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Do Taxes Make You Drink Less Soda?

A Difference-in-Differences Approach on the Cook County Sugar-Sweetened Beverage Tax

By

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Abstract

Sugar-sweetened beverage (SSB) taxes have been implemented by various regions across the world and previous studies have demonstrated their effect of lowering SSB consumption. The current study taps into a unique SSB tax situation in Cook County, Illinois. By analyzing around 2,000 households located in Cook County and its adjacent counties using fixed effects and difference-in-differences estimation, the current research indicated an approximately 30% drop in SSB consumption after the tax went into effect and a full recovery in consumption after the tax was officially repealed.

Introduction

Do sugar-sweetened beverage (SSB) taxes really improve health by reducing soda consumption? Taxes on SSBs have been a contentiously debated topic over the past few years. The reason for the lack of consensus on this topic is closely linked to the interdisciplinary nature of soda taxes. Taxes are a major source of income for government to cover its possible budget deficit, so the topic is extensively discussed in public policy. On the other hand, soda taxes reflect an intrinsic conflict between the public health sector led by Centers for Disease Control and Prevention (CDC) and the large soft drink producers such as Coca-Cola and PepsiCo. Similar conflict could be observed in what people commonly call “sin taxes” on tobacco and alcohol, but the difference lies within the severity of health concern led by the products. It is known to the public that tobacco and alcohol can cause cancers and other illness for users and potentially people around them, but SSBs have much less stigma in public opinions, so it is more difficult to justify for SSB taxes (Bollinger & Sexton, 2018). Soda taxes, therefore, represent an eclectic mix of social science disciplines including public policy, public health, economics and behavioral science.

This paper intends to address the effect of the SSB tax that took place in Cook County, Illinois in 2017. Cook County, one of the largest counties in the U.S. that contains the city of Chicago, implemented a \$0.01 per ounce tax on sweetened beverages including soda, sports drinks, flavored water, energy drinks, pre-made sweetened coffee and tea. The tax went into effect on August 2, 2017, making Illinois the fourth state to have an SSB tax after California, Pennsylvania and Colorado (CookCountyIL.gov, 2020). What sets the SSB tax different from the taxes in other areas is that the tax was reported to be repealed on October 10, 2017 and officially repealed on December 1, 2017 under the pressure from consumers and lobbyists (Washington Post, 2020). The set of actions provided a unique opportunity to investigate Cook County residents’ reactions in multiple time frames. The consumption behaviors between August 2 to October 10 could be captured as a response to the implementation of the tax, whereas the time between October 10 to December 2 could be used to investigate the effect of the news – whether the repeal news alone made people change their consumption behaviors. Lastly, since the tax was eventually repealed on December 2, the period after that could be indicative of whether people

formed a habit of consuming less SSBs (assuming they did reduce consumption after the tax was implemented) or people were rational agents who were solely sensitive to prices. Based on research on the same topic in different regions, a few points need to be addressed in order to reach a convincing conclusion. First, the data sets selected should be representative of the SSB price movements and resident consumption behaviors in the region. Second, the pass-through rate of the tax should be known to ensure that the effects were caused by the tax. Third, valid counterfactuals should be used to eliminate the effect of seasonality and trends. Fourth, other potential confounders and externalities should be considered (Escobar et al; Roberto et al).

Previous work has provided extensive discussions on sin taxes. These discussions have led to two opposing camps of opinions. Sin taxes have received approximately same level of support and objection.

For the proponents of the SSB taxes, the rationales mainly stem from public policy and behavioral economics standpoints. Brownell et al. (2009) composed a proposal for implementing nation-wide SSB taxes, as they provided evidence on the negative health concerns exerted by the overconsumption of sugary drinks. First, significant correlations between SSB consumption and body weight were found and supported by longitudinal studies. The correlational results differ on whether the studies were funded by the beverage industry, with the studies not financially associated with the beverage industry having stronger correlations between SSB consumption and obesity. Second, several prospective observational studies found positive correlations between SSB consumption and the risk for type 2 diabetes for US nurses, Finnish citizens and African American females. Moreover, multiple studies have proven that overconsumption of SSBs, which contains refined carbohydrates such as sugar, can elevate triglycerides, blood pressure and lower HDL cholesterol. These are all risk factors for coronary heart disease (Brownell et al., 2009).

Brownell et al. (2009) and Cummings (2010) then argued the necessity of SSB taxes from a behavioral economics perspective. Since the assumption of consumers being rational agents could fail at times, consumers could ignore some long-term negative effects caused by SSBs. The potential costs of dealing with the aforementioned health issues could be very high and the consumers rarely include them in the calculation of consuming SSBs (Brownell et al.,

2009). Due to bounded rationality, few consumers possess the time, energy and knowledge to fully comprehend the nutritional information of SSBs, but they are sensitive to price movement. Therefore, research suggested that policy makers should make the health concerns more salient by transferring them as taxes (Cummings, 2010). Moreover, time-inconsistent preferences would lead consumers, especially children and teenagers, to favor short-term gratification over long-term health (Brownell et al., 2009). These are all reasons, according to Brownell et al., to levy a federal-level SSB tax that would far exceed the existing state-level SSB taxes in scale.

Yet, it has been 10 years since the proposal by Brownell et al. (2009) and no SSB tax was implemented on a federal level. For the current study, the SSB tax encountered significant resistance which eventually led to a repeal. The evidence indicates that the oppositional voice has at least matched with that of the proponents. One of the most prominent reason against SSB taxes is regressivity. When a tax costs the poor a higher percentage of their income than the rich, the tax is considered regressive (Remler, 2004). Researchers have proposed various methods of implementing SSB taxes to reduce the regressivity, but evidence suggests that an optimal policy would require information on various statistics including: the magnitude of consumer bias, the weights of heterogeneity preference and income effects played in variation in consumption, whether the rich or the poor are more biased, the elasticity of demand across income distribution, and the tax salience (Lockwood & Dmitry, 2017). These factors indicate that SSB taxes, or any sin tax, demand case-by-case analysis, so a federal-level policy would be suboptimal. Also, advocates for autonomy values would raise objections to paternalistic policies such as SSB taxes. In policy making, autonomy is a crucial component, as the freedom choice is a deeply embedded principle. Philosopher John Stuart Mill said that the only purpose of exercising power over one's will is to prevent harm to others. Democratic countries, especially U.S. has traditions to respect such autonomy (Remler, 2004). Third, there is an obvious conflict of interest between SSB companies and the tax advocates. SSB companies could have strong sway over political decisions and consumer behaviors due to their sizes, capital and brand image. American Beverage Association, a trade association that represents the U.S. nonalcoholic beverage industry has invested heavily on advertisements, lobbyists and other campaigns against SSB taxes (Welsh et al., 2013). A study on Australia's SSB tax failure revealed that the public health community

often disagreed on the effectiveness of SSB taxes on reducing obesity, so the pressure for change was lacking (Sainsbury et al., 2020). For these reasons, debates over SSB taxes have the most balanced arguments from both sides.

Another reason for the debate to remain ongoing is the lack of conclusive evaluations. Past literatures could arrive at distinctly different conclusions when using different data sets. Falbe et al. (2015) showed that consumption of SSBs in Berkeley decreased 21% in Berkeley and increased 4% in comparison cities ($P = 0.046$) in 2016, indicating significant drop in SSB consumption. However, another research on Berkeley reached completely opposite results. Bollinger and Sexton later used difference-in-differences and synthetic control and found no significant evidence of pass-through or consumption changes. The reasons given by Bollinger and Sexton for the conflicting conclusion are the data sets. Bollinger and Sexton (2018) made use of high-resolution scanner data from supermarkets and drug stores, which they argued were significantly more accurate in capturing the highly volatile prices of SSBs than using snapshots of prices according to surveys (Bollinger & Sexton, 2018). The current paper intends to deploy strategies similar to Bollinger and Sexton's by using scanner data from supermarkets in order to account for the price volatility.

A pass-through rate indicates the proportion of tax burden that has transferred to consumers. If soda brands do not adjust their prices after a new tax, then consumers will carry the entirety of the tax. Instead, if companies adjust their prices so that consumers don't even feel the tax, then the tax has a pass-through rate of zero. The pass-through rates in different areas could be largely different. Two studies on the Philadelphia tax showed nearly full pass-through rate (Cawley et al, 2019; Seiler et al., 2021). Papers on the Berkeley tax indicated different results as suggested above, whereas research on the Boulder tax indicated less than full pass-through (Alcott et al). On the other hand, the passing through of taxes could be a gradual process but only to be captured in snapshots. Beradi et al. (2016) pointed out SSB tax in France took 6 months to fully pass through. The current research predicts no significant price drops, which means a full pass-through rate. The first reason for such hypothesis is that the tax only existed for two months before it was announced to be repealed, so the SSB suppliers might not have the

time to adjust price tags. Also, a highly possible scenario is that the suppliers might know the tax would not last for long, so they didn't change prices accordingly.

As indicated in multiple literatures that SSB prices could fluctuate weekly (promotions, different types of sales etc.), it is crucial to capture the seasonality and trends independent from the taxes. Most studies used difference-in-differences technique that would take the underlying parallel trends between treatment and control groups into account. For example, in studying the Berkeley tax, areas in San Francisco but outside of Berkeley could be used as controls (Bollinger & Sexton, 2018). Zhong et al. (2018) selected three cities nearby Philadelphia as control. The current study chooses two sets of controls. The first set of controls are the supermarkets in counties immediately adjacent to Cook County from May to December in 2017. The adjacent counties contain data points of only stores that are subject to Chicago marketing area, in order to detect any spillover effect. To weigh in the metropolitan effect, the data from Milwaukee was also added to this control set. The second set of controls are the stores of Cook County from May to December in 2016.

Based on the discussion above, the current study has two hypotheses:

H1: There was a full pass-through rate in the Cook County's SSB tax.

H2: There was a significant impact of the Cook County's SSB tax on SSB consumption in Cook County.

Data and Methods

In other literatures on this topic, data collection can be either costly or time-consuming. Roberto et al. purchased data from Information Resource Inc (IRI), a market research company that holds data from retail stores in the United States, in order to study the effect of soda tax in Philadelphia (Roberto et al., 2019). Another group of scholars generated random-digit dialing surveys before and after the tax was levied to investigate the potential difference in soda consumption (Zhong et al., 2018). This collection method is rather impractical for the current proposed research, as it has been two years since the tax was in effect and the survey method renders little credibility. Bollinger and Sexton adapted similar approach with Roberto et al. by acquiring scanner data from a market research company. The data sets were extracted from Nielsen Analytics (Bollinger & Sexton, 2018). The current study also engaged with two sets of data from Nielsen Analytics provided by Kilts Center for Marketing at the University of Chicago Booth School of Business. The first one is the high-resolution scanner data set that provides weekly price movement for all the products, so it is used to examine the pass-through rate of the tax. The household data set, on the other hand, tracks the consumption behaviors of households in each area. This set resembles survey data in its structure but consistently keeps weekly records to avoid the selection bias problem in surveys.

In the price movement data set, 3 million top-selling products' price movements in a 6-month span were extracted. 142 products contributed to 95% of the sales of all products, suggesting a long tail in sale distribution. Among the 142 products, 29 are SSBs. In the household data set, 1016 households in Cook County are on the record of Nielsen's HMS data set. Among them, 988 households purchased at least one SSB product across a 6-month span. In comparison, 869 households are recorded in the adjacent counties 868 purchased at least one SSB. The time frames were divided into 4 parts: the pre-tax period represents the time frame from 9 weeks before the implementation of the tax; the during-tax period represents the 9 weeks from the implementation day until the announcement of the repeal; the post-repeal periods represents the 6 weeks between the repeal announcement until the tax effectively expired; and the post-tax periods represents the 12 weeks after the tax expired. A week is defined as a 7-day period that includes the weekend.

The methods are mostly based on the panel data structure, so fixed-effect regressions and difference-in-differences regressions are mainly used.

2.1 Fixed Effects

In panel data analyses, fixed effect estimator is used to estimate the changes that take place on time-invariant intercepts. By controlling for time-invariant individual characteristics, fixed effects allow people to observe the changes led by an intervention. In the case of the current study, since the goal is to detect whether there were price movements and consumption behaviors additional to each product and household, the fixed effects of particular products and households can be controlled.

$$Y_i = \beta X_{it} + \mu_i + \epsilon_i \text{ with } i = 1, \dots, N$$

The μ part captures the time-invariant effect that would have been omitted by a simple linear model. In the current study, the time-invariant effect could be income level, economic activity, popularity of soda, health and so on. These factors can all contribute to different levels of soda consumption. Therefore, we are facing an exogenous effect situation with the need to identify a valid control.

2.2 Difference-in-Differences

The most common method in studying an exogenous effect across time is to use difference-in-differences regression. Difference-in-differences estimation can provide a statistically strong result by accounting for the effects from both time-invariant factors and time-variant factors. The assumption for difference-in-differences estimation to work is that the control group has to follow an identical trajectory across time as the treatment group before the treatment. The control group that meets such assumption is referred as a valid counterfactual. By comparing two sets of data differing in interventions but not in seasonality and trends, difference-in-differences model can detect the additional effects introduced by the interventions across time. Therefore, it is crucial to select a comparable set of regions that are similar in population, education level, income level with Cook County. A possible counterfactual in this case could be the adjacent counties outside of Cook, since they are subject to the Chicago

metropolitan market but not subject to the tax. However, we also need to consider the economic activity, income level and other factors affecting soda consumption. Therefore, Milwaukee is added to the counterfactual in order to account for these factors.

$$Y_{ist} = a + \gamma_s * treatment_s + \lambda * time_t + \delta * (treatment_s * time_t) + \epsilon_{ist}$$

Treatment is a dummy variable with 1 indicating the treatment group and 0 for the control group. Time is also a dummy variable that refers to period before and post treatment. The equation thus takes the following values.

Control group before treatment: a

Control group after treatment: $a + \lambda$

Treatment group before treatment: $a + \gamma$

Treatment group after treatment: $a + \lambda + \gamma + \delta$

The first difference of interest is the pre-treatment difference between the control and treatment groups, which is γ (can be calculated by $a + \gamma - a$). Similarly, we can find the post-treatment difference to be $\gamma + \delta$ ($a + \lambda + \gamma + \delta - a - \lambda$). Lastly, the difference-in-differences is calculated by finding the difference between γ and $\gamma + \delta$, which is δ .

In our case, the dependent variable is the weekly spending of households on SSBs. Treatment is a binary variable with 1 referring to households inside of Cook County and 0 as control groups made up of the adjacent counties and Milwaukee. Time is a multi-level variable with 4 categories: pre, during, postRpl and postTax. δ is the additional “soda tax effect” that we are interested in.

Results

3.1 Descriptive Results

1016 households in Cook County are on the record of Nielsen's HMS data set and 988 households had purchased at least one SSB product across a 6-month span, whereas 869 households are recorded for the adjacent counties in which 868 had purchased at least one SSB. Similarly, data from 2016 were extracted. 1021 households in Cook County have records of purchasing at least once and 842 households in adjacent counties have the same records.

3.1.1 Weekly Spending on SSBs

First, we can view the overall statistics across the 28-week span in Table 1.

Table 1

Descriptive statistics of household weekly SSB spending in dollars

| Region-Year | Mean | Std | Min | Max |
|--------------------|-------------|------------|------------|------------|
| Cook-2017 | 3.396 | 8.008 | 0 | 172.22 |
| Adjacent-2017 | 4.884 | 10.872 | 0 | 299.72 |
| Cook-2106 | 3.836 | 8.385 | 0 | 143.96 |
| Adjacent-2016 | 4.287 | 8.909 | 0 | 144.0 |

In Table 1, we can see that the weekly spendings on SSBs of a household are \$3.396 and \$3.836 in Cook County in 2017 and 2016, respectively. That spending is \$4.884 for the adjacent counties in 2017 and \$4.287 for the adjacent counties in 2016. However, the standard deviations, minima and maxima show that the range of spending is wide. It is absolutely normal for a household to purchase no SSBs in a week, as some don't drink SSBs or only do grocery every 2 or 3 weeks. Similarly, a household can spend hundreds of dollars on SSBs on a single trip.

We can also view the descriptive statistics by period in Table 3.

Table 2

Descriptive statistics of household weekly SSB spending in each period in dollars

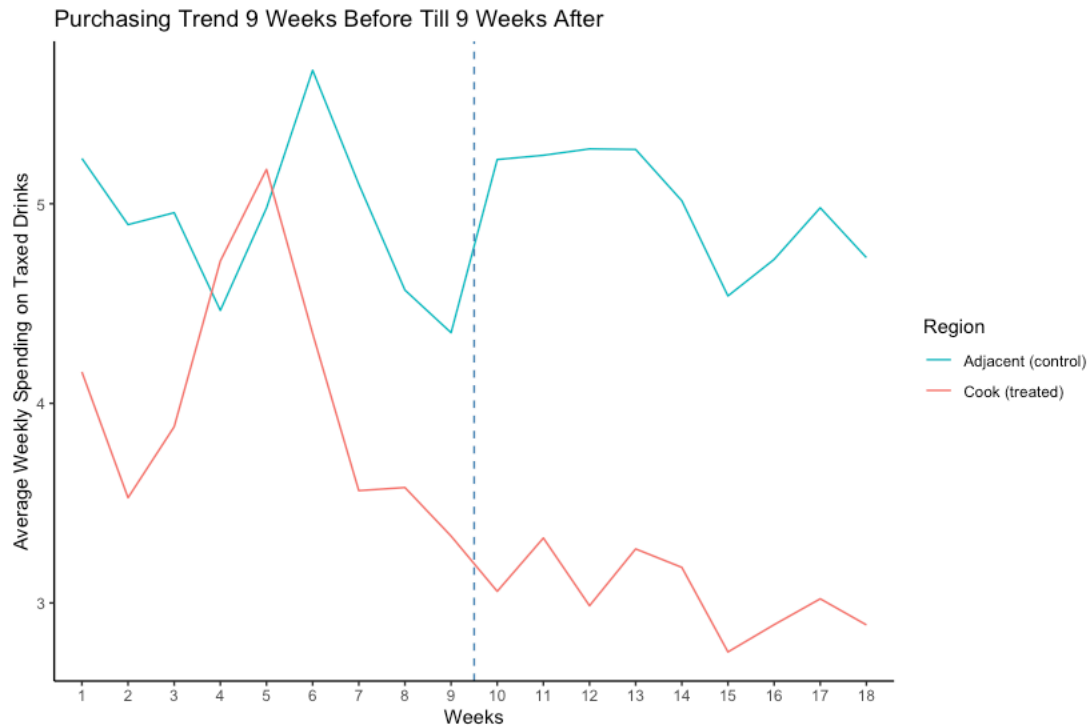
| Region-Year | Period | Mean | Std | Min | Max |
|--------------------|---------------|-------------|------------|------------|------------|
|--------------------|---------------|-------------|------------|------------|------------|

| | | | | | |
|---------------|---------|-------|--------|---|--------|
| Cook-2017 | Pre | 4.031 | 8.811 | 0 | 148.43 |
| | During | 3.042 | 7.813 | 0 | 172.22 |
| | PostRpl | 2.905 | 7.106 | 0 | 110.14 |
| | PostTax | 3.498 | 7.717 | 0 | 80.6 |
| Adjacent-2017 | Pre | 4.824 | 10.772 | 0 | 269.49 |
| | During | 4.807 | 10.348 | 0 | 212.35 |
| | PostRpl | 5.031 | 11.376 | 0 | 299.72 |
| | PostTax | 4.970 | 11.480 | 0 | 250 |
| Cook-2106 | Pre | 4.272 | 8.385 | 0 | 125.91 |
| | During | 3.755 | 8.467 | 0 | 143.96 |
| | PostRpl | 3.572 | 7.910 | 0 | 90.36 |
| | PostTax | 3.436 | 7.345 | 0 | 73.43 |
| Adjacent-2016 | Pre | 4.650 | 9.517 | 0 | 134.65 |
| | During | 4.277 | 8.847 | 0 | 121.23 |
| | PostRpl | 3.972 | 8.377 | 0 | 144 |
| | PostTax | 3.964 | 8.368 | 0 | 102.17 |

Unlike Table 1 that gives a yearly overview on the average weekly spendings on SSBs, Table 2 breaks down the weekly spendings into 4 time windows. “Pre”, “During”, “PostRpl” and “PostTax” refer to the periods before the SSB tax was implemented, during the effect of the tax, after the announcement of repeal and after the tax went out of effect.

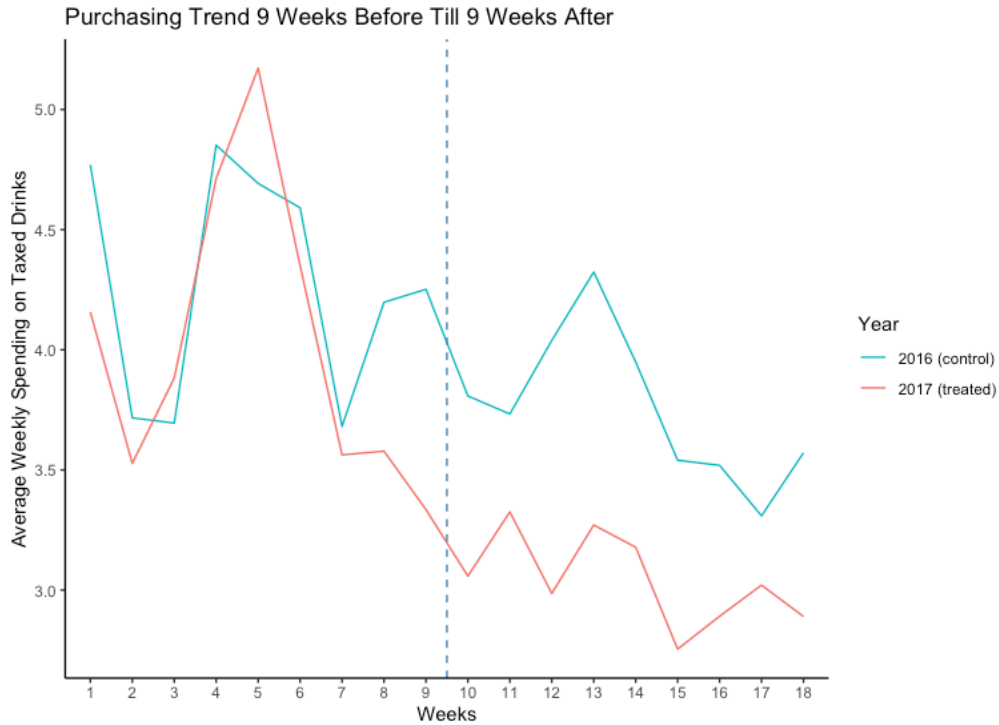
We can generally see from the statistics that the weekly spending on SSBs had a wide range. This is expected, as some households prefer soda and some don't. Moreover, most of the households do grocery shopping once every other week, so in one particular week, most of the household spending on SSBs would be 0. The 0-inflated distribution has been balanced by taking at least 4 weeks for each period.

To construct difference-in-differences, valid counterfactuals must be identified. One of the ways to visualize it is by plotting the spending in treatment group and in control group on a chart.

Fig. 1**SSB Spending Trends: Cook vs. Adjacent in 2017**

As Fig. 1 suggests, spending in Cook and adjacent counties followed a similar trajectory up until Week 9, when the tax was implemented. After Week 9, the gap widens, suggesting that consumers in Cook might spend less due to the tax.

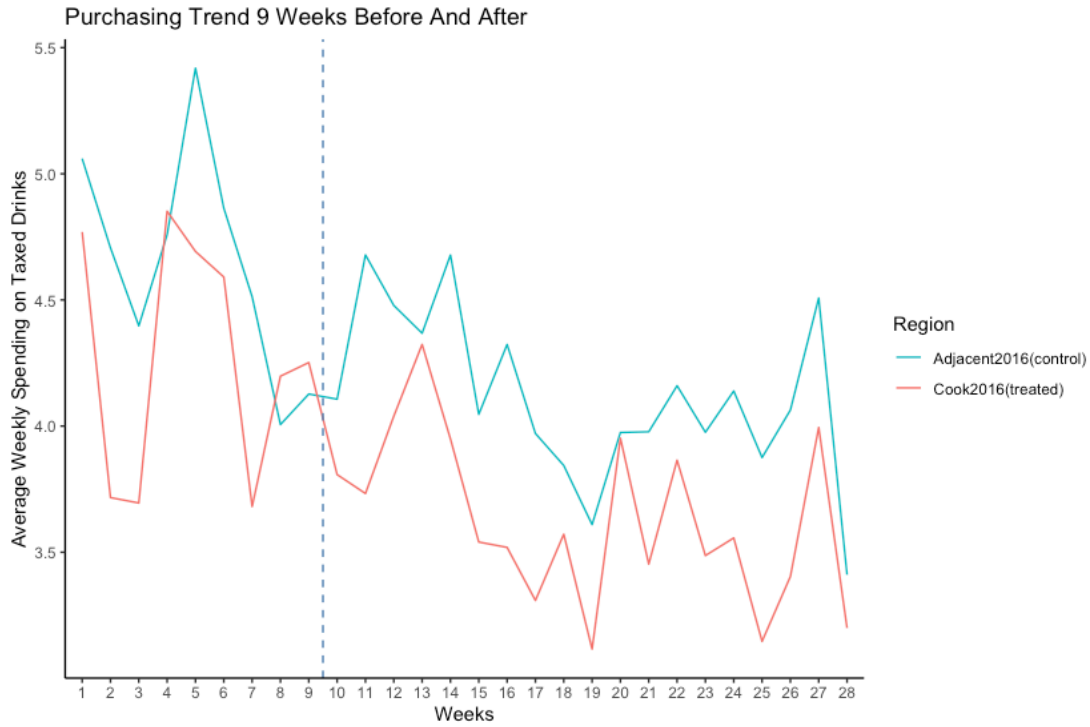
Fig. 2**SSB Spending Trends: Cook 2017 vs. Cook 2016**



Trends between Cook County in 2017 and that in 2016 can also be observed on Fig. 2. Similar to Fig. 2, the parallel trend between the control and treatment broke right around when the tax was implemented. The gap widens after Week 9.

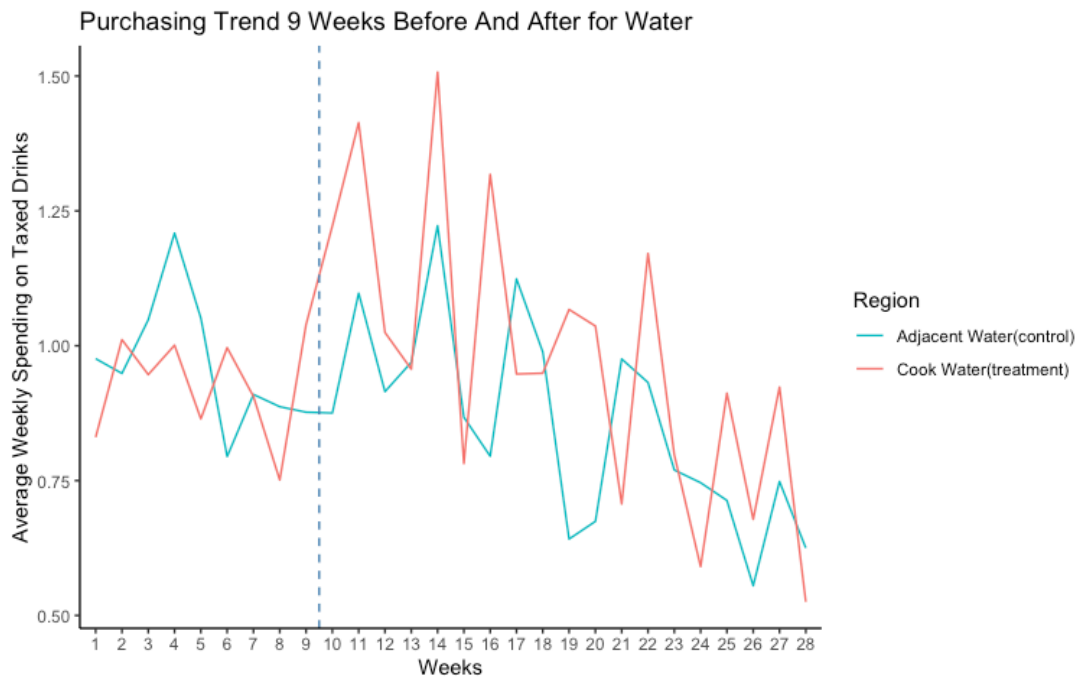
Fig. 3

SSB Spending Trends: Cook 2016 vs. Adjacent 2016



To drive this point even further, Fig. 3 presents the absence of such a difference in a “placebo” setting, a comparison between Cook in 2016 and adjacent counties in 2016. No widening gap can be observed after Week 9.

Fig. 4
Water Spending Trends: Cook 2017 vs. Adjacent 2017



Same pattern can be observed for Fig. 4. No notable difference between the water consumptions in Cook and the adjacent counties in 2017.

3.1.3 Cohort Retention

According to the Consumer Panel Dataset Manual provided by Nielsen, the yearly retention rate for the participated households is around 80%. In order to ensure that the current study is capturing data for a relatively stable group, yearly retentions from 2016 to 2018 were calculated from households' unique ids. The result showed that 848 of 1042 households in Cook County in 2016 remained in 2017 (19% attrition); 824 of 1016 households in 2017 remained in 2018 (19% attrition); 734 of 1042 households in 2016 remained in 2018 (30% attrition in a 2-year span).

For households in the adjacent counties, the yearly attrition was about 17% on average. Therefore, no anomalies were observed for the cohort retention rates.

3.1.4 Control Product

In order to conclude that the consumption changes only occurred on SSBs instead of all beverages. We need to be descriptively convinced that other beverages were not affected by the tax. The current study chose water as the control, as the tax essentially covers any beverage with artificial sweeteners, which only left fresh fruit juice and water. Since the sales for fresh fruit juice were not consistent, we only used water.

3.1.5 Google Search Trend

Since many government regulations and taxes lack public attention, we have to validate that the public had some knowledge about the SSB tax in order to derive behavioral explanations. Therefore, we looked up the Google Search Trend for the key phrase "Soda Tax" in Chicago. 2 critical time points were selected to form an 18-week time frame. Week 0 is the week

that the tax went into effect, and week 8 is the week that the tax was announced to be repealed. Weeks with negative numbers indicate weeks before the tax.

Table 3 shows very little traction for the tax on Google 9 weeks before the tax went into effect. Then, the search index gradually increased with Week -5 being an explosive peak. An explanation is that the tax was reported by news that week. At another important time point, Week 8, there was a spike again due to the announcement of repeal.

Table 3
Google Search Trend

| Week -9 | Week -8 | Week -7 | Week -6 | Week -5 | Week -4 | Week -3 | Week -2 | Week -1 |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 3 | 6 | 6 | 11 | 72 | 15 | 19 | 13 | 34 |
| Week 0 | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
| 69 | 30 | 18 | 20 | 24 | 48 | 22 | 17 | 49 |

The search trend gives evidence that the SSB tax in Cook County did gain traction when it was announced to be implemented and repealed. The public had knowledge about the tax, so the consumption changes might not be totally driven by the prices.

3.2 Regression Outputs

3.2.1 Pass-through Rate

The first regression output to be examined is the pass-through rate. If there is no significant price change for SSBs, the tax burden is completely passed to the customers, as SSB companies have not lowered prices in reaction to the tax. Fixed effect regression is used and no significant change is observed. The variable TaxPeriod is binary with 0 being data in period before the tax implementation and 1 being data after the implementation.

Table 4
Price Change Regression Output

| Coefficient | Estimate | Std | t-value | Pr(> t) |
|--------------------|-----------------|------------|----------------|--------------------|
| TaxPeriod | -0.00105 | 0.0113 | -0.0926 | 0.9262 |

Both the t-value and P value indicate insignificant change in price. This means that the SSB price tags did not change to reflect the tax. Individual SSB prices were also examined. For Coca Cola, one of the most popular SSBs, no significant price change was detected. Next, the consumption pattern can be analyzed through a difference-in-differences method.

3.2.2 Consumption Changes

Table 5

Difference-in-Differences Output

| Coefficient | Estimate | Std | t-value | Pr(> t) |
|--------------------|-----------------|------------|----------------|--------------------|
| During * Cook | -1.076 | 0.195 | -5.525 | 3.319e-08 *** |
| PostRpl * Cook | -1.437 | 0.218 | -6.596 | 4.253e-11 *** |
| PostTax * Cook | -0.853 | 0.248 | -3.434 | 0.000596 *** |

Significance Codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

During, PostRpl and PostTax are all binary variables indicating the time period. The regression uses the pre-tax period as the base level. In the “during” period, the weekly spending on SSBs in Cook County decreased \$1.076, in addition to the change in adjacent counties. After the announcement of repeal, the spending went on to decrease \$0.361 compared to the “during” period. The spending climbed back for \$0.584 after the tax was repealed. 54.3% of the consumption drop caused by the tax restored after the tax went out of effect.

To further validate the results, a “triple difference” effect can be computed by adding the trends of 2016 into the regression.

Table 6

Triple Difference-in-Differences Output

| Coefficient | Estimate | Std | t-value | Pr(> t) |
|--------------------------|-----------------|------------|----------------|--------------------|
| During * Cook* 2017 | -1.150 | 0.304 | -3.786 | 0.000153 *** |
| PostRpl * Cook * 2017 | -1.470 | 0.363 | -4.048 | 5.168e-05 *** |
| PostTax * Cook * 2017 | 0.478 | 0.344 | 1.388 | 0.165 |

Significance Codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

This output can be interpreted as the additional effect of the results in Table 4 to the variation captured in 2016. The base level of time periods is again the pre-tax period, so comparing to the pre-tax period, the “during”, “postRpl” and “postTax” period have weekly spending dropped by \$1.15, \$1.47 and increased by \$0.478 respectively.

There are a few interesting results here. First, relative to the pre-tax level, the period with the tax implementation saw a very significant drop in SSB purchases. \$1.15 is almost a 30% cut from the pre-tax weekly spending, whose average was around \$4. Notably, a 16 oz. Coca Cola can is around \$1.2. We can roughly interpret as that the residents in Cook County consume 1 less can of Coke every week after the tax went into effect. Second, after the repeal announcement was made, the consumption dropped even more. The discussion section will attempt to explain the reasons for this phenomenon. Third, after the tax eventually went out of effect, a consumption recovery was spotted for the SSBs. Though the difference relative to the pre-tax period is only marginally significant, with a p-value of 0.165, an interesting gradual consumption climb was observed. When we only took the data till Dec 31, 2017, we got an insignificant negative difference for the post-tax period. But when we took the data 8 weeks into 2018, the difference turned positive.

Discussion

Evaluation of Research Hypotheses

The current research raises two main hypotheses. First, the tax had a full pass-through rate, meaning that the tax burden would be completely carried by the consumers who made purchases. Second, the tax significantly changed consumers' purchasing behaviors on SSBs.

The first hypothesis is supported by the absence of statistically significant changes in SSB price tags. A full pass-through rate is uncommon in normal tax studies, but three explanations could account for it in this case. First, the SSB companies could be very confident that this tax would be ephemeral, so they didn't feel the need to adjust prices. Second, the SSB companies did not wish to compromise, as they campaigned against the tax and portrayed it as an infringement of consumer rights. Third, the tax was levied at the point of sale instead of on the price tags, so the companies could assume the tax was no salient to the consumers.

The hypothesis on the tax's significant effect can be split into several time frames. The results of the difference-in-differences and triple difference regressions validated a significant drop in SSB consumption after the implementation of the tax. Before the tax, a Cook county household consumes around \$4 worth of SSBs every week. The number dropped by more than \$1, which was almost 30% and equivalent to a 16 oz. Coca Cola. If we calculate the extra tax that would have been paid, it would be \$0.16, which is much lower than the saved spending. This suggests that the households did not maintain spending levels, but rather cut spending levels as a response.

A surprising result is that the repeal announcement made the consumption drop even more. One behavioral explanation could be that the consumers knew the tax would be out of effect soon, so they would rather wait till the tax went out of effect to purchase SSBs. There could also be an inertia argument for the phenomenon. The trend of buying less soda was not stopped and reversed by the repeal announcement, but rather fueled by it. People who were not aware of the tax before might join the trend because other people were buying less soda. To sum it up, when the tax repeal was made public knowledge as a future event, the consumption cut effect was magnified.

In general, the tax in Cook County did make consumers purchase less SSBs, but all of the effect went away when tax was taken off. A gradual recovery instead of an immediate bounce back in SSB consumption was observed. It took the consumption around 12 weeks to return to the pre-tax level. No habit formation was observed after 3 months of SSB tax. This research also confirms a positive correlation between the pass-through rates and the effect on consumption. In this case, the Cook County SSB tax was fully passed to the consumers. The regression results showed significant consumption drop.

Validity and Generalizability

The internal validity of the current research is determined by the quality of data sets to a great extent. Although Nielsen Analytics is one of the nation's largest data banks for supermarkets, there are plenty of other places that sell SSBs such as drug stores, convenient stores and vending machines. Data from different sources could result in distinct results. However, the results should be fairly easy to reproduce with the Nielsen data sets.

The generalizability of this study, same as other studies on the same topic, remains to be restricted on a regional level. People in different regions have different propensity level to SSBs and their price sensitivities are also different. The causes of imposing SSB taxes also vary. Cook County intended to use the tax to fill in the government deficit, while Philadelphia used to tax revenue to support Pre-K education for lower income families (Chicago Tribune). The overall effect of SSB tax on a high level suggests that it leads to lower SSB consumption, but with a high standard deviation (Alcott et al.).

Limitation

The limitation of the current research lies within the quality and availability of the data. As discussed above, Nielsen does not track all of the supermarkets or households in Cook County. There are limited ways to check if any selection bias in choosing the households was present. First, different income groups react differently to taxes. Since the wealth gap widens as a macro trend in the U.S., we need to be aware of the income distribution of the participated

households. Second, more granularities in data are needed to conclude that the tax affected some group more significantly than others.

The validity of difference-in-differences estimation is also dependent on having valid counterfactuals. There are a few sets of counterfactuals and assumptions that this study made use of. First, we assumed that the consumption trends in 2017 and 2016 were similar, with the exception of the tax. This is a reasonable assumption most of the time, but could be wrong if an event like a pandemic hit. We tried to ensure the validity of this counterfactual by observing the data in the pre-tax periods in 2016 and 2017. Another set of counterfactuals is the adjacent region. We used a combination of data from adjacent counties and Milwaukee. The adjacent counties can capture the Chicago metropolitan area that is under the influence of Chicago media, radio and etc. However, the adjacent counties don't share the qualities of one of the biggest cities in the U.S., so we added Milwaukee to compensate for it. Another possible counterfactual will be using a city that is comparable to Chicago in size and household income. And ultimately, a "perfect" control that matches everything with Cook County can be generated by using the synthetic control method, which can be explored by future endeavors.

Conclusion

The current study addresses the unique SSB tax in Cook County that went into effect in August, 2017 and later was repealed. Significant connections between SSB and purchasing behaviors have been validated, showing consumption decline when the tax was in effect and a bouncing-back effect when the tax expired. An interesting finding is that when the tax was announced to be repealed but remained in effect, the consumption dropped more, suggesting potential delayed purchases.

There has not yet been a study on the Cook County SSB tax. The current research fills in that gap. Future endeavors on this topic should focus on ensuring the quality of data. Pilot studies can be used in determining which data sets are representative of the overall behaviors in particular regions.

From the evidence of this research and past literatures, SSB taxes do reduce SSB consumption, as long as the tax remains in effect and it is passed to the consumers. More interdisciplinary efforts are needed to connect purchasing behaviors with SSB-related health status, in order to answer the question of whether SSB taxes make people healthy. And if so, what groups benefit the most from the tax?

Moreover, the current study sheds light on the effectiveness evaluation of SSB taxes in a social science research perspective. Approximately 30% reduction was found in SSB consumption for Cook County residents caused by the tax. Longitudinal studies can be conducted to evaluate health implications for those who quit SSBs and formed new consumption habits. Surveys could also be conducted to investigate whether consumers have become better informed on the potential health concerns brought by SSBs. On the other hand, the current research validated the power of the opposition. SSB companies possessed strong resources to repeal the tax almost immediately after it was implemented. Unlike alcohol or cigarettes that establish direct connection with health issues, the vice of sugar reaches much less consensus. SSBs also don't directly pose health threats to the public, so the range and scope of concerns are mitigated. These reasons ensure that SSB taxes would continue to be a contentious topic, and the tax in Cook County is an example of it. Overall, the current research lays the groundwork for

future social science research endeavors in public health, public policy and behavioral economics.

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Appendix A Descriptive Results

Sales Distribution

142 top-selling drink products that represent 95% of the sales are extracted, 29 of them are SSBs. Fig. 1 shows the distribution of the sales distribution.

Fig. 1
Sales Distribution

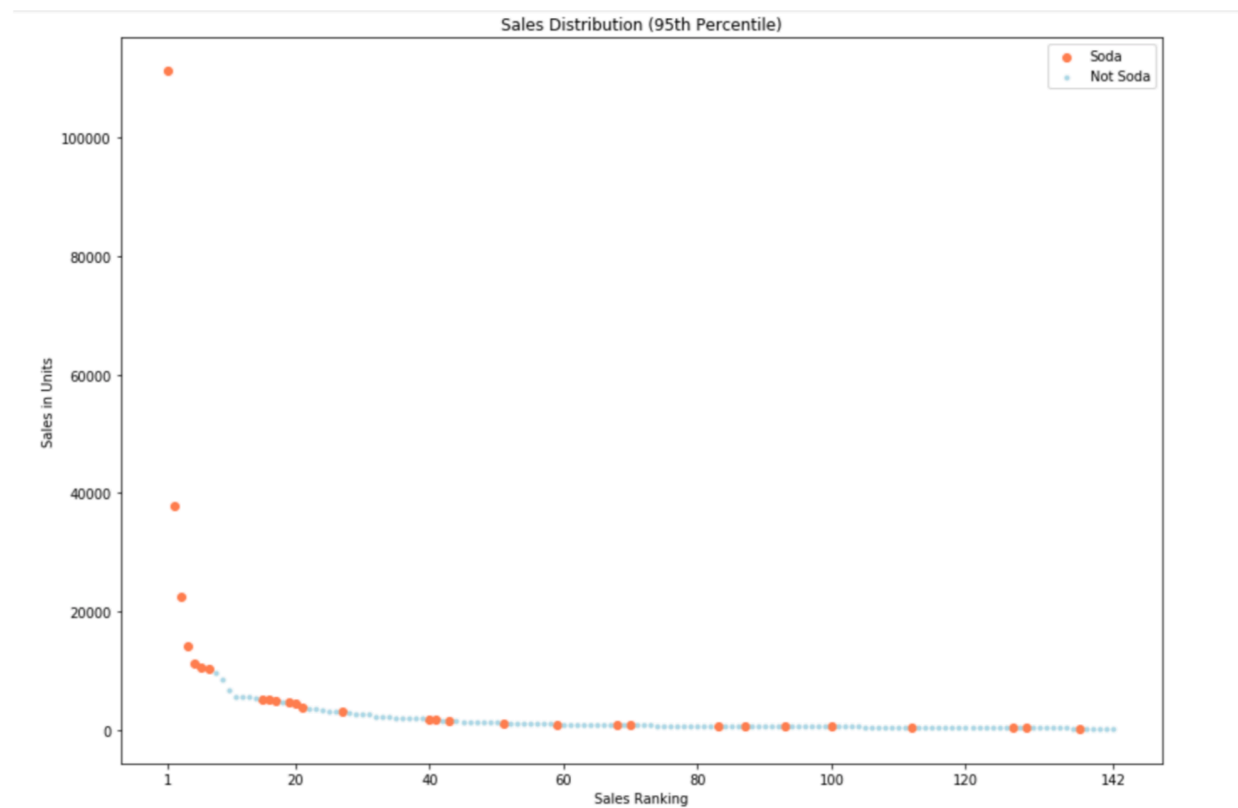


Table 1
Descriptive statistics of sales distribution

| Product | Mean | Std | Min | Max |
|---------|---------|--------|-----|--------|
| SSBs | 23038.6 | 3607.4 | 32 | 113842 |

| | | | | |
|----------|--------|--------|----|-------|
| Non-SSBs | 6027.2 | 1401.9 | 18 | 13045 |
|----------|--------|--------|----|-------|

Table 1 shows the descriptive statistics of the units of sale across a 6-month span (from 3 months before the tax to 3 months after the tax).