Does Banning Carbonated Beverages in Schools Decrease Student Consumption?

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Abstract

I evaluate the effectiveness of carbonated beverage bans in schools by investigating their impact on household soda consumption. I match households in Nielsen Homescan Data to their school district's carbonated beverage policies over an eight-year period (2002-2009). I find that when high schools ban the sale of carbonated beverages to students, households with a high school student experiencing the ban increase their consumption of non-diet soda by roughly the equivalent of 3.4 cans per month. I present evidence that this is a substantial offsetting (67-75%) of the average non-diet carbonated beverage consumption in high schools, when these are available to students, thus demonstrating the persistence of preferences when attempting to alter unhealthy habits.

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1 Introduction

With growing concern regarding the obesity epidemic among children and adults, policy-makers have considered initiatives limiting access to unhealthy foods, under the assumption that this will reduce overall caloric intake among individuals.[1]However, given that it is infeasible to block all sources of unhealthy foods, it may be that individuals will respond to the limitation by finding an alternative source for what is being limited, thus decreasing effectiveness. This paper investigates this debate by evaluating bans on carbonated beverages in schools and their impact on students' household consumption.

I match households in Nielsen Homescan data to their school districts and these school districts' corresponding carbonated beverage availability policies. Overall, I collected carbonated beverage policies over an eight-year period (2002-2009) for 46 large school districts throughout the United States. The introduction of carbonated beverage bans in school districts generates three sources of variation: over time, across school districts, and across school-levels (elementary/middle/high). I therefore estimate whether compensation at the household level occurs in response to carbonated beverage bans using a difference-in-differences-in-differences (triple differences) model. The triple differences framework is advantageous to difference-in-differences (DID) models because it makes use of two, rather than one, control groups: households within school district boundaries which did not implement bans *and* households within school district boundaries which did implement bans who do not have school-aged children. Thus, in the triple differences framework, the only plausible threat to identification would be a factor that is correlated with carbonated beverage restrictions in the school district boundaries and is differentially affecting only households with children in the relevant school-level.

The results show that households with children in high school compensate for the lack of availability of non-diet carbonated beverages when high schools ban their sale. The compensation effect is found only for high school restrictions and not for elementary or middle school restrictions, and this is consistent with the fact that bans implemented at the school district level are typically binding at the high school level, whereas at the elementary and middle school levels this is not so. For diet carbonated beverage restrictions, no significant change in household diet soda consumption is observed in response to bans. The results for diet versus non-diet carbonated beverages are supported by evidence that consumption of diet carbonated beverages in schools is very minimal, even when these beverages are readily available.

Quantitatively, the average household increases consumption of non-diet carbonated beverages, relative to the period prior to the high school carbonated beverage restriction, by roughly 41 fluid ounces per month for each treated high school household member, and this is averaged over more than a year following the ban introduction. This is equivalent to an average monthly increase of 3.4 cans in household non-diet soda consumption. Point-estimates for changes in household consumption after more than 15 months following the ban introduction have lower precision, and thus the magnitude of household changes in non-diet soda

[1]One of the most publicized and heavily-debated of these policy measures was Mayor Bloomberg's attempt in 2012 to restrict the serving size of soda and sugar-sweetened beverages sold in New York City, which was overruled in the court in 2013.

consumption for this later period cannot be estimated as confidently. I present evidence that the average consumption of non-diet carbonated beverages in high schools, when these are available, is roughly 4.5-5 cans per month. Thus, the estimated 3.4-can increase in non-diet soda consumption in response to bans in high schools suggests that compensation at home offsets approximately 67-75% of the average high school student's consumption levels of carbonated beverages when these are available in schools. The results further suggest that treated households exhibit the greatest positive compensation levels during the quarter immediately after the high school ban was introduced. The increase in soda consumption in response to the bans is reflective of *household* consumption and not the individual *student's* consumption. Thus, it may be that student compensation is less than the change observed. Nevertheless, when taking into account that the Nielsen Homescan data does not cover all potential channels through which compensation of carbonated beverages can take place (e.g., convenience stores, vending machines, etc.), I conclude that this is evidence of a substantial offsetting in response to high school carbonated beverage bans.

The results demonstrate that substitution patterns in consumption in response to narrowly-targeted policies can exist, thus limiting their effectiveness. I evaluate a policy which aims to promote a healthier habit beyond the premises in which the policy takes place. Thus, policy evaluations cannot be limited to the local level of policy implementation (i.e. in our case, the school) and a broader approach, which accounts for compensation or substitution of the unhealthy habit, has to be considered.[2] As such, this paper emphasizes the importance of individual preferences and their persistence, even when altering potential access to the desired consumption bundle. The results support previous findings regarding compensatory behavior concerning unhealthy eating habits (Fletcher et al. (2010a); Wisdom et al. (2010)) or cigarette smoking (Adda and Cornaglia (2006, 2010)), as well as substitution of one healthy habit with another (Cawley et al. (2013)). Fletcher et al. (2010a) also look into household responses to policy measures aimed at curbing obesity, namely taxes on soda at the state level. Using data on child and adolescent body mass index (BMI) and food and beverage consumption recall from the National Health and Nutrition Examination Survey (NHANES), the authors find that taxes on soft drinks lead to a decrease in child and adolescent soft drink consumption. However, this reduction in soda consumption is completely offset by increases in consumption of other high-calorie drinks. Both the results of this paper and the results presented in Fletcher et al. (2010a) complement each other by highlighting the persistence of eating habits within the household, even following various policy interventions intended to change these - while in Fletcher et al. (2010a) households find substitute products, in this paper households find alternative sources for obtaining their carbonated beverages. In contrast to the existing literature, the substitution patterns found in this study are across different times of the day, as opposed to different products (e.g., Fletcher et al. (2010a)) or their usage (e.g., Adda and Cornaglia (2006, 2010)).

The paper contributes to the existing literature on school food environments, which mostly examines

[2]Just and Price (2013) and French et al. (1997) are examples of studies which evaluate an intervention to promote healthier eating habits only in the setting where the intervention took place. While the input from these interventions is important and informative, the authors themselves acknowledge that it is not possible to assess the overall dietary intake effects of these interventions due to no tracking of individuals' habits outside the intervention setting.

how specific school food environments affect children's obesity or BMI outcomes (Anderson and Butcher (2006); Currie et al. (2010); Datar and Nicosia (2012)) or evaluates health effects of school meals programs (Schanzenbach (2009); Millimet et al. (2010); Gleason et al. (2009); Bhattacharya et al. (2006)). However, very few papers in the literature address the underlying consumption mechanisms among children when school food environments change - i.e how households or individuals respond to changes in policies related to the school food environment. While it is important to assess the final outcomes of childhood obesity and weight gain in response to variations in school food environments, it is also important to understand the effectiveness of various policy measures in terms of limiting child consumption or access to unhealthy foods. This is particularly true if policies intended to improve student obesity or BMI outcomes prove ineffective, in which case uncovering the underlying mechanism at work is crucial for a better understanding of how to improve policy measures.[3] In this aspect, this paper is different from most of the past literature on childhood obesity and school food environments. While there are a few studies on school beverage bans and student overall beverage consumption (Fernandes (2008); Fletcher et al. (2010b); Huang and Kiesel (2012)), this paper is building upon this small exiting literature by estimating the *causal* effect of carbonated beverage restrictions and exploiting heterogeneity in the restrictions by school-level and over time.

The paper starts by discussing the school food environment, highlighting important landmarks in public awareness and its regulations over the last 25 years, with a focus on carbonated beverage policies at schools. Section 3 discusses the main data sources used for this paper: the Nielsen Homescan Data and an independently constructed data set on school districts' carbonated beverage policies for 2002-2009. Section 4 discusses the empirical strategy used for the analysis, as well as the identifying assumptions. Section 5 presents the results, followed by Section 6, which presents some of the results' robustness to various alternative specifications. Section 7 interprets the results using data on carbonated beverage consumption in schools. Section 8 provides some concluding remarks.

2 School Food Environment - Carbonated Beverages

The U.S. Department of Agriculture (USDA) sets federal standards for the provision of foods and beverages on school grounds to students. Nutritional standards on the fat and sugar content of the foods provided, calories per serving, and nutritional composition have always been in place for the provision of lunch and breakfast, as part of the National School Lunch Program (NSLP) and School Breakfast Program (SBP), respectively. Food items sold on school grounds outside the NSLP and SBP are categorized as competitive foods. Competitive foods can be sold in vending machines, school stores, cafeteria a la carte lines, or at fund raisers. Until July 1, 2014, the USDA had no regulations in place for the sale of competitive foods, with the exception of forbidding the sale of foods of minimal nutritional value (FMNV) in meal service areas during meal time - i.e. when and where the NSLP and SBP are served. FMNV include seltzer, chewing gum, lol-

[3] Datar and Nicosia (2012) is an example of an evaluation of limitations in the availability of junk food in schools which proved primarily ineffective.

lipops, jelly beans, and carbonated sodas.[4,5] With the exception of this restriction concerning FMNV, USDA regulations permitted the sale of FMNV anywhere else on campus, including just outside the cafeteria, at any time of day.[6]

Beginning in the 1990's, competitive foods were increasingly becoming a source of revenue for schools. The proceeds from sale of competitive foods go directly to the school and generally fund extra-curricular activities, such as clubs or athletic activities. To effectively maximize the revenue stream, many large school districts increasingly signed exclusivity agreements, entitling the provision of competitive beverages to one exclusive beverage provider for the entire school district, in exchange for higher commission rates to the schools and school district. Of the three school-levels - high, middle and elementary schools - high schools benefit most from competitive foods sales, in terms of revenues, and a large high school's stream of annual commissions from a beverage provider can range from several thousand dollars to over $20,000 (Government Accountability Office (2005)).[7]

Around the early 2000's there was a rise in public awareness concerning the link between soda drinking and obesity.[8] In response to this, many states and school districts began to question the provision of carbonated beverages on school grounds and to contemplate stricter regulations on the sale of competitive foods, and in particular FMNV, than those mandated by the USDA. The debate concerning these restrictions generated some controversy, due to concern that schools' revenue streams from competitive foods sales would be jeopardized. When restrictions were put in place, they frequently varied between elementary, middle and high schools, with the strictest regulations generally applying to elementary schools, so that high schools' commissions will not be as severely hurt. The restrictions' severity depended on whether the restriction applied to the entire school day or just during school meals[9] and the types of beverages restricted - only non-diet carbonated beverages versus all carbonated beverages.

In June 2004, the U.S. Congress passed the Child Nutrition and WIC Reauthorization Act of 2004. This law conditioned federal funding of the NSLP and SBP on each school district having a written wellness policy, which includes nutritional guidelines for all foods available on school campuses during the school day, by the first day of the 2006-2007 school year. Beyond the existent USDA regulations concerning foods available at schools, this law set no additional criteria on the nutritional guidelines which should be implemented at schools. However, the opportunity to formalize nutritional guidelines for foods available on school grounds prompted some school districts, which were already actively debating which foods should

[4] Source: http://www.cdc.gov/healthyyouth/mih/faq.htm

[5] Many low-nutrition foods are not considered FMNV, such as chocolate, candy bars, chips, cookies, snack cakes, and fruitades (containing little fruit juice), and therefore may be sold in the school cafeteria during meal times.

[6] In July 2013, the USDA issued for the first time ever standards for the sale of competitive foods in schools, and these were to be implemented in all schools by July 1, 2014. The new standards prohibit the sale of many FMNV products, including all carbonated beverages in elementary and middle schools and non-diet carbonated beverages in high schools.

[7] Penetration and availability of competitive foods increase with school-level. According to Fox et al. (2009), during the 2004-2005 school year, vending machines accessible to students were found in 98.4, 87.1 and 26.5 percent of high schools, middle schools and elementary schools, respectively.

[8] Research during this period also increasingly demonstrated the associative link between greater soft drink consumption and higher obesity and overweight rates (Vartanian et al. (2007); Ludwig et al. (2001)).

[9] Restrictions on the timing of vending machine availability are implemented through setting timers on school vending machines.

be available to students, to implement restrictions on the availability of carbonated beverages.

In May 2006, following increasing pressures from the media and public advocacy groups, the American Beverage Association, representing most beverage providers in the U.S., along with The Coca-Cola Company, Dr Pepper Snapple Group, and PepsiCo, voluntarily signed a memorandum of understanding jointly with the Clinton Foundation, the American Heart Association, and the Alliance for a Healthier Generation, setting new guidelines on competitive beverage availability in schools during the school day. The guidelines do not allow any carbonated beverages in elementary or middle schools during the extended school day. In high schools, only diet or no-calorie carbonated beverages are to be available during the extended school day.[10] These regulations were to be gradually phased into schools over the next four years. In 2010, Pepsi reported 99% compliance with the new regulations.

A small number of studies examine consumption patterns in relation to beverage restrictions in schools. However, this paper makes a substantial empirical contribution in comparison to these by evaluating a causal relationship and exploiting variation at the school-level (elementary/middle/high). Fernandes (2008) and Fletcher et al. (2010b) use the Early Childhood Longitudinal Study (ECLS) Kindergarten cohort of 1999 to evaluate the association between beverage bans in schools and student overall soft drink consumption. Fernandes (2008) is a cross-sectional study and the results are associative. In Fletcher et al. (2010b), the analysis compares mean consumption rates between children in schools with vending machine restrictions and children in schools without such restrictions. In contrast to Fernandes (2008) and Fletcher et al. (2010b), this paper utilizes a much richer panel data set, tracking households with children in different school-levels which experience various restrictions over several years and employs a triple differences strategy to establish a causal link between carbonated beverage bans in schools and household consumption. In Huang and Kiesel (2012) a limited subsample of the Nielsen Homescan data is used to examine whether households compensate in response to school carbonated beverage restrictions. However, the variation in school policies is only at the state level, rather than school district level variation used in this paper, and as such only one state experiences any reform.[11] Furthermore, there is no heterogeneity at the school level (elementary/middle/high), which was critical for this study's results. Due to this decreased precision in treatment designation, in comparison to this study, Huang and Kiesel find no effect of carbonated beverage bans on household consumption. This paper addresses the important question of household compensation in response to school carbonated beverage restrictions using richer data and more precise identification methods.

[10]The exact guidelines for high schools are regarding the calories per serving of beverages. Carbonated beverages in high schools are limited to those containing up to 10 calories per 8 oz.

[11]This paper's investigation into school district nutrition policies has revealed that using state-level legislation can be incorrect, as school district policies frequently precede state legislation, or alternatively, school districts implement a policy in states which have no restrictions in place. In fact, a closer look at the five control units used in Huang and Kiesel (2012) in comparison to the school district policies presented in this paper reveals that some of the control units defined as experiencing no restrictions per state laws actually were experiencing restrictions during the sample period at the school district level.

3 Data

3.1 Nielsen Homescan Data

The main data set used in this study is the Nielsen Homescan data for the period January 2004 through December 2009.[12] The Nielsen Homescan data makes use of a nationally representative sample of volunteer households across the United States. These households document their food item purchases at the barcode level using a scanner. The purchases are from a wide variety of store types, including traditional food stores, supercenters and warehouse clubs, as well as online merchants. The households record the date purchased, the price paid and any coupons or promotions used in the purchase.[13] It is important to note that food purchases from restaurants or vending machines are not documented. In addition, while small purchases from convenience stores should be documented by the household, these purchases are generally omitted from most households' scanning activity. Thus, for the most part, the data does not document any beverage purchases students make in school and it very likely does not capture beverage purchases students make on their way to/from school or while on lunch breaks off campus.

In addition to nearly full disclosure of the households' food purchasing patterns, Nielsen also annually documents various demographic characteristics for these households: race; income; household heads' age, education and working status; household size; household composition; and for years beyond 2006, the birth month and year of every household member. Household geographic information is at the census tract level. The number of households covered varies from year to year. For 2004-2006 the number of households was slightly under 40,000, while for 2007-2009 the number of households ranged from 60,000 to 63,000.

The unit of observation in the Nielsen data is a single purchase at the barcode level - every single product the household purchases is documented. For each barcode, the date of purchase is provided, as well as the price paid, the quantity and the amount in ounces, fluid ounces, or units when ounces cannot be measured. To capture household purchasing trends, the data for this study was aggregated to monthly purchases for each household for either non-diet soda or diet soda. Soda is a narrower category than carbonated beverages. The difference between the two categories is that non-diet soda is limited to only beverages categorized as carbonated soft drinks, while the non-diet carbonated category includes any sparkling drinks, such as sparkling water or juices. Soda was chosen as the main product category, although the bans in schools are on carbonated beverages, as soda represents the vast majority of the products purchased within school when carbonated beverages are available.[14]

Recognizing whether a household has a child in the school-level experiencing the change in the avail-

[12] This data was purchased from Nielsen by the U.S. Department of Agriculture, Economic Research Services and was generously provided to me for the purpose of this research.

[13] Relying on individuals' reporting of transactions raises the potential for caveats in the Nielsen Homescan data. Einav et al. (2010) compare the Nielsen Homescan data to transactions reported from a large supermarket retailer and find discrepancies in reported shopping trips, products, prices and quantities. However, to the extent that these discrepancies should not apply differentially to households in treated or control groups, the results from the triple differences strategies applied in this paper should still remain valid.

[14] Previous versions of this paper also looked into carbonated beverage household purchases in response to school districts' carbonated beverage bans, and the results were very similar to those of soda.

ability of carbonated beverages (i.e. whether the child is in elementary, middle or high school)[15] is most precise using the birth year and month of all household members, as well as the age threshold set for that school district for entering kindergarten.[16] As noted above, individual household members' birth year and month are provided in the Nielsen data only beginning January 2006. Fortunately, many households remain in the sample for several years, making it possible to extrapolate members' birth year and month for households in 2004 and 2005, which appear in either 2006 or 2007. Accordingly, over 64% and 53% of households with 3 or more household members in 2005 and 2004, respectively, reappear in either 2006 or 2007 and have their members' birth year and month provided.

3.2 School District Carbonated Beverage Policies

In addition to the Nielsen Homescan data, I use an independently constructed dataset documenting the presence, timing and extent of restrictions on the availability of carbonated beverages in schools for 46 large school districts throughout the United States for the period 2002-2009. As part of this data construction effort, I was in direct contact with school district representatives, as well as officials from state-level departments of education, who assisted in better understanding the state-level regulations and the timing these went into effect. Information provided by school district/state education representatives and found in online and media sources was often verified with documentation requested from school districts, such as: school districts' past and present wellness policies; contracts school districts had in place with beverage providers; board minutes documenting any board decisions or discussions regarding the district's policy on carbonated beverage sales to students; and requests for proposals the school district issued for the provision of carbonated beverages in schools. On numerous occasions the documentation had to be requested through the state's public records act.

The following information on carbonated beverage restrictions was required from school districts: the month and year the restriction went into effect; which school-levels the restriction affected (elementary/middle/high); and which carbonated beverages the restriction covered (diet or non-diet). Many school districts implemented restrictions on the availability of carbonated beverages during part of the school day (generally during lunch period or up to 1 hour after the last lunch period). These restrictions were not considered carbonated beverage restrictions for the construction of the policy data set, and only restrictions on the sale of carbonated beverages during the *entire* school day were considered carbonated beverage restrictions. The

[15] The relevant grades for each school-level were verified for every school district using school information provided on school district web sites. For the most part, elementary school is K-5th grade, middle school is 6th-8th grade, and high school is 9th-12th grade. There were nine school districts which had the highest grade for elementary school defined differently (eight had 6thgrade and one had 4thgrade). In Chicago Public Schools (IL), the vast majority of elementary schools are combined with middle schools and run through the 8thgrade. Nevertheless, because there were still numerous elementary schools running through 5thgrade and middle schools for 6ththrough 8thgrade, it was decided to define for Chicago Public Schools elementary school as K-5thgrade and middle school as $6^{th} - 8^{th}$grade.

[16] The threshold for entering kindergarten at a given state was determined for each birth year using primarily a data set already constructed in Elder and Lubotsky (2009). For Maryland, the information was modified due to online sources providing slightly different information. In Massachusetts and Pennsylvania, the kindergarten cutoff was determined by each school district locally, so separate verifications were made for Boston Public Schools and the School District of Philadelphia using primarily Lexis-Nexis.

logic behind this decision is the desire to capture the timing when carbonated beverages were no longer available in schools at all (at least for all the hours students spend in school).

School districts were targeted for collection of their carbonated beverage policies if they fulfilled either one of two sets of criteria: either the school district covered an entire county and that county had at least 60 households in the 2007 Nielsen Homescan data, or the school district had at least 50,000 students enrolled in it in 2005 and the county where the school district is located had at least 90 households in the 2007 Nielsen Homescan data.[17] Linking households to school districts which cover entire counties is based on the household's county identifier, provided in the Nielsen Homescan data. For large school districts which do not cover entire counties, households are linked to these school districts based on the household's census tract and use of an independently-constructed data set which lists each school district's census tracts using Geographic Information System (GIS) software.[18, 19] The criteria set for targeting school districts resulted in 51 target school districts (in 15 states) which covered an entire county and 33 target school districts (in 20 states) which did not cover an entire county. If details of carbonated beverage restrictions could not be verified sufficiently or produced conflicting information, target school districts were not included in the sample of covered school districts, as including them would likely measure the timing and nature of the treatment with substantial error. Furthermore, if the timing of the policies found for these school districts was between January 2002 and December 2003, these school districts were also excluded from the analysis because the Nielsen data - beginning only in January 2004 - does not capture the initial period after the policy's introduction.[20] School districts with restrictions taking place prior to January 2002 are included in the analysis and categorized as untreated. The underlying assumption behind this is that two years

[17]These thresholds for the number of households in the school districts county were determined based on the fact that approximately 2/3 of households in the Nielsen Homescan data do not have any children under the age of 18 present. Those that do have children present, do not necessarily have school-aged children. It was therefore determined that a minimal number of potential households in a given school district would justify the efforts of obtaining that school district's carbonated beverage policies.

[18]Shape files for school district and census tract geographic boundaries are available for download from the U.S. Census Bureau website at https://www.census.gov/geo/maps-data/data/tiger-line.html. School district geographic boundaries were as of 2007 and the census tract boundaries were as of 2000. The matching process only assigned a school district to a particular census tract if that school district appeared as the *only* school district within that census tract - i.e. census tracts which had more than one school district within their boundaries, according to the overlapping shape files, were not included in the analysis.

[19]There is the possibility that children in the household are attending private schools, rather than the public school system within the school district's boundaries. According to a U.S. Census Bureau School Enrollment Report, the national private school enrollment rate in 2000 was 10.4 percent. Based on enrollment figures at the state and school district levels from the U.S. Census Bureau, the National Center for Educational Statistics (NCES), and State Departments of Education, it was roughly estimated that no more than half of the counties included in the sample have private school enrollment rates exceeding 10 percent. The highest private school enrollment rates is for Washington, D.C. at approximately 30 percent, but all other covered school districts have private school enrollment rates below 20%. Private school enrollment rates are primarily driven by higher-income households in the population. To the extent that the Nielsen Homescan data is less representative of households in the highest income brackets, the private school enrollment rates among households in the sample will be lower (According to Table 2, the fraction of households in the sample with an annual income exceeding $125,000 sometime during the sample period was roughly 7%). If private school enrollment were indeed vast in the sample of Nielsen households used for the analysis, then the estimated effect of carbonated beverage bans would be biased downwards, as public school district policies would not apply to private schools. This would strengthen the argument in favor of compensation occurring at the household level in response to high school carbonated beverage bans even further.

[20]This resulted in the exclusion of six school districts. The main triple differences specification (discussed in Section 4) allows for a differential effect over time and can therefore include these school districts, as observing the delayed response in terms of purchasing patterns in the Nielsen data is taken into account in this specification. However, in the robustness checks, for ease of presentation, we present an alternative specification, without differential effects over time, which cannot include these school districts, and as such, for consistency, the sample of school districts is limited for the main specification. Results for the main specification with differential effects over time were very similar with the inclusion of these school districts.

Table 1: Covered School Districts by State and Treatment

State	Number of School Districts	High School Treatment	Middle School Treatment	Elementary School Treatment
CA	5	5	5	4
CO	2	2	2	2
DC	1	1	1	1
FL	13	5	5	0
GA	1	0	0	0
IL	1	1	0	0
KY	2	2	2	0
LA	2	2	2	2
MD	4	4	3	0
MA	1	1	1	1
NV	1	1	1	1
NM	1	1	1	1
NC	5	2	2	0
OR	1	1	0	0
PA	1	1	1	1
TN	3	1	3	3
VA	1	0	0	0
WV	1	1	0	0
Total	**46**	**31**	**29**	**16**

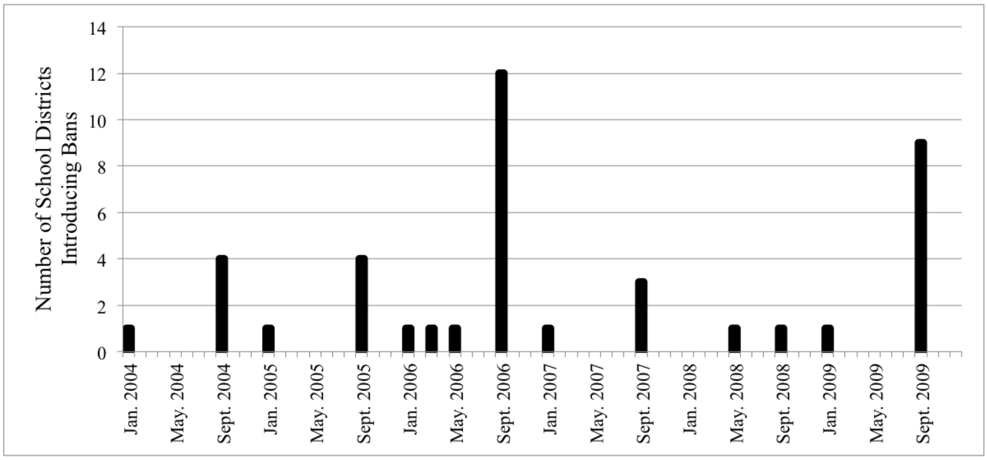
Notes: Treatment refers to any restriction on the availability of carbonated beverages during the entire school day at the indicated school-level in the school district implemented between January 2004 and December 2009.

is sufficient time for all households in the sample to adapt (at least in terms of purchasing *trends*) to any past restrictions implemented in their child's school. This resulted in a final data set of school districts' carbonated beverage policies for the period 2002-2009 comprised of 46 school districts in 18 states - 38 school districts which cover an entire county and 8 large school districts which do not cover an entire county.

Table 1 summarizes the covered school districts by state, and how many school districts received treatment (i.e. implemented bans on carbonated beverage sales) at the high school, middle school and elementary achoo level. Tables 6 and 7 in the Appendix list all target school districts which are excluded from the analysis and the reasons for their exclusion.

The restrictions were most frequently implemented in the summer months, when it was easiest to transition the content of vending machines, as the school year was not in progress. However, some school districts also chose to implement restrictions in the course of the school year. Figure 1 presents the variation in the timing of the restrictions. Tables 8 and 9 in the Appendix provide a detailed list of all covered school

Figure 1: Carbonated Beverage Ban Introductions by Month and Year



Notes: This figure shows the number of carbonated beverage bans for each month and year during the sample period. School districts which introduced bans more than once – whether for different school-levels or for different beverages (or both) – have all ban introductions represented in the figure. Ban introductions during July and August shift to September of that year, to represent the school-year months.

districts in the sample and the timing of restrictions on carbonated beverages.

4 Empirical Strategy

The empirical analysis aims to identify the effect of carbonated beverage restrictions in schools on children's household soda consumption. An increase in household consumption in response to a carbonated beverage ban in a child's school is evidence that households offset for the lack of availability of carbonated beverages in their child's school via home consumption. The term treatment refers to the introduction of a ban on carbonated beverages in a school district for the entire school day during the sample period (2004-2009).

I differentiate between the effect of carbonated beverage bans in elementary, middle and high school. This differentiation is for two reasons: First, the bans take place at different times for each school-level; Second, we would expect the bans to have a minimal effect (if any) on elementary school students' carbonated beverage consumption within school, due to low consumption levels among elementary school students and the fact that carbonated beverages are not necessarily readily available within elementary schools, even when no official ban is in place. In contrast to this, for high schools, the bans should be binding and have an effect on what high school students can actually consume within school. For middle school students, the effect of the ban on actual student consumption in school can be anywhere in the range between that of elementary school students and high school students. I run separate regressions with either non-diet soda or diet soda total fluid ounce household monthly consumption as a dependent variable. This is primarily because the timing of non-diet soda bans frequently differs from the timing of diet soda bans. Furthermore, consumption patterns of non-diet soda both within school and outside of school differ substantially among children, with diet soda representing only a small fraction of children's overall carbonated beverage consumption. In order to capture the true effect of the availability of carbonated beverages in school on household purchasing patterns, the regressions are run only for the months of September-June, when the school year is in place, and aggregated monthly purchases for July and August are dropped.

The assignment of treatment status for each household's monthly purchases of soda is determined based on three dimensions: which school district the household belongs to (treated vs. untreated school districts), when the household is observed (before or after treatment), and whether the household has children in the treated school-level present. This entails the opportunity to utilize a difference-in-differences-in-differences (Triple Differences) strategy. The triple differences strategy combines two control groups - households in untreated school districts and untreated households (due to the age of household members) within treated school district boundaries - in one single specification. In addition to variation over time, across school districts and the age of household members, changes in the presence of school-aged children in each of the three school-levels provides within household variation, due to children entering and exiting the various school-levels, which may or may not be treated.

While a difference-in-differences (DID) strategy is also an option for analyzing the effect of school carbonated beverage bans on household consumption, for the reasons discussed above, the triple differences strategy is viewed as superior to a DID strategy - it utilizes a greater sample size, utilizes more control groups, and exploits additional sources of variation. A description and results for a DID analysis are presented in Section C in the Appendix.

4.1 Triple Differences with Differential Effects Pre-/Post-Treatment

The availability of data for a relatively long period - January 2004 through December 2009 - allows me to estimate the effect of carbonated beverage bans in schools within the triple differences framework differentially over time. The triple differences specification thus includes separate dummies for each quarter before and after the restriction implementation. While the post-treatment estimates assess whether the treatment effect varies over time, the pre-treatment coefficient estimates are extremely useful for detecting whether any pre-existing trends in treated households' soda consumption existed prior the introduction of the carbonated beverage ban. The following estimating equation is defined:

$$
\begin{aligned}
floz_{ijt} = \beta_0 &+ \sum_{q=-10,q\neq 0}^{12} \sum_{s=1}^{3} \beta_1^{s,q} TrtQuarter_{jt}^{s,q} * SclChld_{ijt}^{s} + \sum_{q=-10,q\neq 0}^{12} \sum_{s=1}^{3} \beta_2^{s,q} TrtQuarter_{jt}^{s,q} \\
&+ \sum_{s=1}^{3} \beta_3^{s} TrtDistrict_{ij}^{s} * SclChld_{it}^{s} + \sum_{s=1}^{3} \sum_{m=1}^{M^s} \beta_4^{sm} TrtTime_t^{sm} * SclChld_{it}^{s} \\
&+ \sum_{s=1}^{3} \beta_5^{s} TrtDistrict_{ij}^{s} + \sum_{s=1}^{3} \beta_6^{s} SclChld_{it}^{s} + \gamma X_{it} + h_i + month_t + \phi_j t + \varepsilon_{ijt}
\end{aligned} \tag{1}
$$

The dependent variable in equation (1) is the number of fluid ounces of soda - either non-diet or diet - purchased by household i, residing within school district j's boundaries in month t during the period January 2004 through December 2009.[21] $TrtQuarter_{jt}^{s,q}$ is an indicator variable equal to 1 if household carbonated beverage consumption is observed q quarters relative to the introduction of a carbonated beverage restriction $q \epsilon \{-10, ..., -1, 1, ..., 12\}$ in school-level s $s \epsilon \{elementary, middle, high\}$ within the household's school district j. $q = 0$ represents the quarter the policy was implemented, and it is the omitted period when evaluating changes in household carbonated beverage consumption over the different quarters relative to the ban introduction. The $TrtQuarter_{jt}^{s,q}$ dummy variables for the two extreme values of q receive values of 1 for all observations which are 10 *or more* quarters before the treatment (for $q = -10$) or 12 *or more* quarters post-treatment (for $q = 12$). The indicator $TrtQuarter_{jt}^{s,q}$is multiplied by $SclChld_{ijt}^{s}$, which measures the number of children in the household in school-level s. This variable ranges from zero to four in the sample of households, and therefore can be thought of as capturing the intensity of treatment, in terms of how many treated children in school-level s are actually in the household when looking at a household in a school district treating school-level s. Equation (1) provides 66 coefficients of interest, represented by the vector $\beta_1^{s,q}$: (10 pre-treatment quarter dummies + 12 post-treatment quarter-dummies) * 3 school-levels. Each component of the vector $\beta_1^{s,q}$ asks the following: For each additional treated household member in school-level s, what is the change in household carbonated beverage consumption q quarters relative to the quarter of the change in the school district's carbonated beverage policy?

$TrtDistrict_{ij}^{s}$ is a dummy for whether the school district imposed a restriction on the availability of carbonated beverages during the entire school day at any time during the sample period for school-level s.[22] $TrtTime_t^{sm}$ is a series of dummy variables indicating the beginning of each treatment period at the month level (differentiated by superscript m) for school-level s and the specific carbonated beverage in the dependent variable.

The inclusion of lower-order interaction terms in equation (1) controls for consumption patterns mutual to treated households irrespective of when they are observed ($TrtDistrict_{ij}^{s} * SclChld_{it}^{s}$), general consumption trends among treated households regardless of the number of treated school children in the household ($TrtQuarter_{jt}^{s,q}$),[23] and mutual purchasing patterns in all households in the various post-treatment periods, irrespective of whether the households are in treated school districts or not ($TrtTime_t^{sm} * SclChld_{ijt}^{s}$). The

[21] An additional dependent variable was considered - an indicator for whether the household consumes diet/non-diet soda - in order to determine the effect of carbonated beverage bans on household soda consumption at the extensive margin. While the coefficient estimates of these regressions were consistent with the results presented below, they were not statistically significant, and therefore, due to inability to conclusively assert whether an effect indeed existed at the extensive margin, these results are not presented in the paper.

[22] Note that some school districts may have a value of zero for $TrtDistrict_{ij}^{s}$, although they actually do restrict carbonated beverage sales during the entire school day in school-level s. These are school districts which introduced the restriction at least 2 years prior to the start of the sample period (i.e. prior to 2002). The assumption is that households in these school districts with children in the school-level with the restriction had sufficient time to adjust their purchasing patterns by the start of the sample period, and therefore we do not gain any information on households' purchasing patterns in response to carbonated beverage restrictions in schools by classifying these school districts as treated for that specific school-level.

[23] Over 16%, 10% and 23% of treated high school, middle school and elementary school households, respectively, have more than one treated child at that school-level.

inclusion of the dummy variables $TrtDistrict^{s}_{ij}$ controls for purchasing patterns mutual to all treated school districts for each school-level s.[24] The inclusion of the variables $SclChld^{s}_{it}$ for each of the three school-levels controls for purchasing levels among households with a certain number of children in each of the school-levels, irrespective of whether the household is treated and when it is observed. Household fixed effects (h_i) are included to control for unobserved household characteristics, and month-year fixed effects ($month_t$) are included to control for both seasonality in food purchasing patterns and shocks in purchasing patterns which are common to all households over time. The inclusion of a series of dummies for post-treatment periods is captured by the month-year fixed effects.[25] X_{it} controls for time-varying household characteristics - household size, the presence of children under six years old in the household, whether either household head is 55 or over, whether annual household income is less than \$10,000 per household member, and full-time employment of either household heads. These variables vary annually, when Nielsen updates its surveys of household members' demographic characteristics.[26] ϕ_j estimates school-district-specific linear time trends to account for any changes over time in households' soda consumption that are specific for households residing within a specific school district's boundaries. Robust standard errors that account for the correlation of unobservables within a school district are reported for all coefficients.

4.2 Identification

The validity of the triple differences design depends on the exogeneity of the introduction of the carbonated beverage restriction in the school district. It can be argued that these restrictions are put in place in response to certain trends in the school district's community. If there were pressures from within the community to impose these restrictions, then it may be that any change within the household in carbonated beverage consumption following a restriction will be biased downwards, as these restrictions are also accompanied by increased awareness concerning the potential harmful effects of carbonated beverages. Therefore, we should see households decreasing their consumption of carbonated beverages with the policy implementation (or slightly before). If a trend of increased soda consumption within households is causing local policy makers to revise the school district policy regarding carbonated beverage availability, then the estimates of the effect of carbonated beverage restrictions on household consumption will be biased upwards. While these are potentially valid arguments, the former possibility is not of as much concern, due to the positive effect found. Therefore, if the results are biased downwards, then this implies that household compensation following carbonated beverage restrictions is even greater than that estimated.

I address the potential for endogeneity of the carbonated beverage restrictions in school districts with

[24] With the inclusion of household fixed effects (see description of h_i below), β_5 is estimated based only on a very small number of households which are observed changing school districts during the sample period.

[25] Note that equation (1) controls for trends in the post-treatment period among all school districts in the sample with the series of dummies $TrtTime^{sm}_{t}$ at the monthly level, rather than quarterly dummies, because quarterly treatment dummies are individual for each school district and are relative to the individual timing of the school district's policy, and therefore cannot be applied to all school districts in the sample, as is required when controlling for post-treatment trends among *all* school districts.

[26] Non-time-varying household characteristics, such as race or household heads' education levels, cannot be controlled for due to the household fixed effects in the regression.

three arguments: First, I argue that at least the *exact timing* of the implementation of these restrictions is unrelated to household preferences in their respective school district. Second, the inclusion of school-district-specific linear time trends in the regression specifications (ϕ_j) should alleviate at least some of the concern for not capturing any pre-existing trends in households' consumption of carbonated beverages. Last and most importantly, I argue that the triple differences specification alleviates concerns that events/factors/shocks which are correlated with the occurrence of carbonated beverage restrictions in schools but not related to these restriction are driving the results. This is because any such events/factors/shocks would have to differentially affect households with treated high school children within the boundaries of the school district, in comparison to all other households in the school district boundaries.

With regards to the timing of these restrictions: restrictions were often enacted many months before their implementation. This was either because the decision was made during the school year and it was decided to change the content of vending machines only between school years, when the change is easier to implement, or because the school district made a decision to restrict carbonated beverages while still signed on a contract with a beverage provider and it was decided to implement the new policy only after the contract expires.[27] In addition, due to the expected loss in revenues from the sale of competitive foods, the actual decisions were often preceded by several years of an ongoing debate among board members, and the carbonated beverage restrictions passing (or not passing) only marginally.[28] Lastly, some school district changes in carbonated beverage policies were due to state laws (e.g., Louisiana, New Mexico and California), which are not necessarily determined by local trends. Moreover, the state law could have passed many months prior to the implementation of the policy.[29]

To address concern that the policies are in response to pre-existing trends in household carbonated beverage consumption, I include in all my preferred regression specifications school-district-specific linear time trends. Thus, in order for school-district-specific pre-existing trends to be confounding any results, their effect on household carbonated beverage consumption would have to be not sufficiently captured by linear time trends.

Nevertheless, the threat to identification is substantially alleviated in the triple differences specification, which controls for trends within school district boundaries through the inclusion of households in this

[27]For example, Miami-Dade County Public Schools (FL) ruled on a soda ban in all its schools in November 2005, but the policy only came into effect in July 2006. Baltimore County Public Schools (MD) implemented its ban on non-diet carbonated beverages in high schools and all carbonated beverages in middle schools in August 2008, when its exclusivity agreement for 2002-2008 expired. Chicago Public Schools (IL) introduced its carbonated beverage ban in January 2005, following the expiration of its exclusivity contract with Coke on Nov. 15, 2004.

[28]In Jefferson County Public Schools (KY), the board ruled to eliminate all FMNV from school vending machines and promote healthier snacks, with the exception of soda, already in 2004. Only in 2006, after two years of debates, did a decision pass to eliminate all carbonated beverages from school vending machines as well (and not just restrict the availability to certain hours during the school day). Hillsborough County Schools (FL) had an item in its July 2008 board meeting agenda to approve implementation of the Alliance for a Healthier Generation Guidelines in all its schools. However, this item was withdrawn at the last minute (appears crossed out in archived board meeting agendas), due to high school principals' objections. All carbonated beverages remained available in Hillsborough County Schools as of the end of 2011.

[29]In Albuquerque Public Schools (New Mexico) the state law forbidding carbonated beverage sales during the school day (but allowing diet carbonated beverages in high schools) passed in February 2006. However, the school district only implemented the new ruling in Summer 2006. California state legislation in 2005 provided high schools nearly four years advanced notice to eliminate availability of carbonated beverages.

geographic area which do not have children in the particular treated school-level. Because the triple differences analysis below shows that households with treated high school students compensate for the lack of availability of non-diet soda in their children's schools once carbonated beverage restrictions are in place, any potential threat to identification would have to be a factor that is correlated with carbonated beverage restrictions in high schools and differentially affects households with high school students, in comparison to households within the same school district boundaries which do not have high school students present.

5 Results

5.1 Descriptive Statistics

Table 2 provides summary statistics for households in the sample, as well as for households from the Nielsen data which are not in any of our covered school districts. Overall, there are 10,308 households, appearing for an average of 22 months, out of which 7,517 reside within the boundaries of treated school districts. Nearly 80,000 households from the Nielsen 2004-2009 data are not in our analysis. The probability that a household in our sample had a child in elementary, middle or high school during the sample period ranges from 0.12 to 0.14. These low probabilities are consistent with the average household size being slightly above two and the high fraction (~50%) of households with a household head who is 55 or over. Nielsen households which are excluded from the analysis have more children and larger household sizes, reflecting the fact that the majority of school districts in our sample are urban. The racial composition of the households in our samples is about 16 percent black and 8 percent Hispanic. Nielsen families excluded from the analysis have lower rates of Blacks and Hispanics, again a reflection of the urban nature of our sample of school districts. Roughly 53% of households have a bachelor's degree or higher, and about 11% of households earned less than $10,000 annually per household member while 7% had earned an annual household income exceeding $125,000 during the sample period.

Comparing the descriptive statistics between the households in the samples and those in the Nielsen data reveals that the households in the analysis are likely not representative of the entire U.S. population. This raises the question of how much our results can be generalized to household consumption patterns for the general population and compensation in response to carbonated beverage bans in schools. With respect to this, it is reassuring that a robustness check in Table 4 exhibits that the results do not change substantially when adding time-varying household characteristics. This suggests that the results are not being driven by household characteristics specific to the sample of households in use.

A test for non-random selection/assignment of households into treatment would compare the characteristics of treated households to those of untreated households. Columns (1)-(2) of Table 3 show that there are differences between households residing within treated and untreated school district boundaries. However, our triple differences specification does not assign treatment based solely on households' geographic

Table 2: Descriptive Statistics

	46 Covered School Districts	Nielsen Data Excluding Covered SD's
Total Number of Households	10,308	79,781
Number of Households in Treated S.D.	7,517	N/A
Number of Months in Sample	21.950	16.263
	(13.650)	(13.112)
Elementary Child in Household sometime during Sample Period	0.129	0.150
	(0.333)	(0.357)
Middle Child in Household sometime during Sample Period	0.122	0.132
	(0.324)	(0.339)
High Child in Household sometime during Sample Period	0.141	0.159
	(0.347)	(0.366)
Black	0.164	0.084
	(0.368)	(0.276)
Hispanic	0.078	0.051
	(0.263)	(0.216)
16+ Years of Schooling	0.530	0.498
	(0.491)	(0.492)
Annual Income <$10K per Household Member	0.110	0.136
	(0.289)	(0.319)
Annual HH Income > $125K sometime during Sample Period	0.069	0.060
	(0.252)	(0.238)
Household Size	2.284	2.464
	(1.234)	(1.308)
Child Less than 6 Years Old Present	0.077	0.096
	(0.252)	(0.279)
Full-Time Work by at least one Household Head	0.654	0.677
	(0.456)	(0.448)
Head 55 Years or Older	0.490	0.465
	(0.485)	(0.485)
Top 15% of Nielsen HHs' Non-Diet Soda Consumption	0.153	0.154
	(0.295)	(0.318)
Internet Connectivity	0.809	0.804
	(0.376)	(0.380)
Monthly Non-Diet Soda Consumption per HH Member (fl oz)	80.212	69.880
	(135.372)	(132.017)
Monthly Diet Soda Consumption per HH Member (fl oz)	86.278	83.058
	(176.290)	(171.563)

Notes: Means are calculated at the household-year level. Standard deviations are in parentheses. Household purchases for July and August are excluded. All variables cover the entire sample of households, with the exception of internet connectivity, which only covers roughly 72% of households. Top 15% of Nielsen households' non-diet soda consumption is an indicator for whether the yearly average of household non-diet soda monthly fluid ounce consumption per person was in the top 15% of total per-person monthly non-diet soda purchases from the entire Nielsen data set.

location (in addition to the time dimension), but rather looks also at the age of the household members in order to determine treatment. It is for this reason that the most appropriate test for non-randomness of households into treatment is a series of falsification tests, utilizing a very simplified variation of the triple difference specification outlined in equation (1), with the dependent variables being exogenous household characteristics. Specifically, the falsification tests estimate whether plausibly exogenous characteristics changed for households with a school-aged child that is treated, while controlling for trends in household characteristics among households within the same school district boundaries which do not have a treated child and for trends among households with school aged children in general, regardless of whether they experienced a carbonated beverage ban in their school or not. Furthermore, as in equation (1), district-specific fixed effects, district-specific linear time trends, and month-year fixed effects are controlled for. The results of these falsification tests are presented in column (3) of Table 3, and they show that out of 12 exogenous household characteristics there is only one statistically significant relationship between the characteristic and households' treatment status. This lack of a correlation indicates that it is unlikely that non-random factors determine households' treatment status.

5.2 Triple Differences with Differential Effects Over Time

The triple differences analysis, as specified in equation (1), allows me to vary the effect of carbonated beverage restrictions in schools over time and to test for pre-existing trends in household soda consumption. The different estimates for the post-treatment periods can examine whether any compensation observed post-treatment applies to the long-run, short-run, or both. These results are presented in Figure 2, for non-diet soda (left side) and diet soda (right side). Figure 2 plots each of the 66 coefficient estimates for the interaction terms on $TrtQuarter_{jt}^{s,q} * SclChld_{it}^{s}$ from equation (1). Each smaller figure shows the coefficient estimates for 22 interaction terms at a specific school-level (and beverage - diet or non-diet soda) for a specific quarter (10 pre-treatment quarters and 12 post-treatment quarters), along with their 95% confidence intervals. The excluded period from the regression specification is the quarter during which the restriction was introduced, and therefore, all coefficient estimates measure how household carbonated beverage consumption differed q quarters relative to the quarter of the ban introduction for each treated child in the household at the relevant school-level. For the quarter of introduction (zero on the horizontal axis), this measure is zero without having confidence intervals.

The first thing to evaluate in Figure 2 is whether pre-existing trends in treated households' soda consumption exist prior to the introduction of the various bans for the different school-levels. This is possible through examining the coefficient estimates for $q \leqslant -1$ and whether any upward or downward trend is found in these estimates. For the most part, such trends are not found in Figure 2, with the exception of sub-Figure (b), which presents evidence of a rising trend in diet soda consumption among households with a high school student in a high-school-treatment school district prior to high school diet carbonated beverage bans (for $q = -4$ through $q = -1$) and sub-figure (f), which shows a steady lower consumption level

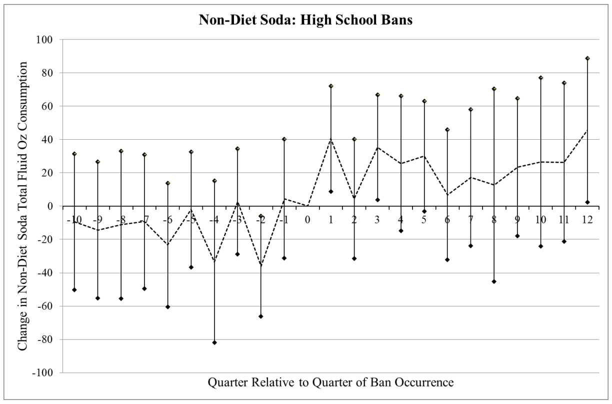
Table 3: Comparing Household Characteristics between Treated and Untreated Households

Household Characteristic	(1) Treated	(2) Non-Treated	(3) Triple Differences
Number of Months in Sample	29.942	28.434	0.429
	(18.311)	(18.135)	(0.689)
Black	0.187	0.102	-0.024
	(0.387)	(0.302)	(0.028)
Hispanic	0.089	0.046	0.049*
	(0.281)	(0.204)	(0.026)
16+ Years of Schooling	0.536	0.511	0.001
	(0.490)	(0.492)	(0.037)
Annual Income <$10K per Household Member	0.109	0.112	-0.020
	(0.286)	(0.294)	(0.027)
Annual Household Income > $125K sometime during Sample	0.066	0.072	0.023
Period	(0.249)	(0.259)	(0.023)
Household Size	2.284	2.281	-0.068
	(1.243)	(1.208)	(0.058)
Child Less than 6 Years Old Present	0.077	0.076	-0.004
	(0.251)	(0.253)	(0.019)
Full-Time Work by at least one Household Head	0.671	0.607	-0.019
	(0.449)	(0.471)	(0.031)
Head 55 Years or Older	0.472	0.539	0.044
	(0.484)	(0.485)	(0.036)
Top 15% of Nielsen Household	0.163	0.146	-0.018
Non-Diet Soda Consumption	(0.330)	(0.320)	(0.023)
Internet Connection	0.804	0.823	-0.025
	(0.379)	(0.366)	(0.033)
Households	7,517	2,791	

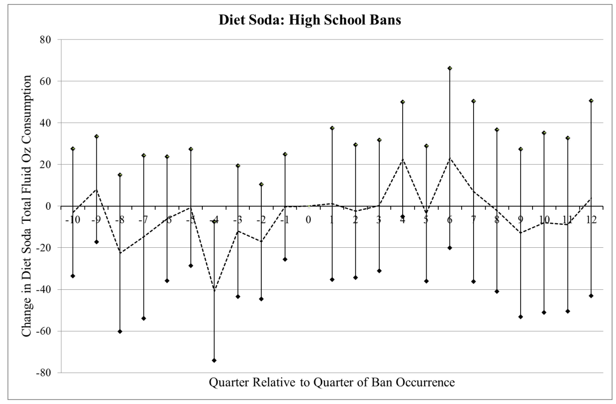
Notes: Means in columns (1)-(2) are at the household-year level. Numbers in parentheses in columns (1)-(2) are standard deviations. Column (3) presents coefficient estimates for the household having a school-aged child that is treated, while controlling for district-specific fixed effects, district-specific linear time trends and month-year fixed effects. Numbers in parentheses in column (3) are standard errors clustered at the school district level. Household purchases for July and August are excluded. The number of observations for all regressions is 304,343, with the exception of the regression for internet connection, which has missing values in the data and the number of observations is 232,051. Variable definitions are as in Table 2. *** p<0.01, ** p<0.05, * p<0.1

Figure 2: Quarterly changes in monthly soda consumption, relative to the quarter of ban introduction

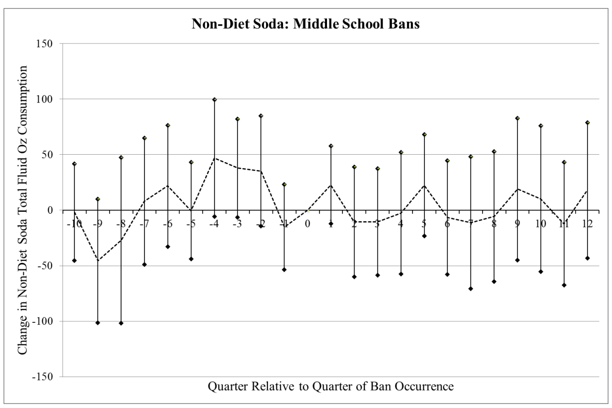
(a)



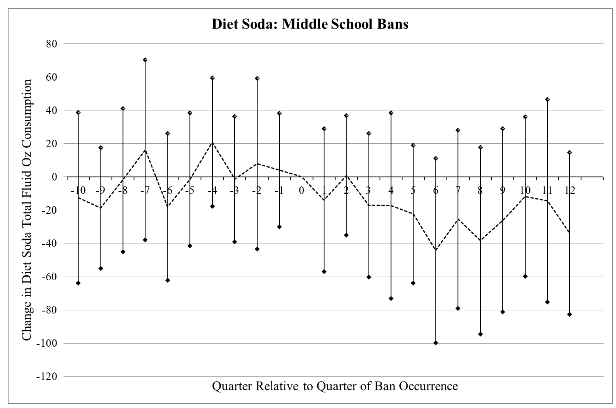
(b)



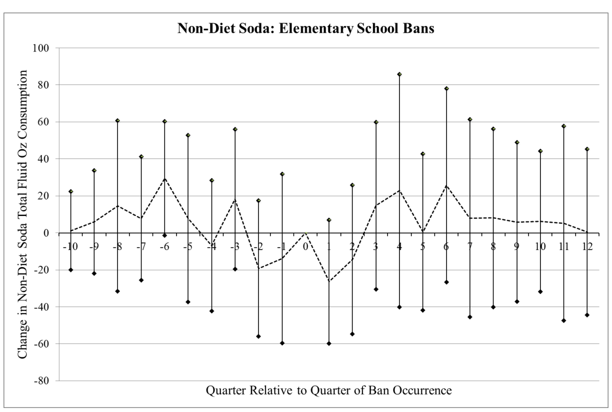
(c)



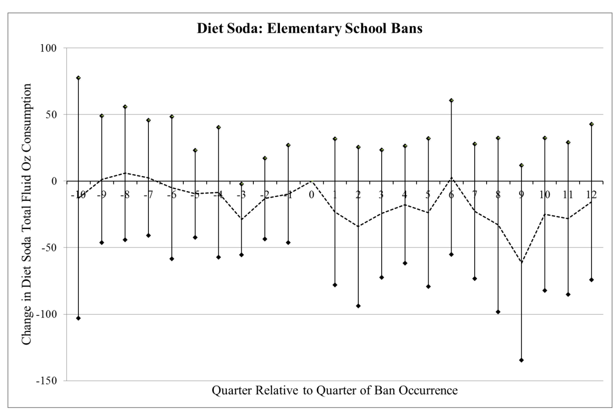
(d)



(e)



(f)



Notes: This figure shows the change in monthly household non-diet and diet soda consumption (in fluid ounces) in comparison to the quarter that the beverage restriction was introduced, as estimated from the coefficients in equation (1). The left-hand-side plots are for non-diet soda consumption and the right-hand-side plots are for diet soda consumption. Each estimate can be interpreted as the difference in household beverage consumption in comparison to the quarter the restriction on that beverages was introduced in high school, elementary, or middle school for each treated child in the household. The horizontal axis represents the number of quarters relative to the policy implementation. The vertical lines span the 95% confidence intervals for each coefficient estimate. The coefficient estimate for the period of the ban introduction (zero on the horizontal axis) is omitted from the regression specification and its value is zero without confidence intervals. The regressions producing the above estimates have as the dependent variable monthly household total fluid ounce consumption for the relevant beverage. The specifications include: month-year and household fixed effects, school-district-specific linear time trends, and time-varying household characteristics. Robust standard errors are clustered at the school district level. Number of observations is 304,434. Household purchases for July and August are excluded.

of diet soda one year prior to elementary school diet bans (in comparison to the quarter of the ban and to the period of 6-9 quarters prior to the ban) among households with treated elementary school children.

For the post-ban coefficient estimates, it is very evident that households with high school students who experienced non-diet carbonated beverage bans (sub-figure (a)) increased non-diet soda consumption immediately following the ban, and this increase appears to persist even more than a year after the ban's introduction (as is shown with the coefficient estimate for $q = 5$, which is statistically significant at the 10% level). Sub-Figure (a) in Figure 2 also suggests that the increase was greatest in the quarter immediately following the ban, as is evident from the coefficient estimate for $q = 1$ receiving the highest value (40.43 fluid ounces, or 3.37 cans of soda). However, tests for whether this coefficient estimate was statistically significantly different from most other post-ban coefficient estimates did not indicate this. Figure 2 does not present evidence of significant changes in household soda consumption in response to elementary and middle school bans and diet soda bans at all school levels.[30]

The precision of the coefficient estimates appears to decline in sub-figure (a), as the post-treatment quarters increase, in particular after the 5^{th} quarter following the ban's introduction. Furthermore, the pre-treatment period appears to be characterized by slightly lower levels of consumption (on average) relative to the quarter of the ban introduction ($q = 0$). Thus, in order to obtain a single rough estimate for the change in household non-diet soda consumption after a high school non-diet carbonated beverage restriction for each treated high school student in the household based on the estimates presented in sub-figure (a), I calculate the average of the point-estimates from the 5 quarters following the ban introduction (27.15 fluid ounces) and subtract from that the average of the point-estimates from the 8 quarters preceding the ban introduction (-13.5 fluid ounces).[31] This results in an estimated change in household monthly non-diet soda consumption in response to carbonated beverage bans in high schools, relative to consumption levels before the ban introduction, of 40.65 fluid ounces for each treated high school student residing in the household.[32] This is equivalent to 3.39 cans of soda. According to Table 2, the average household in the sample consumes about 183 fluid ounces of non-diet soda per month.[33] Thus, households with a high school student are increasing non-diet soda consumption by roughly 22 percent of the average household monthly consumption during the first 15 months following the introduction of non-diet carbonated beverage bans in their child's high school.[34] According to Table 10 in the Appendix, households with a high school student

[30]Following middle school diet soda bans, there appears to be a slight downward trend in household consumption.

[31]It can be seen from the magnitude of the estimates presented in sub-figure (a) that this calculation is not substantially sensitive to taking different combinations of quarters either preceding or proceeding the ban introduction.

[32]Note that this is only a rough and slightly imprecise estimate, as it takes the mean of all point-estimates in sub-figure (a), despite that different point-estimates are based on a different number of school districts. For example, school districts which implemented a high school non-diet carbonated beverage restriction only at the start of the 2009-2010 school year (9 such school districts), are only included in the estimation of the point-estimate for $q = 1$ in sub-figure (a) and not in the estimation of any proceeding point-estimates, due to the sample period ending in December 2009. Nevertheless, as will be shown in columns (1)-(2) of Table 4 in the Robustness Checks section, this estimate is very close to what is obtained when estimating the average one-year change in household non-diet soda consumption in response to high school restrictions using a triple differences specification with a single dummy variable for the entire year following the ban introduction.

[33]This figure can be reached by taking average monthly consumption per household member and multiplying it by average household size.

[34]Note that this period can also be interpreted as the first 16-19 months following the ban introduction, as the estimate for $q = 0$

present consume on average 339 fluid ounces of non-diet soda per month. Thus, the 40.65 fluid ounce increase in non-diet soda consumption in response to high school carbonated beverage restrictions represents a 12 percent increase from the average monthly consumption for households with a high school student.

6 Robustness Checks

To ensure the validity of the results presented above, I perform several robustness checks. The robustness checks are presented using a more simple specification of the triple differences approach than that specified in equation (1), so as not to over-burden the results presentation with 66 coefficient estimates, as in Figure 2. Specifically, the estimating equation used for the robustness checks is:

$$\begin{aligned} floz_{ijt} &= \beta_0 + \sum_{s=1}^{3} \beta_1^s DistrictBan_{jt}^s * SclChld_{it}^s + \sum_{s=1}^{3} \beta_2^s \sum_{t=1}^{T} DistrictBan_{jt}^s \\ &+ \sum_{s=1}^{3} \beta_3^s TrtDistrict_{ij}^s * SclChld_{it}^s + \sum_{s=1}^{3} \sum_{m=1}^{M^s} \beta_4^{sm} TrtTime_t^m * SclChld_{it}^s \\ &+ \sum_{s=1}^{3} \beta_5^s TrtDistrict_{ij}^s + \sum_{s=1}^{3} \beta_6^s SclChld_{it}^s + \gamma X_{it} + h_i + month_t + \phi_j t + \varepsilon_{ijt} \end{aligned} \tag{2}$$

The dependent variable, $TrtDistrict_{ij}^s$, $TrtTime_t^{sm}$, $SclChld_{it}^s$, X_{it}, h_i, $month_t$ and $\phi_j t$ are as defined above for equation (1). $DistrictBan_{jt}^s$ is an indicator variable for monthly household purchases which are observed when a ban on school-level s is in place in their assigned school district. Equation (2) multiplies $DistrictBan_{jt}^s$ by $SclChld_{it}^s$, which measures the number of children in the household in school-level s. Thus, each of the three $\beta_1^s (s\epsilon \{elm, mid, hs\})$ estimates provides a measure for the change in household monthly soda consumption after implementation of the carbonated beverage restriction at school-level s, and this is done at the intensive margin - i.e. for each treated child in school-level s residing in the household. These are the three main coefficients of interest in equation (2), and this is in contrast to 66 coefficients of interest in equation (1). The main difference between equation (1) from the main results above (Section 5) and equation (2) used for the robustness checks is that equation (1) allows for differential effects over time of the carbonated beverage bans, while equation ((2)) estimates the effect of the ban for a single period post-treatment. Furthermore, equation ((2)) compares the change in consumption following the ban to the entire pre-treatment period, while equation (1)'s coefficient estimates present the change in household consumption in comparison to the quarter the change occurred, due to measuring household consumption patterns prior to the restriction's introduction (coefficient estimates for $TrtQuarter_{jt}^{s,q}$ for $q \leq -1$) in equation (1).

Figure 2 shows that the precision of the point estimates for the changes in household carbonated beverage consumption in response to restrictions in school decrease over time, in particular with respect to high school non-diet soda bans. For this reason, the sample of monthly consumption observations for treated

includes 1-3 months immediately after the ban introduction.

households for all estimations of equation (2) is 12 months following the latest ban introduction and 24 months prior to the earliest ban introduction.[35] In this respect, equation (2)'s estimates can be interpreted as capturing the short-term effect (approximately one year post-treatment) of carbonated beverage bans in schools on household consumption.

The inclusion of $DistrictBan^s_{jt}$ in equation ((2)) is controlling for similar purchasing patterns in households within school district boundaries which treat school-level s, following the implementation of the policy, irrespective of whether a treated child is present in the household. The interaction between $TrtDistrict^s_{ij}$ and $SclChld^s_{it}$ controls for similarities in purchasing patterns among households with children at the treated school-level in their respective school districts, irrespective of the timing of the policy implementation. β_4 is a vector with $M^{elm} + M^{mid} + M^{hs}$ components for every post-treatment period at the relevant school-level, and it estimates purchase trends in all households with children in the various post-treatment periods.

6.1 Base Results

The base results for equation ((2)) are in columns (1)-(2) in Table 4, which present the estimated coefficients (and standard errors in parenthesis) on $DistrictBan^s_{jt} * SclChld^s_{it}$ for $s = \{Elementary, Middle, High\}$. Each column in a panel (non-diet soda for the top and diet soda for the bottom) presents the three coefficient estimates from one single regression. Column (1) presents coefficient estimates when time-varying household-level characteristics are not included in the regression, and column (2) adds these characteristics to the regression specification. As can be seen, the coefficient estimates hardly change with the inclusion of time-varying household-level characteristics. This is reassuring in light of our sample of households not being representative of the entire U.S. population, as shown in Table 2, as it is indicative that the results of our regression analysis are not being driven by demographic characteristics specific to the households used in the sample.

The results in column (2) of Table 4 show that households with treated high school children are positively responding to carbonated beverage bans in terms of non-diet soda consumption, but no such response is evident for households with treated elementary or middle school students or for diet soda bans. Households with treated high school students increased their non-diet soda consumption by roughly 37 fluid ounces per month for each treated high school household member (equivalent to an increase of a little over 3 cans of soda per month). This represents a 20.4 percent increase from the average total household non-diet soda consumption. Average monthly household non-diet soda consumption when a high school child is present is 339.2 fluid ounces (see Table 10, panel I in the Appendix), and as such, the estimated increase in non-diet soda consumption in response to a high school ban represents nearly 11 percent of the average monthly non-diet soda consumption for households with a high school child. This estimated effect

[35]For five school districts (Fresno Unified (CA), San Bernardo Unified (CA), San Diego Unified (CA), East Baton Rouge (LA), and Jefferson (LA)), the timing of bans during the sample period differs between school-levels, and as such the post-treatment period for observations receiving the earlier treatment within these school districts is longer than 12 months. See Tables 8 and 9 for details on the timing of bans for these school districts.

for households with treated high school students is very close to the overall effect calculated for the first 5 quarters following the ban introduction based on sub-figure (a) in Figure 2: 40.65 fluid ounces.

A statistically significant *decrease* in diet soda consumption is observed in response to diet elementary school bans (p-value 8%). Given the limited soda consumption of elementary school students, it is not clear why households should respond in any way to carbonated beverage bans at elementary schools. A closer look at sub-figure (f) in Figure 2 reveals that this result can be partially observed in the longer-term analysis, represented by equation (1): the coefficient estimates for the first four quarters following the ban are negative, with values averaging -25, which is very close to the -21.7 coefficient estimate presented in column (2) of Table 4.[36] Sub-figure (f) in Figure 2 also presents evidence of relatively low diet soda consumption among households with elementary school children roughly a year prior to elementary school diet soda restrictions. Thus, it appears that households experiencing elementary school diet soda bans were not necessarily decreasing their consumption of diet soda in response to the ban (as the results of column (2) in Table 4 may indicate), but rather this decrease is already evident about a year prior to the ban. A robustness check presented further in this Section (Figure 3) also shows that the apparent decrease in diet soda consumption in response to elementary school restrictions may be driven by pre-ban diet soda consumption trends among these households.

6.2 Exclusion of School Districts

To ensure the results were not driven by a single state or school district in the sample, the baseline triple differences regression presented in equation (2) was run excluding single states which had more than one school district or the states which had a single school district. The results, which remained qualitatively and for the most part quantitatively unchanged are presented in Table 4. In each column in columns (3) through (11) a different set of school districts is excluded from the sample, based on the state of the school districts. The high school non-diet coefficient estimates are all statistically significant and range from over 33 to nearly 45 fluid ounces. This is with the exception of when taking out Florida school districts (13 school districts), which produces a coefficient estimate of 25.5 fluid ounces and statistical significance only at the 12% level. To ensure that the results are not being driven by school districts in Florida, Figure 4 in the Appendix presents the long-term analysis for high school non-diet carbonated beverage bans and shows that this more precise specification still presents evidence of an increase in household non-diet soda consumption in response to high school bans, even when Florida is excluded from the sample. For elementary school diet soda bans, the negative and statistically significant coefficient estimate from columns (1)-(2) in Table 4 is not robust to the exclusion of all states.

Another robustness check in Table 4 is presented in column (12) and excludes from the triple differences

[36]When calculating the mean of the point-estimates for the first 4 quarters following elementary school diet soda restrictions from sub-figure (f) while taking into account the lower consumption levels observed pre-treatment, and thus subtracting the mean of the pre-treatment point-estimates from the mean for the first 4 quarters, the average negative value decreases in magnitude to -17 fluid ounces, which is still relatively close to the -21.7 point estimate observed in column (2) of Table 4.

Table 4: Robustness checks - triple differences with exclusion of school districts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Excluded State/s or School Districts	**No Exclusions - No Controls**	**No Exclusions - With Controls**	**California**	**Colorado**	**Florida**	**Kentucky**	**Louisiana**	**Maryland**	**N. Carolina**	**Tennesee**	**Single States**	**Non-Treated Districts**
Number of School Districts	46	46	41	44	33	44	44	42	41	43	36	27/25
Dep. Variable - Total Fluid Oz						**Non-Diet Soda**						
Elementary	-3.212	-1.797	6.237	-1.197	1.302	0.769	11.073	-4.166	-5.720	-6.801	-20.871	-3.462
	(23.718)	(23.578)	(27.914)	(29.299)	(21.910)	(23.733)	(23.649)	(23.738)	(24.624)	(24.032)	(22.802)	(23.028)
Middle	-20.344	-20.264	-31.169**	-23.542	-8.177	-24.379	-11.818	-15.670	-21.118	-16.779	-25.315*	-2.373
	(15.514)	(15.478)	(13.761)	(16.088)	(21.123)	(15.747)	(16.312)	(17.339)	(16.470)	(17.104)	(13.359)	(19.850)
High	36.898***	36.939***	44.864***	32.403**	25.453	38.062***	39.612***	33.640**	38.970***	36.118***	41.349***	40.476***
	(12.128)	(12.216)	(11.690)	(12.923)	(16.026)	(12.677)	(12.355)	(14.446)	(12.535)	(12.510)	(12.229)	(14.475)
Dependent Variable Mean	180.9	180.9	182.7	181.3	195.6	178.1	178.7	180.0	179.2	180.2	179.1	194.4
Number of Observations	176,732	176,732	165,358	169,739	91,929	171,065	171,573	167,166	153,125	169,739	154,162	96,752
Number of Households	8,146	8,146	7,500	7,740	4,856	7,819	7,927	7,610	7,079	7,752	6,904	5,343
						Diet Soda						
Elementary	-21.751*	-21.698*	-16.385	-12.215	-19.455	-20.201*	-21.873	-21.531*	-25.411**	-34.438***	-23.228	-17.659
	(12.063)	(12.085)	(14.569)	(13.216)	(12.067)	(11.924)	(13.385)	(12.076)	(11.664)	(12.130)	(13.857)	(12.359)
Middle	-4.966	-4.915	-1.459	-4.177	-6.974	-4.889	-7.563	-9.547	-2.026	-7.380	-3.475	-0.126
	(10.836)	(10.691)	(11.968)	(11.343)	(12.873)	(10.623)	(11.476)	(11.165)	(11.219)	(10.578)	(12.291)	(9.755)
High	8.189	8.324	9.285	18.367	12.908	8.535	8.140	6.855	7.655	8.870	-0.906	22.007
	(11.989)	(11.958)	(12.208)	(11.557)	(12.110)	(12.322)	(12.037)	(15.467)	(12.823)	(12.088)	(12.212)	(14.524)
Dependent Variable Mean	182.2	182.2	184.1	183.7	185.8	178.5	182.4	182.7	180.6	179.2	184.3	172.8
Number of Observations	176,417	176,417	165,043	169,424	89,532	170,483	173,996	166,851	151,132	171,028	153,847	89,339
Number of Households	8,102	8,102	7,456	7,696	4,779	7,748	7,970	7,566	7,020	7,740	6,860	4,802

Notes: The dependent variable is household monthly total fluid ounce consumption for non-diet soda and diet soda in the top and bottom panels, respectively. Each group of three coefficient estimates (for elementary, middle and high school) in the column of a panel represents coefficient estimates on $DistrictBan^s_{jt} * SclChld^s_{it}$ for $s = \{Elementary, Middle, High\}$ from a single regression, as specified in equation (2). Household-level characteristics are: household size, child less than 6 present, annual income less than $10K per household member, at least one head of household employed in full-time work, at least one head of household over 55. Treated school districts' observations are in the time frame between 24 months prior to the earliest and 12 months after the latest restrictions on carbonated beverages were introduced. Household purchases for July and August are excluded. Columns (3)-(11) exclude a single state or a group of states which have a single school district in the sample. Column (12) excludes untreated school districts, with treatment defined for either non-diet or diet carbonated beverage restrictions, depending on the dependent variable in the regression (27 treated school districts for non-diet carbonated beverage restrictions and 25 treated school districts for diet carbonated beverage restrictions). Robust standard errors in parentheses clustered at the school district level. *** p<0.01, ** p<0.05, * p<0.1

regression school districts which are not treated.[37] As can be seen, the high school non-diet coefficient estimate when looking at only the treated school districts remains mostly similar to the high school non-diet coefficient estimate presented in column (2) of Table 4. For high school diet, the coefficient estimate increases and for middle school non-diet, the coefficient estimate decreases in magnitude.

6.3 Placebo Timing for the Restrictions

In further robustness testing, the baseline regression in equation (2) was run with a placebo timing of +/- 18 months for the restrictions in each school district experiencing a ban during the period 2004-2009. This robustness check serves two purposes. First, it tests whether statistically significant results are driven by a randomness of the data, or underlying non-random patterns within the data. Second, this check can alleviate concern that the high school increase in non-diet soda consumption is being driven by within-household changes in school-children's ages, rather than by the restrictions themselves - i.e. it can be argued that increases in non-diet soda consumption are being driven by school-children within the household transitioning over time into high school, which increases household non-diet soda consumption, and this transition over time is correlated with the greater prevalence of high school bans over time. Therefore, the increase in non-diet soda consumption is a result of the natural transition over time of households into high school status, rather than the restrictions themselves. However, in this robustness check, the order of within-school-district restrictions is still maintained, such that restrictions at lower school-levels are never occurring after restrictions at high school-levels and more high school restrictions are added in later years. As such, if the results for non-diet soda consumption are being driven by within-household transition of school-aged children into high school, this random coefficient analysis should also produce similarly positive coefficient estimates with at least some levels of statistical significance.

Figure 3 plots the distribution of the elementary, middle and high school random coefficient estimates for non-diet soda (left side) and diet soda (right side) from 100 such placebo tests. In addition, the distribution plots include and point out the true coefficient estimate, as presented in column (2) of Table 4. The results in sub-Figure (a) of Figure 3 show that the high school non-diet coefficient estimate is substantially higher than any of the random coefficient estimates obtained from 100 placebo timing analysis regression runs. Interestingly, this is also true of the coefficient estimates for high school diet soda restrictions (sub-Figure (b)) and for middle school non-diet soda restrictions (sub-Figure (c)). For high school diet restrictions, it is possible that there is compensation at the household level, but as discussed in Section 7, the school-based consumption is so low that it is not possible to produce statistically significant coefficient estimates. However, both the high school diet soda coefficient estimate and the middle school non-diet soda coefficient estimate should be interpreted with caution, as Figure 2 does present evidence of pre-existing trends in diet soda consumption in treated households with a high school student and in non-diet soda

[37] To some extent, this is a more comprehensive version of the DID analysis presented in Panel II of Table 10 in the Appendix, which limits the sample of households only to those in treated school districts.

consumption in treated households with a middle school student. Sub-Figure (f) in Figure 3 shows us that the negative coefficient estimate for elementary school diet restrictions in column (2) of Table 4 may be consistent with general trends in diet soda consumption among elementary school households, based on this coefficient estimate falling well within the distribution of the placebo coefficient estimates (over 30% of the placebo random timing tests resulted in a coefficient estimate for diet elementary school bans which was less than that of the diet elementary school bans coefficient estimate in column (2) of Table 4). Interestingly, most distribution plots in Figure 3 span substantially more negative coefficient estimates than positive coefficient estimates. This is most likely due to the general decrease in soda (both diet and non-diet) consumption during this period among households. An exception to this is the positively-skewed distribution of coefficient estimates for non-diet middle school restrictions. It may be that in particular for middle school household members, there is an increase in non-diet soda consumption, maybe due to adolescent preferences becoming more dominant.

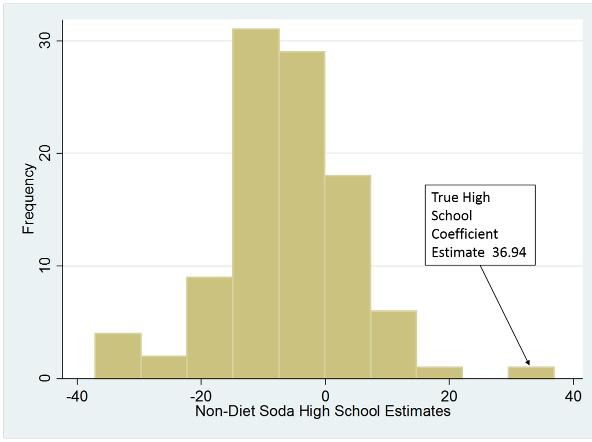
7 Discussion

A better understanding of the results above requires information on student carbonated beverage consumption rates and patterns in schools when these are not officially restricted for the entire school day. This information is available to some extent from two separate sources. The first source is a report issued by the American Beverage Association (ABA) in 2005 (Wescott (2005)). In this report, the ABA obtained proxies of carbonated beverage shipments intended for student consumption during the 2004 calendar year to each of the school-levels, and divided these figures by the total number of students enrolled in the U.S. for the relevant school-levels in 2004. The second source was obtained as part of the school district policy collection efforts for this project, and it is a Request for Proposal (RFP) issued by Sarasota County Schools (FL) in early 2001 for an exclusivity agreement with a beverage provider for the entire school district. This RFP included documentation of total sales for specific beverages in various schools during 2000, which allowed me to calculate the average consumption levels of various types of beverages in schools. In 2000, Sarasota County Schools had no limitations on sale of carbonated beverages in high schools. Middle schools could only sell carbonated beverages (or any competitive foods, for that matter) one hour after the last lunch period. In elementary schools, carbonated beverages were restricted for the entire school day, per state regulations. The Sarasota results are primarily for high schools, as middle school data was only available for a single school, whereas for high schools, beverage sales data was provided for all four high schools in Sarasota County.

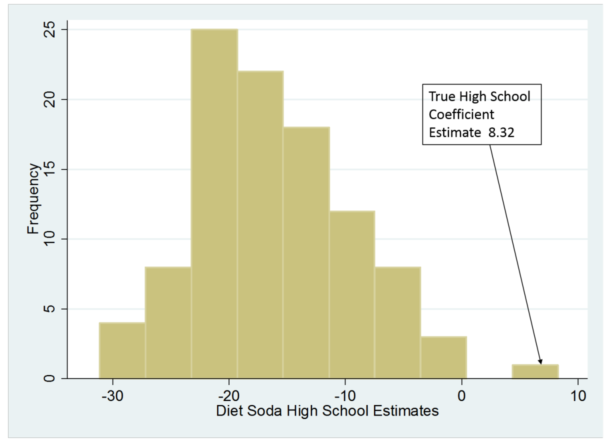
Table 5 summarizes the average student weekly consumption levels in school by carbonated beverage type (non-diet vs. diet) and school-level according to the two sources obtained for this purpose. According to the ABA figures, the average high school student consumes 12.5 ounces of non-diet carbonated beverages per week. This roughly translates into 4.5 cans of non-diet carbonated beverages per month. For high

Figure 3: Random treatment timing placebo tests - Distribution of 100 triple differences random coefficient estimates and the true coefficient estimate from Table 4 column (2)

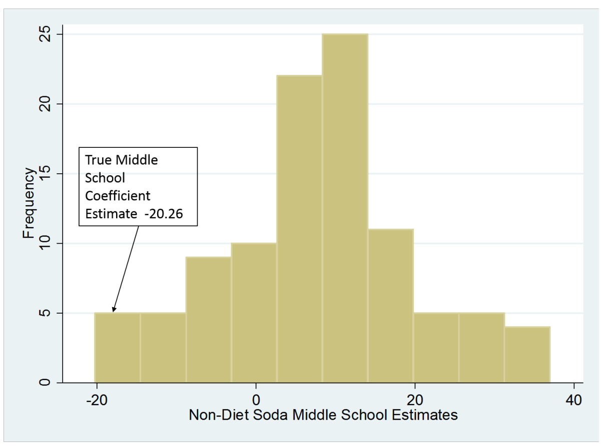
(a) Non-Diet Soda High School



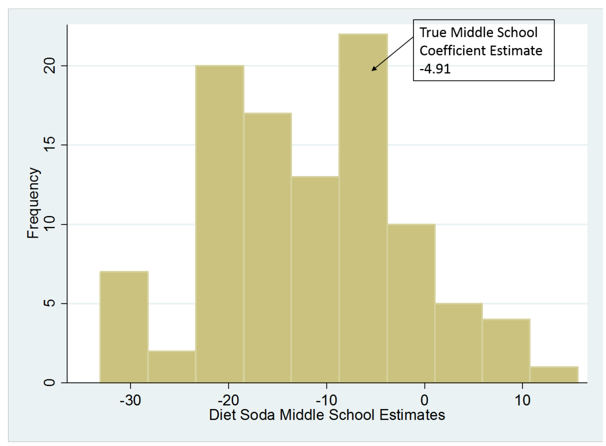
(b) Diet Soda High School



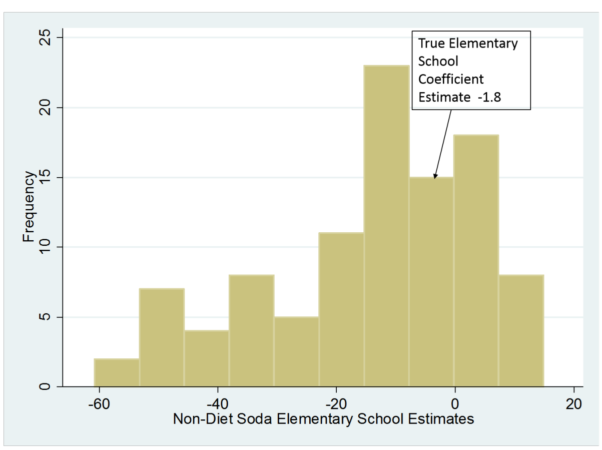
(c) Non-Diet Soda Middle School



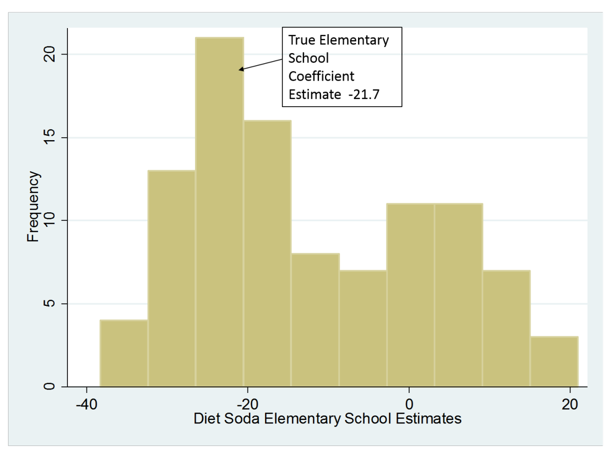
(d) Diet Soda Middle School



(e) Non-Diet Soda Elementary School



(f) Diet Soda Elementary School



Notes: This figure shows the distribution of coefficient estimates from 100 placebo tests which randomly assign treatment to treated school districts 18 months before/after the actual policy changes. The dependent variable is either non-diet soda (left figures) or diet soda (right figures) monthly household consumption with regression specifications as in equation (2). Sample restrictions are as in Table 4, based on the new random treatment timings. The marked coefficient estimate is the true coefficient estimate, as presented in column (2) of Table 4.

schools in Sarasota County, this figure is slightly greater at 13.8 ounces of non-diet carbonated beverages per week, which is equivalent to 5.07 cans of non-diet carbonated beverages per month.[38] The difference between the ABA figures and the Sarasota figures for high school makes sense, as the ABA estimates are likely to be slightly under-reporting high school carbonated beverage consumption when carbonated beverages are available. This is because the calculations for the average student consumption are based on enrollment in *all* schools in the U.S., thus including some schools which may have already restricted carbonated beverage sales by 2004. Nevertheless, in 2004 just a small fraction of high schools in the entire U.S. had limitations on carbonated beverage sales, so the under-reporting would likely be small (as is also evident from the comparison of the ABA results with the Sarasota results).[39]

Based on the ABA and Sarasota County Schools carbonated beverage consumption figures, we can safely presume that the average high school student consumes roughly between 4.5 and 5.07 cans of non-diet carbonated beverages in school when these are readily available. A rough estimate of the change in monthly household non-diet soda in response to high school carbonated beverage restrictions, based on the main triple differences results presented in Figure 2 and discussed at the end of Section 5.2, suggests that the average monthly increase in household non-diet soda consumption for more than a year after introducing carbonated beverage restrictions in high schools is roughly 3.39 cans per month for each treated high school student in the household. This suggests an offsetting of roughly 67-75% from what is being consumed in school by high school students when carbonated beverages are available. Given that the Nielsen Homescan data does not capture all potential consumption channels through which offsetting the lack of availability of carbonated beverages may take place (see Section 3 for a discussion on the omission of restaurant, vending machines and small purchases from the Nielsen Homescan data), I conclude that households' offsetting of non-diet carbonated beverages in response to high school bans is substantial.

Table 5 also shows that high school students consumed significantly more carbonated beverages than middle and elementary school students. It is worth keeping in mind that the ABA calculations include elementary and middle schools which already banned carbonated beverages, and in comparison to high schools, in 2004, this was a more significant fraction of schools. Thus, the ABA consumption figures for elementary and middle school consumption are under-estimating the actual student consumption levels

[38]The Sarasota sales records do not distinguish between diet and non-diet sales. I therefore estimated non-diet and diet carbonated beverage consumption using the same distribution between non-diet and diet carbonated beverages that was observed in the ABA results. My calculations of overall carbonated beverage consumption in Sarasota were under the same assumptions made in the ABA reports. The main assumption is that only 75% of beverages shipped to high schools are accessible to students. The remainder go to vending machines in faculty lounges, administration buildings, or are sales to persons outside of the student body within the school premises. The ABA reports also assume that the school year comprises of 36 weeks. Thus, in order to maintain consistency with the ABA reported weekly estimate, annual consumption levels for Sarasota were divided by 36. I find that high school students' average consumption of diet and non-diet carbonated beverages in Sarasota County in 2000 ranged from 4 to 7.6 cans per month, depending on the high school. Averaging this out among the four high schools resulted in an estimate of 6 cans per month of diet and non-diet carbonated beverages for each high school student. The calculation of the average used school enrollment as of 2001 as weights (2001 is the earliest year Florida school enrollment figures were found for). The simple unweighted average resulted in slightly lower figures.

[39]Note that in the sample of 46 school districts used in this study, 7 already had banned non-diet carbonated beverages in high schools by the end of 2004. Of the six additional school districts which were excluded from this study because of having implemented bans during 2002-2003, 4 had bans in place for high schools by the end of 2004. However, the sample in this study very likely over-represents earlier adopters of restrictions, as policy information was most easily obtained and verified via media and online sources when restrictions (especially at the high school level) were implemented early.

Table 5: Average weekly student carbonated beverage consumption in school - fluid ounces

	ABA - 2004		Sarasota County Schools (FL) - 2000		
	Non-Diet	Diet	Non-Diet & Diet	Estimated Non-Diet	Estimated Diet
High School	12.5	1.9	16.3	13.82	2.48
Middle School	3	0.7	0.88	0.71	0.17
Elementary School	0.3	0.2	N/A	-	-

Notes: Sources are the American Beverage Association (ABA) Report from 2005 (first two columns) and an RFP issued by Sarasota County Schools (FL) in 2001 (last three columns). Calculations from the raw data for Sarasota County Schools are based on the same assumptions used in the ABA report (see footnote 38 for details). Estimated distribution between non-diet and diet soda consumption in Sarasota County Schools is based on the distribution in the ABA report data.

for elementary and middle schools when the schools do not have carbonated beverage restrictions in place. The triple differences results show that households with elementary and middle school students did not compensate in response to carbonated beverage bans in their children's schools. I argue that this result makes sense because the restrictions at these school-levels were likely not binding. This is either because some restrictions on carbonated beverage availability were already in place in these schools (although not a full restriction for the entire school day) or because elementary and middle school students simply do not consume carbonated beverages at the same level that high school students do when these are available in schools. The Sarasota middle school figure, which is significantly lower than the national ABA middle school figure, provides some evidence that restrictions in place even for some of the school day may limit substantially middle school students' carbonated beverage consumption in schools, as Sarasota middle schools in 2000 were restricted from selling carbonated beverages until one hour after the last lunch period. However, because the middle school figure is based on just a single Sarasota middle school, it cannot be determined whether the restriction is what is driving the lower consumption or whether this school is simply an outlier in middle school students' carbonated beverage consumption. Comparing the ABA middle and high school non-diet consumption levels shows that middle school students were consuming less than 1/4 of what high school students were consuming. Thus, if middle school students consumed the same amount as high school students when carbonated beverages were available in schools, then the ABA figure of the average middle school student consuming less than the average high school student would only be consistent with a situation where carbonated beverages in middle schools were restricted in 3/4 of the school districts which allowed carbonated beverages in high schools. It is highly unlikely that so many school districts already banned carbonated beverages in middle schools as of 2004, especially among those who still had the beverage available at high schools. Therefore, it must be the case that many of these middle schools either did not have carbonated beverages fully available, although no official ban was in place, or that they consumed less than high school students, and the null findings for middle school students in the triple differences analysis are consistent with this.

The ABA figures show that high school students consume significantly more non-diet carbonated beverages than diet carbonated beverages (over 84% of high school carbonated beverage consumption is attributed to non-diet). These significantly lower consumption levels of diet carbonated beverages are consistent with the triple differences findings, showing no significant change in diet soda consumption in response to diet carbonated beverage bans in high school - with such low consumption levels, even if any potential offsetting does occur in response to bans, it is statistically unlikely that such a point estimate would be significantly different from zero. While the ABA figures for carbonated beverage consumption at the elementary and middle school level are inaccurate due to many carbonated beverage restrictions already prevalent at these school levels by 2004, it can be safely asserted that average diet soda consumption by elementary and middle school students should not significantly surpass average diet soda consumption by high school students. As such, we should not expect a response at the elementary and middle school levels to diet soda bans. This is consistent with the results in Figure 2, in particularly after accounting for the robustness checks in Table 4 and Figure 3, which indicate that the negative and statistically significant coefficient estimate for elementary school diet bans is a spurious result.

To summarize the results: households are compensating in response to non-diet carbonated beverage restrictions in high schools. These compensation levels are a substantial fraction of what was actually consumed by children in high school when carbonated beverages were available. I presented evidence that carbonated beverage consumption in middle and elementary schools is relatively limited even when an official ban on the sale of carbonated beverages is not in place. Therefore, it is only the restriction at the high school level which is actually binding and having a significant effect on students' sources for carbonated beverages, and this is why household compensation is only observed in response to restrictions at the high school level. I also presented evidence that diet soda consumption is limited in schools, and this is consistent with the results that no offsetting at the household level is observed in response to diet carbonated beverages bans.

8 Conclusions

Childhood obesity is a major public health concern. In an effort to decrease this phenomenon, many policy measures have been introduced. This paper evaluates one such policy measure: banning carbonated beverages in schools. I show that banning carbonated beverages in high schools, where the restriction is generally most binding, does not necessarily reduce carbonated beverage consumption for the average high school student, due to compensation occurring at the household level. The evidence suggests that the compensation is greatest during the quarter immediately following the ban and that the household compensation persists, even more than a year post policy implementation. If restricting carbonated beverages in schools is intended to reduce student school consumption levels prior to the restriction, this paper shows that this policy measure is less effective than intended. The results are robust to several alternative specifications, including the exclusion of numerous combinations of school districts.

The results are consistent with some past empirical findings in the literature. Anderson and Butcher (2006) find that access to junk food in schools increases student body mass index (BMI). However, their results are driven entirely by adolescents who have an overweight (and not obese) parent, so for nearly 70% of the student population in their sample, the provision of junk food in school has no effect on BMI. This is consistent with most students' steady consumption of junk food, irrespective of whether it is available in school or not, and possible compensation and/or substitution at the household level in response to lack of availability, as this paper's results suggest. Dubois et al. (2014) compare household food purchases between the US, UK and France and find that while the economic environment, as reflected in food prices and attributes, has a large impact on food purchase differences across countries, it does not provide a full explanation of this, and differences across countries in consumer preferences also have to be accounted for. Their results emphasize the importance of predetermined preferences, which is likely the reason behind the compensatory behavior observed in this paper. This paper's results are also complementary to papers regarding habit persistence, in particular when evaluating a policy intended to limit access to resources associated with unhealthy habits (Adda and Cornaglia (2006, 2010); Fletcher et al. (2010a); Wisdom et al. (2010)).

While this paper does not provide evidence of compensatory behavior in response to beverage bans in the elementary and middle school levels, this cannot be ruled out, and it may be that habit persistence exists at these lower grade-levels as well and not just at the high school level. As already argued, school district policies are highly reflective of what is actually available at the high school level but less so at the elementary and middle school levels, with many elementary and middle schools limiting carbonated beverages availability to students independently of the school district official policy. Indeed, the results in Fletcher et al. (2010b) support such compensatory behavior among 5^{th} and 8^{th} grade students in the ECLS data. Furthermore, Datar and Nicosia (2012) show that BMI and overall junk food consumption among 5^{th} grade students in the ECLS is not affected by the availability of soft drinks/competitive foods in school.

While the results in this paper show persistence of the household compensation even more than a year following the ban's introductions, it is still possible that in the very long term (e.g. possibly after nearly two years), limiting availability of carbonated beverages in schools will decrease students' overall consumption. Indeed, in recent years, consumption patterns have shifted away from full-calorie drinks to low-calorie drinks, even among children (Kit et al. (2013); Piernas et al. (2013); Sylvetsky et al. (2012)). These changes in preferences may have taken a long time to shape, but they are consistent with the idea that there may be policy measures which are having some effect on individuals' preferences, or at least their revealed preferences.

If policy makers wish to battle obesity, this paper shows that restricting access to unhealthy foods is not likely to suffice. Alternative policy measures to consider include changes in the relative prices of unhealthy foods or nutritional education. With regards to prices, Fletcher et al. (2010a) show that taxing carbonated beverages is not effective in limiting children's caloric consumption if calorie-dense drinks are available from other beverage sources. Similarly, taxing cigarettes may result in increased nicotine intake through greater extraction from each cigarette (Adda and Cornaglia (2006)) or increased cigarette consumption across state borders in search of lower tax jurisdictions (Harding et al. (2012)). Thus, pricing strategies have also proven ineffective when consumers can readily find suitable substitutes. Further research is required to investigate the impact of educational policy measures on obesity. However, it should be noted that this paper shows that even by restricting carbonated beverages in an educational setting, and thus invalidating its consumption at least to some extent, compensation is still observed. Thus, this specific educational measure may not be as effective as policy makers may wish. If educational policy measures are considered, it appears they should either be more aggressive or, alternatively, target the non-adolescent population in the household.

If preferences persist so adamantly, and policy makers wish to change these preferences, it may be required to tackle directly channels through which preferences are shaped and/or formed. In the United States, 98% of the television food ads seen by children are for products high in fat, sugar or sodium (Powell et al. (2007)). Children and the general population are exposed to additional food marketing efforts through product placements in the content of entertainment outlets and social media.[40] If these marketing campaigns are effective in shaping preferences and persist while other policy measures are introduced, then they may be partially responsible for reducing the effectiveness of various policy measures.

The last two decades have witnessed a change in understanding what drives obesity and overweight among individuals. The initial emphasis was on individuals changing their own behavior, but more recently, there is increased recognition of environmental and/or economic factors related to food, which may have played a role in the increasing rates of obesity and overweight.[41] While this is an important development for understanding the factors attributed to obesity, this paper shows that individual preferences should not be entirely neglected when evaluating the obesity epidemic. Although these preferences may have been formed by changes in individuals' food environments over the last few decades, it appears that changing them requires more than simple modifications in food environments.

[40] See Harris et al. (2009) for a summary of how food marketing contributes to childhood obesity.

[41] See Cutler et al. (2003); Chou et al. (2009); Lakdawalla et al. (2005); Bertrand and Schanzenbach (2009) for analysis, theories, and empirical findings on the economic factors contributing to the rise in obesity rates.

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A Excluded Target School Districts

B Covered School Districts

C Difference-in-Differences (DID) Analysis

The three sources of variation in the triple differences analysis presented above are across time, school districts and age of household members. As such, a DID approach, which exploits only two sources of variation, is possible in two different designs: either exploiting variation across time and across school districts, or exploiting variation across time and across household members' school levels.

For the first design, changes in households' carbonated beverage consumption in school districts which introduced carbonated beverage restrictions are compared to changes in household consumption in school districts which had not introduced carbonated beverage restrictions. This design exploits variation over time, in terms of changes in school district policies occurring at different time-periods, and geography, in terms of school districts which are either treated or not treated. Because the timing of treatments often differs between school-levels (elementary, middle and high) within the same school district, this DID approach estimates the effect of the restriction for each school-level in a separate regression, with each regression run only for households which have children in that particular school-level.

I estimate the following DID regression for the sample of households with at least one child in school-level Q (Q representing elementary, middle or high school).

$$\begin{aligned} floz_{ijt} = \beta_0 &+ \beta_1 DistrictBan^Q_{jt} * SclChld^Q_{it} + \beta_2 TrtDistrict^Q_{ij} * SclChld^Q_{it} \\ &+ \beta_3 DistrictBan^Q_{jt} + \sum_{m=1}^{M^Q} \beta_4^m TrtTime_t^{Qm} * SclChld^Q_{it} \\ &+ \beta_5 TrtDistrict^Q_{ij} + \sum_{s=1}^{3} \beta_6^s SclChld^s_{it} + \gamma X_{it} + h_i + month_t + \phi_j t + \varepsilon_{ijt} \end{aligned} \tag{3}$$

The dependent variable, $TrtDistrict^s_{ij}$, $TrtTime^{sm}_t$, $SclChld^s_{it}$, X_{it}, h_i, $month_t$ and $\phi_j t$, as well as standard errors reported, are as defined for equation (1) in Section 4. $DistrictBan^Q_{jt}$ is an indicator variable for monthly household purchases which are observed when a ban on school-level Q is in place in their assigned school district. In a standard DID specification, this variable is the variable of interest, which represents the interaction between being treated and being observed post-treatment. However, equation (3) multiplies $DistrictBan^Q_{jt}$ by $SclChld^Q_{it}$, which measures the number of children in the household in school-level Q. The inclusion of the interaction between $DistrictBan^Q_{jt}$ and $SclChld^Q_{it}$ results in β_1, our coefficient of interest in equation (3), which estimates the intensity of treatment effect, as in equation (1). The inclusion of lower-order interaction terms in equation (3) controls for consumption patterns mutual to treated house-

Table 6: Excluded target school districts - states CA-NC

School District	**State**	**Reason not in the Sample of School Districts**
Capistrano Unified School District	CA	Carbonated beverages restricted in high schools beginning September 2002
Long Beach Unified School District	CA	Carbonated beverage policies could not be verified.
Oakland Unified School District	CA	Carbonated beverages restricted in all schools beginning Spring 2002
Santa Ana Unified School District	CA	All carbonated beverages in schools were eliminated by 2006 but it was a phased-in process over an 18-month period that was based on individual schools' beverage provider contracts expiring.
Sacramento Unified School District	CA	Carbonated beverage policies could not be verified. While a district-wide contract with Pepsi was rejected in Summer 2000, no policy restricting carbonated beverages was put in place and some schools initiated individual contracts with beverage providers.
San Francisco Unified School District	CA	Carbonated beverages restricted in all schools beginning August 2003
Denver Public Schools	CO	Carbonated beverages restricted in elementary schools beginning August 2003
Broward County Public Schools	FL	Conflicting information - School policy from 2004 states that middle schools should have no carbonated beverages beginning August 2004, but school district representatives claim all carbonated beverages were still available in middle and high schools during 2011. Former communications director, who worked in school district through Nov. 2005 claims carbonated beverages were taken out of schools before he left. Also, FL Dept. of Education documentation state that Alliance for a Healthier Generation Guidelines went into effect prior to Dec. 2009.
Lake County Schools	FL	exclusivity contract with Coke that excluded carbonated beverages already in 2004. District representative claimed carbonated beverages banned only in 2006 when wellness policy came out. However, the wellness policy from 2006 does not explicitly mention any restriction on the availability of carbonated beverages.
Polk County Public Schools	FL	Conflicting information - Exclusive contract with Pepsi from 2007 explicitly indicates that low-calorie carbonated beverages will be available in high schools. However, wellness policy from 2006 states that within 6 months all carbonated beverages will be eliminated from all schools.
Sarasota County Schools	FL	Conflicting information - Exclusive 5-year contract with Coke expired in Summer 2006. Nutrition Services claimed AHG Guidelines went into effect May 2006, prior to contract expiration. Purchasing claimed new standards went into effect during Summer 2006. However, the 2006 contract was extended through the end of December 2006 with the same product composition as the prior contract to allow time to renegotiate the conditions of the new contract under the AHG Guidelines. Only in Oct. 2006 did the Board approve implementing the AHG Guidelines in the new contract with Coke. In the January 2007 contract, the new guidelines are explicit, but it is not clear when they went to into effect.
Caddo Parish Public Schools	LA	No response to any requests for information (telephone, e-mail, FOIA)
Anne Arundel County Public Schools	MD	Conflicting information - According to contracts received, there are no restrictions on sugar drinks in Anne Arundel schools. Machines have to be turned off between the start of the school day and the last lunch period. However, in the media, there is plenty of evidence that the board voted to ban soda during the school day with the implementation of the wellness policy in July 2006. No one was able to confirm or negate this.
Detroit Public Schools	MI	Carbonated beverage policies could not be verified. The school board voted in August 2006 to remove all carbonated beverages from its vending machines but no information could be obtained on when this was actually implemented.
New York City Department of Education	NY	Inconsistent policy - The Chancellor ruled in 2002 to restrict all carbonated beverages in all schools by the start of the 2003-2004 school year. However, an audit by the State Comptroller in New York City schools in 2009 revealed that 20 out of 30 schools visited sold soda during the school day, in direct violation of the Chancellor's policies.
Gaston County Schools	NC	Inconsistent policy - Abrupt changes in policy implementation in 2004-2005 due to state auditing and lack of enforcement prior to this.
Lincoln County Schools	NC	No response to any requests for information (telephone, e-mail, FOIA)
Rowan-Salisbury School System	NC	Conflicting Information - Evidence from school district policy that already in 1998 carbonated beverages were not allowed in schools, but no school district representative was able to confirm or negate that.

Table 7: Excluded target school districts - states OH-WA

School District	State	Reason not in the Sample of School Districts
Cleveland Metropolitan School District	OH	Carbonated beverage policies could not be verified.
Columbus City Schools	OH	Carbonated beverage policies could not be verified.
Memphis City Schools	TN	School district was disband in July 2013 and therefore no school district representative was available to discuss or confirm carbonated beverage policies in the past.
Austin Independent School District	TX	Carbonated beverages restricted in all schools beginning August 2003
Aldine Independent School District	TX	State laws went into effect beginning July 2004 restricting the sale of carbonated beverages in Texas schools. However, investigation of Texas school districts' carbonated beverage policies revealed several inconsistencies with these state regulations. In Houston, the school district was fined in 2013 for violating state laws on the sale and availability of FMNV in schools; Cypress-Fairbanks nutrition policy from 2009-2010 was found to contradict state laws; an online article from 2011 described a 10-year-old child in El Paso purchasing sodas in school, in contradiction to state laws at the time.
Arlington Independent School District	TX	
Cypress-Fairbanks Independent School District	TX	
Dallas Independent School District	TX	
El Paso Independent School District	TX	
Fort Bend Independent School District	TX	
Fort Worth Independent School District	TX	
Garland Independent School District	TX	
Houston Independent School District	TX	
North-East Independent School District	TX	
Northside Independent School District	TX	
Plano Independent School District	TX	
San Antonio Independent School District	TX	
Virginia Beach City Public Schools	VA	No response to any requests for information (telephone, e-mail, FOIA) - Virginia public records law only requires a response to Virginia residents (this was the school district's official response.).
Seattle Public Schools	WA	Carbonated beverages restricted in middle schools in Aug. 2003

Table 8: Covered school districts and the assignment of treatment by month and year - states CA-IL

School District	State	Non-Diet Carbonated Beverages			Diet Carbonated Beverages		
		Elementary	Middle	High	Elementary	Middle	High
Elk Grove Unified School District	CA	Sept. 2006	Sept. 2006	Sept. 2006	Sept. 2006	Sept. 2006	Sept. 2006
Fresno Unified School District	CA	Jul. 2007	Jul. 2007	Jul. 2009	Jul. 2007	Jul. 2007	Jul. 2009
Los Angeles Unified School District	CA	Pre-2002	Jan. 2004	Jan. 2004	Pre-2002	Jan. 2004	Jan. 2004
San Bernardino Unified School District	CA	Jul. 2007	Jul. 2007	Jul. 2009	Jul. 2007	Jul. 2007	Jul. 2009
San Diego Unified School District	CA	Jul. 2007	Jul. 2007	Jul. 2009	Jul. 2007	Jul. 2007	Jul. 2009
Douglas County School District	CO	Aug. 2009	Aug. 2009	Aug. 2009	Aug. 2009	Aug. 2009	Aug. 2009
Jefferson County Public Schools	CO	Aug. 2009	Aug. 2009	Aug. 2009	Aug. 2009	Aug. 2009	Aug. 2009
DC Public Schools	DC	Pre-2002	Sept. 2006	Sept. 2006	Sept. 2006	Sept. 2006	Sept. 2006
Brevard Public Schools	FL	Pre-2002	Post-2009	Post-2009	Pre-2002	Post-2009	Post-2009
Duval County Public Schools	FL	Pre-2002	Post-2009	Post-2009	Pre-2002	Post-2009	Post-2009
Hillsborough County Public Schools	FL	Pre-2002	Post-2009	Post-2009	Pre-2002	Post-2009	Post-2009
School District of Lee County	FL	Pre-2002	Post-2009	Post-2009	Pre-2002	Post-2009	Post-2009
School District of Manatee County	FL	Pre-2002	Jan. 2009	Jan. 2009	Pre-2002	Jan. 2009	Post-2009
Marion County Public Schools	FL	Pre-2002	Jan. 2007	Jan. 2007	Pre-2002	Post-2009	Post-2009
Miami-Dade County Public Schools	FL	Pre-2002	Jul. 2006	Jul. 2006	Pre-2002	Jul. 2006	Jul. 2006
Orange County Public Schools	FL	Pre-2002	Jul. 2005	Jul. 2005	Pre-2002	Jul. 2005	Jul. 2005
School District of Palm Beach County	FL	Pre-2002	May 2008	May 2008	Pre-2002	May 2008	Post-2009
Pasco County Schools	FL	Pre-2002	Post-2009	Post-2009	Pre-2002	Post-2009	Post-2009
Pinellas County Schools	FL	Pre-2002	Post-2009	Post-2009	Pre-2002	Post-2009	Post-2009
Saint Lucie County Public Schools	FL	Pre-2002	Post-2009	Post-2009	Pre-2002	Post-2009	Post-2009
School District of Volusia County	FL	Pre-2002	Post-2009	Post-2009	Pre-2002	Post-2009	Post-2009
Atlanta Public Schools	GA	Pre-2002	Pre-2002	Pre-2002	Pre-2002	Pre-2002	Pre-2002
Chicago Public Schools	IL	Pre-2002	Pre-2002	Jan. 2005	Pre-2002	Pre-2002	Jan. 2005

Table 9: Covered school districts and the assignment of treatment by month and year - states KY-WV

School District	State	Non-Diet Carbonated Beverages			Diet Carbonated Beverages		
		Elementary	Middle	High	Elementary	Middle	High
Fayette County Public Schools	KY	Pre-2002	Jul. 2005	Jul. 2005	Pre-2002	Mar. 2006	Mar. 2006
Jefferson County Public Schools	KY	Pre-2002	Aug. 2006	Aug. 2006	Pre-2002	Aug. 2006	Aug. 2006
East Baton Rouge Parish School System	LA	Jul. 2005	Jul. 2005	Aug. 2009	Jul. 2005	Jul. 2005	Post-2009
Jefferson Parish Public School System	LA	Jul. 2005	Jul. 2005	Aug. 2006	Jul. 2005	Jul. 2005	Post-2009
Baltimore County Public Schools	MD	Pre-2002	Aug. 2008	Aug. 2008	Pre-2002	Aug. 2008	Aug. 2008
Harford County Public Schools	MD	Pre-2002	Aug. 2006	Aug. 2006	Pre-2002	Aug. 2006	Aug. 2006
Montgomery County Public Schools	MD	Pre-2002	Pre-2002	Sept. 2004	Pre-2002	Pre-2002	Sept. 2004
Baltimore City Public Schools	MD	Pre-2002	Jul. 2006	Jul. 2006	Pre-2002	Jul. 2006	Jul. 2006
Boston Public Schools	MA	Sept. 2004	Sept. 2004	Sept. 2004	Sept. 2004	Sept. 2004	Sept. 2004
Clark County School District	NV	Jul. 2004	Jul. 2004	Jul. 2004	Jul. 2004	Jul. 2004	Jul. 2004
Albuquerque Public Schools	NM	Aug. 2006	Aug. 2006	Aug. 2006	Aug. 2006	Aug. 2006	Post-2009
Forsyth County Schools	NC	Pre-2002	Pre-2002	Aug. 2009	Pre-2002	Pre-2002	Aug. 2009
Guilford County Schools	NC	Pre-2002	Pre-2002	Post-2009	Pre-2002	Pre-2002	Post-2009
Iredell-Statesville Schools	NC	Pre-2002	Aug. 2006	Post-2009	Pre-2002	Post-2009	Post-2009
Charlotte-Mecklenburg Schools	NC	Pre-2002	Aug. 2006	Aug. 2006	Pre-2002	Aug. 2006	Aug. 2006
Wake County Public School System	NC	Pre-2002	Pre-2002	Pre-2002	Pre-2002	Pre-2002	Pre-2002
Portland Public Schools	OR	Pre-2002	Pre-2002	Sept. 2006	Pre-2002	Pre-2002	Sept. 2006
School District of Philadelphia	PA	Aug. 2004	Aug. 2004	Aug. 2004	Aug. 2004	Aug. 2004	Aug. 2004
Metropolitan Nashville Public Schools	TN	Jan. 2006	Jan. 2006	Post-2009	Jan. 2006	Jan. 2006	Post-2009
Hamilton County Schools	TN	May 2006	May 2006	Aug. 2009	May 2006	May 2006	Post-2009
Knox County Schools	TN	Aug. 2006	Aug. 2006	Post-2009	Aug. 2006	Aug. 2006	Post-2009
Fairfax County Public Schools	VA	Pre-2002	Pre-2002	Pre-2002	Pre-2002	Pre-2002	Pre-2002
Kanawha County Schools	WV	Pre-2002	Pre-2002	Aug. 2009	Pre-2002	Pre-2002	Post-2009

holds irrespective of when they are observed ($TrtDistrict^{Q}_{ij} * SclChld^{Q}_{it}$), general consumption trends among treated households regardless of the number of treated school children in the household ($DistrictBan^{Q}_{jt}$), and mutual purchasing patterns in all households in the various post-treatment periods, irrespective of whether the households are in treated school districts or not ($TrtTime^{Qm}_{t} * SclChld^{Q}_{it}$). The inclusion of the dummy variable $TrtDistrict^{Q}_{ij}$ controls for purchasing patterns mutual to all treated school districts. The inclusion of the variables $SclChld^{s}_{it}$ for each of the three school-levels ($s \epsilon \{elementary, middle, high\}$) controls for purchasing trends among households with a certain number of children in each of the school-levels.

For the second DID design, only households in treated school districts are accounted for. In this design, treatment is determined based on household members' age and whether children in any school-level are present (in addition to whether the household is observed before or after the ban). The treatment group is households with at least one child in the relevant school-level and the control group is households with no children in any school-level. Similar to the first DID design, the different timing of treatments for each school-level requires a separate estimation for the effect of a restriction at each school-level. The sample size in this DID setting is substantially greater than that of the first DID setting, due to the inclusion of households without school-children. Due to this, the treated household sample can be smaller, with treatment assigned more precisely such that only households who have children in the designated school-level for that regression and no children in the other two school-levels are in the treated sample.

I estimate the following DID regression for the sample of households in school districts which treated school-level Q, which either have at least one child in school-level Q (and no children in the other school-levels) or have no school-aged children at all.

$$
\begin{aligned}
floz_{ijt} = \beta_0 &+ \beta_1 DistrictBan^{Q}_{jt} * SclChld^{Q}_{it} + \beta_2 DistrictBan^{Q}_{jt} \\
&+ \beta_3 SclChld^{Q}_{it} + \sum_{m=1}^{M^Q} \beta_4^m TrtTime^{Qm}_{t} * SclChld^{Q}_{it} \\
&+ \gamma X_{it} + h_i + month_t + \phi_j t + \varepsilon_{ijt} \qquad (4)
\end{aligned}
$$

The variables in equation (4) are as in equation (3). Our coefficient of interest is β_1, the coefficient on the interaction term between being observed when a district ban is in place and the number of children in school-level Q in the household. β_1 measures for each child in school-level Q which experiences a carbonated beverage ban, what is the change in soda consumption, in comparison to households within the same school district boundaries who are without children in school-level Q? The inclusion of $DistrictBan^{Q}_{jt}$ controls for general consumption trends among treated households regardless of the number of treated school children in the household. The inclusion of $SclChld^{Q}_{it}$ controls for the number of children in school-level Q in the household, regardless of whether the household is observed before or after the ban implementation. The series of variables $TrtTime^{Qm}_{t} * SclChld^{Q}_{it}$ control for mutual purchasing patterns in all households in the various post-treatment periods, irrespective of whether the households' school district has already implemented the ban or not.

C.1 Difference-in-Differences Results

The results from both DID specifications for each of the three school-levels are presented in Table 10. Panel I presents the results from equation (3), where the sample is households with school-children in all school districts (treated and untreated), while Panel II presents the results from equation (4), where the sample is all households (with and without school-children) in treated school districts.

Each cell in columns (1)-(3) presents the coefficient estimate on $DistrictBan^{Q}_{jt} * SclChld^{Q}_{it}$ for the school-level Q (elementary, middle or high school) indicated at the start of the row. In column (2), district-specific time trends are added to the regression specification, in addition to household and month-year fixed effects. The addition of time-varying household-level characteristics in column (3) does not substantially change the results in comparison to columns (2). In column (6), dependent variable means are presented for each school-level and beverage type set of regressions. In Panel I, all households in the sample have school-children, and column (6) in Panel I demonstrates an increase in household-level consumption at a much greater rate for non-diet soda, as opposed to diet soda, when higher school-level children are present. This is evidence of the difference in children's consumption patterns between diet and non-diet soda - it appears that the presence of older children (who consume a greater amount of any beverage, in comparison to younger children) has a greater effect on non-diet soda consumption as opposed to diet soda.

The point estimates in Panel I suggest that for each high school student in the household attending a school district which introduced a non-diet carbonated beverage ban, the household increased its monthly non-diet soda consumption by over 73 fluid ounces per month, which is equivalent to slightly more than six cans of soda per month. This represents an increase of 21.8% of the mean total household consumption of non-diet soda. The point estimate from the preferred specification (column (3)) is marginally statistically significant with a p-value of 10.01%. The results in Panel II are also consistent with an increase in household non-diet soda consumption in response to high school carbonated beverage bans, although the point estimate is substantially smaller than that of Panel I and is not statistically significant at conventional levels (p-value 16.8%). According to the DID results in Table 10, there do not appear to be any significant changes in household-level consumption in response to non-diet carbonated beverage bans at the other school-levels or in response to diet carbonated beverage bans. Furthermore, the results in Panels I and II may even be qualitatively inconsistent with each other for other school levels and for diet carbonated beverage bans.

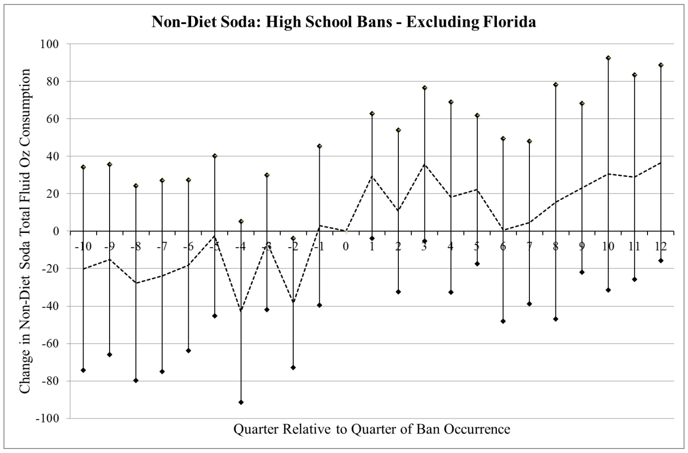
The differences in the point estimates between Panels I and II in Table 10 suggest that different control groups provide different results, even for the high school non-diet carbonated beverage bans, with a large quantitative difference. For this reason, the preferred specification will account for purchasing trends in all possible control groups - this is our triple differences specification.

Table 10: The effect of carbonated beverage bans in schools on household soda consumption - Difference-in-differences analysis

	(1)	(2)	(3)	(4) Number of Observations	(5) Number of Households	(6) Dependent Variable Mean
Panel I. Households with School Children in Untreated School Districts as Controls						
Elementary	59.184	45.873	48.064	19,635	1,183	268.5
	(72.706)	(70.838)	(70.686)			
Middle	-18.401	-0.239	-2.417	10,942	877	316.7
	(54.154)	(49.845)	(51.187)			
High	70.836	77.276*	73.853	14,184	1,013	339.2
	(43.302)	(45.044)	(45.043)			
Elementary	42.421	32.604	25.877	19,550	1,182	197.9
	(36.055)	(35.348)	(37.588)			
Middle	21.825	2.626	2.199	11,202	897	214.6
	(51.850)	(50.981)	(50.383)			
High	-63.639	-56.950	-57.182	15,616	1,062	226.8
	(41.120)	(42.975)	(42.072)			
Panel II. Households without School-Children in Treated Districts as Controls						
Elementary	23.281	23.109	26.488	23,267	1,528	176.3
	(49.556)	(50.131)	(49.880)			
Middle	-17.101	-21.828	-22.845	67,750	3983	175.7
	(38.290)	(38.327)	(38.346)			
High	27.501	28.059	28.480	74,994	4,388	179.3
	(19.948)	(19.678)	(20.156)			
Elementary	-9.214	-10.791	-10.459	25,241	1,631	162.3
	(14.835)	(14.542)	(14.384)			
Middle	5.259	8.851	6.493	65,227	3830	161.7
	(33.463)	(33.775)	(34.960)			
High	23.653	25.907	24.697	59,616	3,523	163.3
	(16.703)	(16.639)	(16.951)			
Month-Year Fixed Effects	X	X	X			
Household Fixed Effects	X	X	X			
District-Specific Time Trends		X	X			
Household-Level Characteristics			X			

Notes: Each cell in columns (1)-(4) presents coefficient estimates (and standard errors clustered at the school district level in parenthesis) from separate regressions. In Panel I, each regression includes only households which have at least one child in the school-level analyzed (indicated at the start of each row) (equation (3)). In Panel II, each regression includes households only within school district boundaries which were treated for the school-level analyzed sometime during the sample period and have either a child in the school-level analyzed or no school-children at all (equation (4)). Household-level characteristics are: household size, child less than 6 present, annual income less than $10K per household member, at least one head of household employed in full-time work, at least one head of household over 55. Treated school districts' observations are only in the time frame between 24 months prior to and 12 months after the relevant school-level restrictions on carbonated beverages were introduced. Household purchases for July and August are excluded. *** p<0.01, ** p<0.05, * p<0.1

Figure 4: Quarterly changes in monthly non-diet soda consumption, relative to the quarter of ban introduction - High school non-diet bans, excluding Florida school districts



Notes: This figure is the same as sub-Figure (a) in Figure 2, only Florida school districts are excluded from the sample. 33 school districts are included in the analysis with 196,652 monthly household purchases.

D Triple Differences Differential Effects Over Time Results Excluding Florida