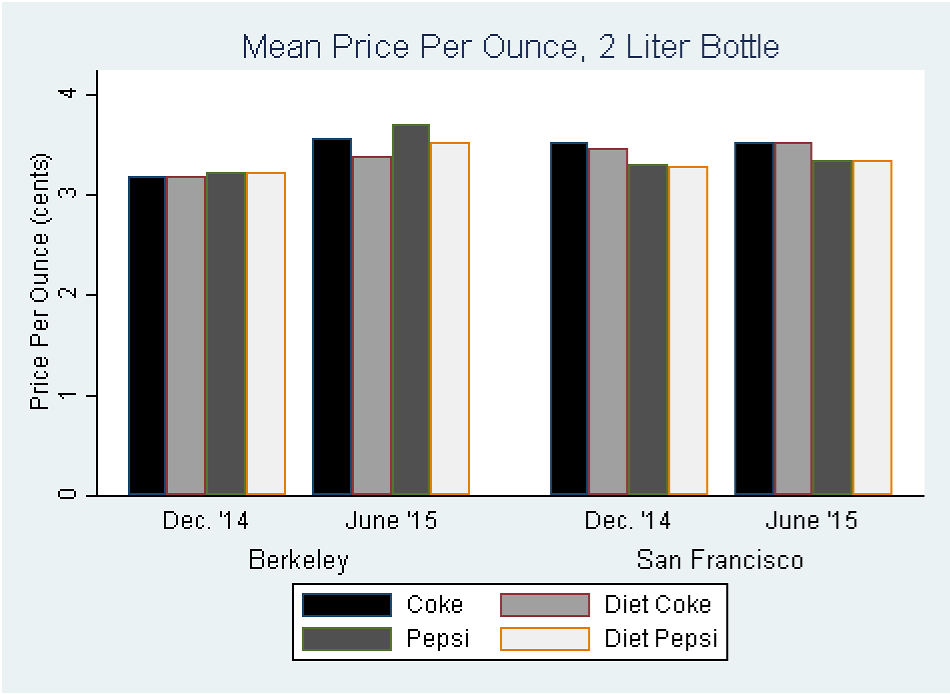

Figure 3: Prices of Regular and Diet Versions of Coke and Pepsi, Berkeley and San Francisco, December 2014 and June 2015, 12-pack of 12 oz. Cans

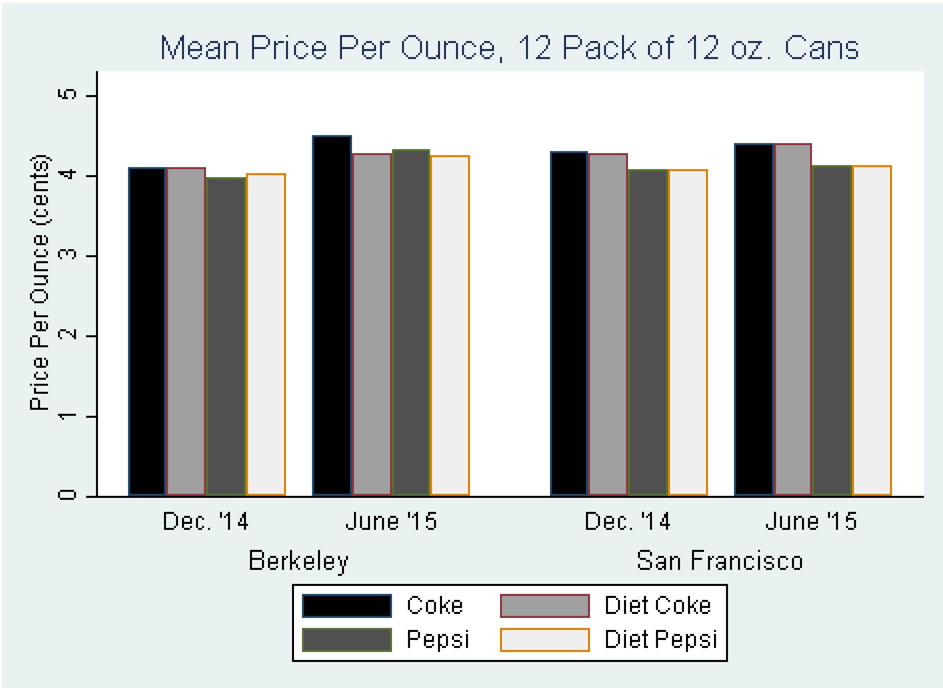

Table 1: Mean Price in Cents by City and Time Period

	Berkeley			San Francisco		
	December 2014 (Pre-Tax)	June 2015 (Post-Tax)	Difference	December 2014 (Pre-Tax)	June 2015 (Post-Tax)	Difference
Coke 20 oz.	179.375	187.708	8.333	189.000	189.222	0.222
	(4.018)	(3.969)	(5.648)	(1.986)	(2.257)	(3.007)
	N=24	N=24		N=45	N=45	
Coke 2 Liter	215.687	240.625	24.938	237.808	237.808	0.000
	(5.014)	(10.635)	(11.758)	(8.259)	(7.600)	(11.224)
	N=16	N=16		N=26	N=26	
Coke 12 Pack 12 oz.	589.733	649.533	59.800	618.286	631.857	13.571
	(19.846)	(14.254)	(24.435)	(11.648)	(12.154)	(16.834)
	N=15	N=15		N=14	N=14	
Diet Coke 20 oz.	180.696	182.870	2.174	190.256	190.721	0.465
	(4.252)	(4.211)	(5.984)	(1.904)	(2.066)	(2.810)
	N=23	N=23		N=43	N=43	
Diet Coke 2 Liter	215.687	229.000	13.313	234.107	238.214	4.107
	(5.014)	(8.416)	(9.797)	(6.304)	(7.719)	(9.966)
	N=16	N=16		N=28	N=28	
Diet Coke 12 Pack 12 oz.	589.733	614.333	24.600	614.882	631.941	17.059
	(19.846)	(14.731)	(24.716)	(9.704)	(12.120)	(15.526)
	N=15	N=15		N=17	N=17	
Pepsi 20 oz.	184.842	195.105	10.263	189.406	191.781	2.375
	(3.989)	(3.984)	(5.638)	(2.030)	(1.524)	(2.539)
	N=19	N=19		N=32	N=32	
Pepsi 2 Liter	217.812	250.063	32.250	223.296	225.889	2.593
	(6.137)	(10.613)	(12.259)	(4.086)	(4.342)	(5.962)
	N=16	N=16		N=27	N=27	
Pepsi 12 Pack 12 oz.	572.077	621.923	49.846	588.286	595.429	7.143
	(17.555)	(17.420)	(24.732)	(10.714)	(6.343)	(12.451)
	N=13	N=13		N=14	N=14	
Diet Pepsi 20 oz.	184.842	193.000	8.158	189.700	192.567	2.867
	(3.989)	(3.836)	(5.534)	(2.136)	(1.500)	(2.610)
	N=19	N=19		N=30	N=30	
Diet Pepsi 2 Liter	218.400	238.400	20.000	222.440	225.240	2.800
	(6.530)	(10.672)	(12.511)	(4.286)	(4.590)	(6.280)
	N=15	N=15		N=25	N=25	
Diet Pepsi 12 Pack 12 oz.	579.769	610.846	31.077	587.462	595.154	7.692
	(16.543)	(23.914)	(29.078)	(11.538)	(6.844)	(13.416)
	N=13	N=13		N=13	N=13	
Mt Dew 20 oz.	183.050	194.300	11.250	189.793	193.241	3.448
	(3.503)	(3.864)	(5.216)	(2.235)	(1.519)	(2.702)
	N=20	N=20		N=29	N=29	
Mt Dew 2 Liter	215.733	251.467	35.733	220.895	222.474	1.579
	(6.172)	(11.246)	(12.828)	(5.115)	(4.922)	(7.099)
	N=15	N=15		N=19	N=19	

Table 1: Mean Price in Cents by City and Time Period (*cont.*)

	Berkeley			San Francisco		
	December 2014 (Pre-Tax)	June 2015 (Post-Tax)	Difference	December 2014 (Pre-Tax)	June 2015 (Post-Tax)	Difference
Mt Dew	564.000	626.400	62.400	604.556	604.556	0.000
12 Pack 12 oz.	(22.423)	(20.311)	(30.254)	(5.556)	(5.556)	(7.857)
	N=10	N=10		N=9	N=9	
Gatorade 20 oz.	171.308	178.231	6.923	175.154	174.615	-0.538
	(6.008)	(5.366)	(8.056)	(3.352)	(2.921)	(4.447)
	N=13	N=13		N=26	N=26	
Dasani 20 oz.	172.600	174.600	2.000	176.316	177.000	0.684
	(10.021)	(10.357)	(14.412)	(5.673)	(5.642)	(8.001)
	N=10	N=10		N=19	N=19	
Red Bull 8.4 oz.	233.826	242.000	8.174	243.735	250.118	6.382
	(4.882)	(3.328)	(5.909)	(4.298)	(4.279)	(6.065)
	N=23	N=23		N=34	N=34	
Red Bull	819.308	826.231	6.923	813.588	819.529	5.941
4 Pack 8.4 oz.	(17.838)	(15.631)	(23.717)	(19.745)	(14.577)	(24.543)
	N=13	N=13		N=17	N=17	
Snapple Iced Tea	170.333	188.667	18.333	139.650	141.950	2.300
16 oz.	(12.184)	(19.186)	(22.728)	(6.229)	(6.085)	(8.708)
	N=6	N=6		N=20	N=20	

Standard errors in parentheses.

Table 2: Difference-in-Differences: Berkeley Versus San Francisco
Impact of Soda Excise Tax on Price (Cents),
Product by Size

	20 oz.	2 Liter (68 oz.)	12 Pack 12 oz.	8.4 oz.	4 Pack 8.4 oz.	16 oz.
Panel A: Taxed Products						
Coke	8.224**	22.84**	19.80			
	(3.322)	(9.331)	(33.13)			
	[1.595, 14.85]	[3.999, 41.69]	[-48.06, 87.66]			
	N=138	N=84	N=58			
Pepsi	9.160***	30.85***	46.46**			
	(2.699)	(9.494)	(17.77)			
	[3.739, 14.58]	[11.69, 50.01]	[9.935, 82.98]			
	N=102	N=86	N=54			
Mt Dew	8.855***	34.24***	62.40***			
	(3.031)	(10.47)	(19.50)			
	[2.761, 14.95]	[12.95, 55.54]	[21.43, 103.4]			
	N=98	N=68	N=38			
Gatorade	8.732*					
	(4.698)					
	[-0.779, 18.24]					
	N=78					
Red Bull				4.973	-3.573	
				(7.610)	(25.39)	
				[-10.27, 20.22]	[-55.50, 48.35]	
				N=114	N=60	
Snapple Iced Tea						14.01
						(17.46)
						[-21.80, 49.81]
						N=52

Table 2 (continued)

	20 oz.	2 Liter (68 oz.)	12 Pack 12 oz.	8.4 oz.	4 Pack 8.4 oz.	16 oz.
Panel B: Untaxed Products						
Diet Coke	1.621 (4.287) [-6.941, 10.18] N=132	4.094 (10.39) [-16.87, 25.05] N=88	-35.40 (48.70) [-134.7, 63.92] N=64			
Diet Pepsi	6.519** (2.470) [1.553, 11.48] N=98	18.41* (9.262) [-0.324, 37.14] N=80	26.53 (27.96) [-31.05, 84.11] N=52			
Dasani	-3.075 (7.354) [-18.14, 11.99] N=58					

Note: *p<0.10, **p<0.05, ***p<0.01
Standard errors are shown in parentheses and 95% confidence intervals are shown in brackets. Each cell contains the results of separate regressions based on equation (1) and are difference-in-differences estimates of the change in prices from after to before the tax in Berkeley relative to San Francisco for each product.

Table 3: Difference-in-Differences: Berkeley Versus San Francisco
Impact of Soda Excise Tax on Price (Cents/Oz), Product by Size

	20 oz.	2 Liter (68 oz.)	12 Pack 12 oz.	8.4 oz.	4 Pack 8.4 oz.	16 oz.
Panel A: Taxed Products						
Coke	0.411**	0.338**	0.137			
	(0.166)	(0.138)	(0.230)			
	[0.0797, 0.743]	[0.0591, 0.616]	[-0.334, 0.609]			
	N=138	N=84	N=58			
Pepsi	0.458***	0.456***	0.323**			
	(0.135)	(0.140)	(0.123)			
	[0.187, 0.729]	[0.173, 0.739]	[0.0690, 0.576]			
	N=102	N=86	N=54			
Mt Dew	0.443***	0.506***	0.433***			
	(0.152)	(0.155)	(0.135)			
	[0.138, 0.747]	[0.191, 0.821]	[0.149, 0.718]			
	N=98	N=68	N=38			
Gatorade	0.437*					
	(0.235)					
	[-0.03, 0.912]					
	N=78					
Red Bull				0.592	-0.106	
				(0.906)	(0.756)	
				[-1.223, 2.407]	[-1.652, 1.439]	
				N=114	N=60	
Snapple Iced Tea						0.875
						(1.092)
						[-1.362, 3.113]
						N=52

Table 3 (continued):

	20 oz.	2 Liter (68 oz.)	12 Pack 12 oz.	8.4 oz.	4 Pack 8.4 oz.	16 oz.
Panel B: Untaxed Products						
Diet Coke	0.0811 (0.214) [-0.347, 0.509] N=132	0.0605 (0.154) [-0.249, 0.370] N=88	-0.246 (0.338) [-0.936, 0.444] N=64			
Diet Pepsi	0.326** (0.123) [0.0777, 0.574] N=98	0.272* (0.137) [-0.00, 0.549] N=80	0.184 (0.194) [-0.216, 0.584] N=52			
Dasani	-0.154 (0.368) [-0.907, 0.599] N=58					

Notes: *p<0.10, **p<0.05, ***p<0.01
Standard errors are shown in parentheses and 95% confidence intervals are shown in brackets. Each cell contains the results of separate regressions based on equation (1) and are difference-in-differences estimates of the change in prices per ounce from after to before the tax in Berkeley relative to San Francisco for each product.

Table 4: Difference-in-Differences: Diet Versus Regular in Berkeley
Impact of Soda Excise Tax on Price (Cents), Product by Size

	20 oz.	2 Liter	12 Pack 12 oz.
Coke	6.159	11.62	35.20**
	(4.087)	(7.361)	(14.53)
	[-2.296, 14.61]	[-4.065, 27.32]	[4.034, 66.37]
	N=94	N=64	N=60
Pepsi	2.105	12.25	18.77
	(1.477)	(7.393)	(13.35)
	[-0.99, 5.20]	[-3.50, 28.01]	[-10.31, 47.85]
	N=76	N=62	N=52

Notes: *p<0.10, **p<0.05, ***p<0.01
Standard errors are shown in parentheses and 95% confidence intervals are shown in brackets. Each cell contains the results of separate regressions based on equation (2) and are difference-in-differences estimates of the change in prices in Berkeley from after to before the tax for the regular relative to the diet version of each product.

Table 5: Difference-in-Differences: Diet Versus Regular in Berkeley
Impact of Soda Excise Tax on Price (Cents/Oz), Product by Size

	20 oz.	2 Liter	12 Pack 12 oz.
Coke	0.308	0.172	0.244**
	(0.204)	(0.109)	(0.101)
	[-0.115, 0.731]	[-0.060, 0.404]	[0.0280, 0.461]
	N=94	N=64	N=60
Pepsi	0.105	0.181	0.130
	(0.0738)	(0.109)	(0.0927)
	[-0.04, 0.26]	[-0.05, 0.414]	[-0.071, 0.332]
	N=76	N=62	N=52

Notes: *p<0.10, **p<0.05, ***p<0.01
Standard errors are shown in parentheses and 95% confidence intervals are shown in brackets. Each cell contains the results of separate regressions based on equation (2) and are difference-in-differences estimates of the change in prices per ounce in Berkeley from after to before the tax for the regular relative to the diet version of each product.

Table 6: Difference-in-Difference-in-Differences:
Impact of Soda Excise Tax on Price, Coke/Pepsi by Size

	20 oz.	2 Liter	12 Pack 12 oz.	All Sizes
Coke	6.303	15.45*	40.17**	18.05**
	(4.061)	(8.451)	(15.22)	(6.942)
	[-1.799, 14.40]	[-1.583, 32.48]	[9.124, 71.22]	[4.215, 31.89]
	N=270	N=172	N=122	N=564
Pepsi	2.403	12.36*	20.02	10.21*
	(1.497)	(7.265)	(13.34)	(5.372)
	[-0.604, 5.410]	[-2.296, 27.03]	[-7.357, 47.40]	[-0.561, 20.99]
	N=200	N=166	N=106	N=472
Coke & Pepsi	4.470*	14.22*	30.73**	14.43**
	(2.412)	(7.379)	(11.50)	(5.666)
	[-0.341, 9.282]	[-0.614, 29.04]	[7.314, 54.15]	[3.138, 25.72]
	N=470	N=338	N=228	N=1036

Notes: *p<0.10, **p<0.05, ***p<0.01
Standard errors are shown in parentheses and 95% confidence intervals are shown in brackets. Each cell contains the results of separate regressions based on equation (3) and are difference-in-difference-in-differences estimates of the change in prices from after to before the tax for the regular relative to the diet version of each product in Berkeley relative to San Francisco.

Table 7: Difference-in-Difference-in-Differences:
Impact of Soda Excise Tax on Price (Cents/Oz), Coke/Pepsi by Size

	20 oz.	2 Liter	12 Pack 12 oz.	All Sizes
Coke	0.315	0.228*	0.279**	0.282**
	(0.203)	(0.125)	(0.106)	(0.128)
	[-0.089, 0.720]	[-0.023, 0.480]	[0.0634, 0.495]	[0.0275, 0.536]
	N=270	N=172	N=122	N=564
Pepsi	0.120	0.183*	0.139	0.144*
	(0.0749)	(0.107)	(0.0927)	(0.0739)
	[-0.030, 0.270]	[-0.033, 0.400]	[-0.051, 0.329]	[-0.003, 0.293]
	N=200	N=166	N=106	N=472
Coke & Pepsi	0.224*	0.210*	0.213**	0.217**
	(0.121)	(0.109)	(0.0798)	(0.0931)
	[-0.017, 0.464]	[-0.009, 0.429]	[0.0508, 0.376]	[0.0316, 0.402]
	N=470	N=338	N=228	N=1036

Notes: *p<0.10, **p<0.05, ***p<0.01
Standard errors are shown in parentheses and 95% confidence intervals are shown in brackets. Each cell contains the results of separate regressions based on equation (3) and are difference-in-difference-in-differences estimates of the change in prices per ounce from after to before the tax for the regular relative to the diet version of each product in Berkeley relative to San Francisco.

Table 8: Number of Stores with the Same Prices for Regular and Diet, and Average Difference in Price When Not the Same

			Berkeley		San Francisco	
			December 2014	June 2015	December 2014	June 2015
Coke	20 Ounce	# Same	22	20	42	41
		# Different	1	3	0	1
		Avg. Difference	-20	43	0	10
	2 Liter	# Same	16	12	22	23
		# Different	0	4	3	2
		Avg. Difference	---	46	22	-25
	12 Pack	# Same	15	10	14	13
		# Different	0	5	0	1
		Avg. Difference	---	106	---	-60
Pepsi	20 Ounce	# Same	19	17	29	30
		# Different	0	2	1	0
		Avg. Difference	---	20	10	---
	2 Liter	# Same	15	12	24	24
		# Different	0	3	1	1
		Avg. Difference	---	69	20	20
	12 Pack	# Same	12	12	12	12
		# Different	1	1	0	0
		Avg. Difference	-100	144	---	---

Notes: Data for the exact same set of stores is shown for December and June for each product, but the number of stores varies by item since not all stores carry every item. The average difference is the difference in price, in cents, between the regular and diet versions of the product.