Can Soft Drink Taxes Reduce Population Weight?

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Abstract
Soft drink consumption has been hypothesized as one of the major factors in the growing rates of obesity in the US. Nearly two-thirds of all states currently tax soft drinks using excise taxes, sales taxes, or special exemptions to food exemptions from sales taxes to reduce consumption of this product, raise revenue, and improve public health. In this paper, we evaluate the impact of changes in state soft drink taxes on body mass index (BMI), obesity, and overweight. Our results suggest that soft drink taxes influence BMI, but that the impact is small in magnitude.

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Introduction

Obesity has been labeled as an ongoing epidemic in the US and many other developed countries (James et al., 2001) as a result of the substantial increase in the prevalence of adult obesity over the last thirty years (Ogden et al., 2006).[1] Increases in obesity rates may pose substantial externalities on society through increases in health care costs and losses in productivity (Lakdawalla, Goldman, and Shang, 2005). The long term health consequences of adult obesity include increases in Type II diabetes, coronary heart disease, stroke, and cancer (National Task Force on the Prevention and Treatment of Obesity, 2000). In 2000, the social costs of obesity were estimated at $117 billion (Office of the Surgeon General, 2001). Strum (2002) suggests that the influence of obesity on chronic health conditions is similar to aging twenty years and the impact on health and health costs due to obesity is greater than both smoking and drinking.

Soft drink consumption has been hypothesized as one of the major factors in the growing rates of obesity in the US. One primary reason for this hypothesis is that relatively small increases in consumed calories can accumulate over time and may generate large changes in population weight. For instance, the medical literature suggests that changes in soft drink consumption as small as one serving per day can lead to significant weight change over time if not offset by caloric expenditures (e.g., Ludwig et al., 2001). In fact, the US Department of Agriculture (USDA) has reported that per capita soft-drink consumption has increased by almost 500% over the past 50 years (Putnam and Allshouse, 1999) and soft drinks have been the single largest contributor of energy intake during the last decade (Block, 2004).

[1] Obesity increasingly afflicts young children and adolescents (Fletcher, 2007, Kimbro et al., 2007), and it has been shown to persist into adulthood (Dietz, 1998, Friedman et al., 2001). An analysis on the influence of soft drink taxes on childhood obesity is beyond the scope of this paper.

One policy through which governments can influence individuals' consumption choices and potentially affect the increase in obesity rates is the taxation of specific categories of food that contribute to weight gains. Similar to "sin taxes" imposed on alcohol and tobacco, taxes on soft drinks have been introduced by states to reduce consumption of this product, raise revenue, and improve public health. In fact, nearly two-thirds of all states currently tax soft drinks using excise taxes, sales taxes, or special exemptions to food exemptions from sales taxes. Additionally, in recent years, many states and localities have proposed excise taxes on soft drinks to curb the rise in obesity (Chouinard et al., 2007). Although there is extensive research on the impact of alcohol and tobacco taxes on a variety of health outcomes, there is little research regarding the influence of soft drink taxes.

In this paper, we evaluate the effectiveness of soft drink taxes as a policy to reduce obesity. States have taxed soft drinks directly through excise taxes and indirectly by excluding soft drinks from the food exemptions to sales taxes. We examine the impact of both the *incremental* soft drink tax rate, which is the tax specifically on soft drinks that is net of any taxes on other foods, and the *total* soft drink tax rate, which incorporates state's specific exclusions of soft drinks from the food exemptions to the sales tax. We analyze the impact of changes in states' taxation rates from 1990 to 2006 on changes in body mass index and obesity status utilizing the repeated cross-sections of the Behavioral Risk Factor Surveillance System (BRFSS). During this time period, approximately half of all states changed their soft drink tax rate. By estimating regression models that include state, year, and quarter of year fixed effects, we identify the impact of soft drink tax rates on individuals' weight from changes in the tax rate within states over time.

Our results demonstrate that weight responds to changes in soft drink tax rates. An increase of one percentage point in the state soft drink tax rate leads to a decrease in body mass index (BMI) of 0.003 points. The influence of soft drink taxes varies across demographic groups; we find that soft drink taxes have a larger influence on BMI and obesity for low income adults and Hispanics. Overall, we find that at the current tax rates, with an average of approximately three percent, the behavioral response of adults is small in magnitude. Our results suggest that even a relatively large increase of approximately 20 percentage points, as recently proposed by Maine, may not have a substantial effect on population weight.

Background

Cutler, Glaeser, and Shapiro (2003) suggest that the increase in obesity rates since the 1970s has resulted largely because of an increase in calories consumed, as opposed to a decrease in calories expended. These increases in calories consumed need not be dramatic to affect population weight, however. For example, Hill et al. (2003) suggest that affecting energy balances by only 100 calories per day could prevent weight gain in over ninety percent of the population. A decrease in energy intake of this magnitude could be achieved by consuming one fewer 12-ounce can of sugar sweetened soda per day.[2] On the other hand, an increase of energy expended of this magnitude would require walking approximately one mile per day.

Such small energy balance magnitudes have suggested to some researchers and policymakers that targeting specific consumption goods could promote weight reduction in the

[2]A typical 12-ounce can of soft drink contains approximately 150 calories and 40 to 50 grams of sugar (Apovian, 2004). Further, increasing sugar sweetened soda consumption by one 12-ounce can per day can lead to a 15 pound weight gain in one year (Apovian, 2004). In 1999, Americans on average consumed nearly 50 gallons, or 530 12-ounce cans, of soft drinks (Kuchler et al., 2005).

population. In particular, soft drink consumption has been of interest for several reasons.[3] First, Block (2004) shows that the single largest contributor of energy intake during the last decade was soft drinks, contributing over seven percent. Second, drinks that are rich in free sugars[4] (such as soft drinks) have been shown to reduce appetite control, leading to increases in weight gain and greater risk of obesity (World Health Organization (WHO), 2003).[5] Third, the increase in soda consumption has mirrored the increase in obesity rates (Vartanian et al., 2007). In particular, the USDA has reported that per capita soft-drink consumption has increased by almost 500% over the past 50 years (Putnam and Allshouse, 1999). Further, Ludwig et al. (2001) find that for each additional serving of soft drink consumed, BMI increased by 0.24 over a two year period. Similarly, Ebbeling et al. (2006) show in a randomized, controlled trial that the availability of free non-caloric beverages significantly reduced the consumption of sugar-sweetened beverages and BMI in adolescents with a high initial BMI. Recently the WHO has recommended a population goal of consuming less than 10 percent of energy through free sugars and has specifically recommended restricting the intake of sugar-sweetened soft drinks for children and adolescents (WHO, 2003).

Soft drink consumption has garnered enough attention that many states have attempted to affect consumer behavior through the price mechanism (Jacobson and Brownell, 2000). Although soft drink taxes have existed since at least 1920 (New York Times, 1920) and until recently these taxes have been used primarily to generate revenue (Caraher and Cowburn, 2005), states and localities are increasingly viewing the taxation of soft drinks as a policy to curb the

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[3] See Malik et al. (2006) and Vartanian et al. (2007) for reviews of the literature on the association between soft drink consumption and health. James and Kerr (2005) suggest that decreasing soft drink consumption could substantially affect rates of youth obesity.

[4] The term ‘‘free sugars’’ refers to all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and fruit juices.

[5] In particular, it has been shown that when individuals increase liquid carbohydrate consumption, they do not respond by reducing their solid food consumption. In fact, increases in liquid carbohydrate consumption lead to even greater caloric consumption (Demelgio and Mattes 2000).

rise in obesity (Chouinard et al., 2007). For example, six states proposed legislation in 2006 to tax soft drinks (National Conference of State Legislatures, 2007).[6] State representatives in Maine have recently (April 2008) raised the tax on soft drinks to help fund state health programs and reduce childhood obesity.[7] Further, in 2005 the American Medical Association (AMA) developed a resolution calling for a small federal tax on soft drinks (AMA, 2006).[8] Outside of the US, many other countries including Mexico, Canada, Australia, and the United Kingdom have implemented or are considering similar taxes (Chouinard et al., 2007). Additionally, many leading public health researchers are advocating for soft drink taxes (e.g., Jacobson and Brownell, 2000). While the taxation of soft drinks is increasingly being considered as a policy to influence obesity, there is little research regarding the efficacy of these policies.

There are a variety of reasons to expect that soft drink taxes may influence obesity. First, previous research has shown that food consumption is sensitive to price changes (Jeffrey et al., 1994; French et al., 2001). Second, changes in food prices have been linked to changes in obesity. Lakdawalla and Philipson (2002) estimate that declining food prices can explain about 40 percent of the rise in obesity between 1976 and 1994. Gelbach, Klick, and Stratmann (2007) find that an increase in the prices of unhealthy foods, including soft drinks, relative to the prices of healthy foods increased BMI between 1982 and 1996.

Third, there is suggestive evidence that soft drink taxes reduce the consumption of soft drinks. Tefft (2008) estimates the relationship between soft drink taxes and household expenditure and finds that an increase in soft drink taxes does not change household soft drink expenditures and reduces the probability of having any expenses on soft drinks. These results

[6] The six states are California, Indiana, Kansas, Maryland, New Mexico, and Wisconsin.
[7] http://www.timesrecord.com/website/archives.nsf/56606056e44e37508525696f00737257/8525696e00630dfe0525742c00522811?OpenDocument (last accessed April 28, 2008).
[8] The AMA has since dropped their resolution supporting a federal soft drink tax and has instead developed a resolution supporting collaborative efforts with the beverage industry to reduce obesity (Stanek, 2007).

are consistent with the conclusion that soft drink taxes reduce soft drink consumption because an increase in the tax rate without a reduction in consumption would have increased soft drink expenditures.

Fourth, other food-related taxes have been shown to reduce food consumption. Chouinard et al. (2007) calculate that a 10 percent ad valorem tax on the percentage of fat in dairy products would reduce fat consumption, albeit by less than one percent. Kuchler, Abebayehu, and Harris (2005) find that 'junk food' tax rates of 20 percent would reduce the consumption of calories from salty snacks and chips by 830 per year.

Fifth, the taxation of tobacco and alcohol demonstrates that it is possible to influence consumer behavior and health outcomes through the tax system. Cigarette taxes have been shown to reduce youth and adult smoking (e.g., Carpenter and Cook, 2008)[9] and improve health outcomes (e.g., Evans and Ringel, 1999). Grossman, Sindelar, Mullahy, and Anderson (1993) document that adults, especially young adults, are sensitive to the price of alcohol and that increases in alcohol taxes would reduce mortality, injuries, and crime.

On the other hand, the effectiveness of soft drink taxes as a policy to reduce obesity will be influenced by the availability of close substitutes to soft drinks and the associated cross-price elasticity (Schroeter, Lusk, and Tyner, 2008). As discussed by Schroeter, Lusk, and Tyner (2008), an increase in soft drink taxes will be less effective in reducing obesity if there are strong substitutes available with similar caloric composition.[10] Thus, although it is plausible that an

[9] An important exception to this conclusion is DeCicca, Kenkel, and Mathios (2002).
[10] A strong substitute for high calorie soft drinks is diet soft drinks. However, the availability of diet soft drinks as a substitute for high calorie soft drinks is not likely to reduce the effectiveness of the taxes in our study because diet soft drinks are commonly included in states' definition of "soft drinks" for taxation. Additionally, although diet soft drinks are low or no calorie drinks, consumption of diet soft drinks is linked to obesity because of the artificial sweeteners used in diet soft drinks (Fowler et al., 2008).

increase in soft drink taxes will reduce obesity, analysis of the efficacy of this increasing popular proposal as a means to reduce obesity is important.

Data

A. Soft Drink Taxes

We construct a set of total and incremental soft drink taxes at the state and quarter level from 1990 to 2006 following the strategy used by Tefft (2008). The total effective soft drink tax rate is the total tax collected on soft drinks after accounting for sales taxes, food exemptions, and specific excise taxes. The incremental effective soft drink tax rate is the tax on soft drinks relative to the level of taxation on other foods.

We first collect information on states' taxation of soft drinks with respect to specific excise taxes on soft drinks and other snack taxes, general state sales taxes, and special soft drink exceptions to food exemptions from sales taxes. Jacobson and Brownell (2000) provide guidelines and in many cases served as a comparison to measure accuracy in data collection (see Tables 1 and 2 of that article). Research tools used in this effort included web searches, LexisNexis Academic searches, and information gathered directly from states' Departments of Revenue web sites.

We convert all tax descriptions[11] such that they may be incorporated into total and incremental tax rates. For taxes that are quoted in dollars per quantity, we refer to the Bureau of Labor Statistics annual nationwide price index for a quantity of soda,[12] and convert any level tax into a percent of expenditure. We do not include taxes on soft drink syrups because we do not have information on the expected amount of syrup per quantity of soft drink.

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[11] "Soft drinks" are commonly defined similarly across states, although this is not always true. They are often defined broadly to include non-alcoholic, artificially sweetened or "diet" drinks, and carbonated water.
[12] See http://www.bls.gov/cpi/home.htm (last accessed June 16, 2008).

In order to build total and incremental soft drink tax rates we must account for general sales tax and food tax information. First, we collect state level sales tax information between 1990 and 2006. The primary sources for this collection effort include *The Book of the States*, published annually or biennially during the period of interest by The Council of State Governments (CSG, 1990-2007), and LexisNexis Academic database searches. In some cases, we also use information from *All States Tax Handbook*, published by the Research Institute of America (RIA, 2001). These sources include information on the sales tax rate for each state and effective dates of changes in those tax rates.

Next, a special consideration with respect to the taxation of food is that a number of states exempt food from the sales tax. One reason for this is that food is considered to be a basic necessity, so including it in the sales tax is a particularly regressive policy. We included these exemptions (identified in the sources listed above) in calculating the soft drink tax rates by coding net food taxes as zero when exempted. It is also important to note that some states that exempt food from the sales tax do not include some snack foods in this exemption, so we adjusted the rates accordingly in these cases.

We merge the specific soft drink tax rates with the information on general sales taxes and food exemptions to generate total and incremental effective soft drink tax rates. The total soft drink tax rate for each state is calculated by summing the specific soft drink tax rate and the general sales tax if the state does not exempt food from the sales tax or if the state exempts food from the sales tax but excludes soft drinks from the food exemption. If the state exempts food from the sales tax and does not exclude soft drinks from this exemption, then the total soft drink tax rate is equal to the specific soft drink tax rate. The incremental soft drink tax rate for each state is calculated as the total soft drink tax rate net of the tax rate for other food categories.

Using the effective dates of each tax, we are able to calculate quarterly soft drink tax rates for each state. We determine mean annual tax rates by aggregating quarterly tax rates.

The weighted means of the total and incremental effective soft drink tax rates faced by respondents are 4.13 and 3.16 percent, respectively, and each of their minima and maxima are 0 and 59 percent. In addition, 66.6% of the total tax rates faced are greater than zero while 40.6% of the incremental tax rates are greater than zero.

B. Person Data

In order to examine the potential effect on population weight status of soft drink taxes, we use data from the 1990 through 2006 waves of the Behavioral Risk Factor Surveillance System (BFRSS). BRFSS is conducted annually by state and U.S. territory health departments and the Centers for Disease Control to provide up-to-date information on health risks for use by local health officials and health researchers.

Some of the advantages of the BRFSS sample are that it is a nationally representative survey with a large sample size and that it contains relevant geographic information. These characteristics allow for a comprehensive analysis of tax changes across the U.S. for the duration of our soft drink tax data. Each respondent identifies his or her state of residence, thus allowing us to assign a soft drink tax rate to each observation. Finally, as a result of the large sample size, we are able to precisely estimate small weight responses to the low levels of taxation that would be difficult to detect in smaller datasets.

BRFSS includes information on the height and weight of each respondent, and body mass index (BMI) is calculated from these variables. Because self-reports of height and weight are known to be biased, following Cawley (2000), we compare self-reported measures of height and weight to measured values using NHANES III for each race and gender, and adjust the self-reported height and weight of respondents in the BRFSS accordingly. We then re-calculate BMI based on these adjustments. Dichotomous variables measuring overweight (BMI ≥ 25) and obesity (BMI ≥ 30) are constructed from this adjusted measure of BMI.

We exclude individuals from our analysis who are residents of Guam, Puerto Rico, and the Virgin Islands, restricting attention to the 50 states and the District of Columbia. We drop observations for which either age or race is not reported (approximately 1.6% of the sample). Next, we drop women who identify themselves as pregnant (1.1% of the remaining sample). Finally, we drop individuals from the sample who do not report BMI (7.9% of the remaining sample) or whose calculated BMI is less than 13 or greater than 70 (0.02% of the remaining sample), based on individuals' unadjusted self-reports of height and weight.

The final sample used in the analysis is reported in Table 1, with men and women shown separately. Reported values are weighted using the BRFSS survey weights to be representative of the national adult population. BRFSS only interviews individuals who are age 18 or older (with a top code at age 99), so our analysis does not apply to children or adolescents. Over 57 percent of the sample respondents are overweight and 20 percent are obese, while a very small fraction is underweight (BMI < 18). The BMI correction yields an overall mean upward shift of approximately 0.4 units relative to the reported values.

Empirical Methodology

In order to estimate the effects of soft drink taxation on weight outcomes, we closely follow the methodology used in the large literature that estimates the effect of taxation and prices on tobacco consumption.[13,14] The most recent work in this area uses within-state variation in taxes to identify changes in cigarette consumption. As discussed by Carpenter and Cook (2007), there are several data requirements necessary to use the state fixed effects approach. First, we require multiple observations on states. Second, the tax rate must vary within states over time (or else the tax variable will be perfectly collinear with state dummies). A third limitation with the approach is the potential for time-varying state-level unobservables that predict both changes in weight and changes in taxes. In the tobacco-tax literature, measures of "anti-smoking sentiment" have been shown to be important omitted state-level variables that substantially change the estimated price elasticities of tobacco consumption (DeCicca et al., 2006).

We use a two-way fixed effects OLS framework in order to estimate the effect of state soft drink prices on various weight outcomes, including BMI, overweight status, and obesity. In particular, we specify the following model:

$$outcome_{istq} = \beta_1' X_{istq} + \beta_2 T_{stq} + \mu_s + \delta_t + \gamma_q + \varepsilon_{istq}, \qquad (1)$$

where $outcome_{istq}$ is the weight outcome of individual *i* in state *s* at time *t* in quarter *q*, X is a vector of individual level covariates (e.g. race, income, etc), T is the state-level tax on soft drink sales, μ represents state fixed effects, δ represents year fixed effects, γ represents quarter-of-year fixed effects, and ε is the error term.[15] The coefficient of interest is β_2, which captures the effect of state soft drink taxes on weight by comparing individuals in the same state who face different soft drink taxes over time. Standard errors are clustered to allow for arbitrary

[13] See Chaloupka and Warner (2000) for a review of this literature.
[14] While there is a large literature that estimates price and income elasticities of consumption goods (e.g. Kuchler et al., 2005; Tefft, 2008; Chouinard et al., 2007), we estimate the reduced form relationship between soft drink taxes and weight because the BRFSS does not have information on consumption.
[15] A variant of this model was first introduced in the economics literature in the context of liquor taxation by Cook and Tauchen (1982).

correlation at the state level and observations are weighted using the BRFSS survey weights in all regressions.

Within the fixed effects framework, the impact of state soft drink taxes is identified from changes within states over time.[16] By using BRFSS data from 1990 to 2006, which is a period when 28 states changed their soft drink tax rates, we are able to overcome the two primary data limitations of this empirical strategy.

An additional limitation of this strategy, as outlined above, is the potential that unobserved characteristics that vary within states and over time are related to soft drink taxes and BMI. To address this limitation, following Gruber and Frakes (2005), we modify equation (1) to include state-specific time trends and estimate the relationship between soft drink taxes and weight outcomes as:

$$outcome_{istq} = \alpha_1' X_{istq} + \alpha_2 T_{stq} + \mu_s + \delta_t + \gamma_q + \phi_s \times t + \varphi_s \times q + \varepsilon_{istq} . \quad (2)$$

In equation (2), α_2 measures the effect of state soft drink taxes on weight outcomes.

To further examine the potential that time-varying state characteristics are related to soft drink taxes and BMI, we estimate additional specifications that include state economic conditions, specifically the one-year lagged state annual unemployment rate, and annual cigarette taxes. To address the possibility that unobserved state social norms regarding physical health and obesity are related to soft drink taxes and BMI, we estimate specifications that include one-year lagged values of state BMI averages and also estimate the impact of state soft drink taxes on whether an individual exercises outside of work activities. Finally, as falsification tests, we

[16] An alternative approach, implemented by Chouinard et al. (2007) and Kuchler et al. (2005), is to estimate demand systems to investigate price elasticities and then simulate the effects of a tax. A drawback to their approach is that price is not exogenous. Our approach directly examines the effects of a tax on health outcomes and therefore bypasses issues surrounding price endogeneity.

estimate the impact of state soft drink taxes on mental health status (recorded as a component of CDC's Healthy Days measures) and whether the individual received a flu shot.

Results

Table 2 displays the impact of both total and incremental state soft drink taxes (as defined in the Data section) on BMI, overweight, and obesity as estimated by equation (2), which includes state-specific time trends.[17] These results demonstrate that state soft drink taxes have a statistically significant impact on behavior and weight; however, the magnitude of the effect is small. An increase in the state soft drink tax rate of one percentage point leads to a decrease in BMI of 0.003 points and a decrease in obesity and overweight of 0.01 percentage points. We present results for both the total soft drink tax rate and the incremental soft drink tax rate and find similar results. In appendix Table 1, we show that limiting the analyses to states with non-zero soft drink taxes does not substantially change the main results.

Table 3 displays the results of the impact of state soft drink taxes based on income categories. We present only the results for the incremental soft drink tax rate in this table and the remaining tables; the results for the total soft drink tax rate are similar. We find evidence that state soft drink taxes have a greater influence on behavior for adults in the tails of the income distribution. A one percentage point increase in the soft drink tax rate decreases BMI by over 0.01 points for the lowest three categories (income below $20,000) and nearly 0.01 points the highest category (income above $50,000). For individuals with the lowest category of income (income below $10,000), a one percent increase in the soft drink tax rate decreases obesity by 0.08 percentage points and overweight by 0.10 percentage points. For individuals with the

[17] The results without state-specific time trends based on equation (1) are similar.

highest category of income, the corresponding decreases are 0.05 percentage points for obesity and 0.08 percentage points for overweight.

Table 4 presents the impact of state soft drink taxes for various demographic groups. The impact of state soft drink taxes is larger for females, middle aged and older individuals, individuals with greater education, and varies according to race and ethnic categories. A one percentage point increase in the soft drink tax rate decreases BMI by nearly 0.02 points for Hispanics, 0.003 points for whites, and 0.001 for blacks, though this last result is not statistically significant.

The results in Tables 2 through 4 demonstrate a statistically significant impact of soft drink taxes on weight that varies according to demographic and economic characteristics, but is generally small in magnitude. These results suggest that soft drink taxes influence behavior but that these behavioral changes are not sizeable enough to lead to large changes in population weight, based on the current magnitudes of state soft drink tax rates. Table 5 examines the robustness of these results. Controlling for one-year lagged average state BMI, one-year lagged state unemployment rates, and state cigarette taxes do not alter the results described above. These additional specification checks suggest that estimates of the impact of the soft drink tax rate on weight are not influenced by unobserved characteristics that are related to state soft drink tax rates and BMI. In Table 5, we also estimate falsification tests to provide further evidence that unobserved state-level factors are not driving the results linking soft drink taxes and weight outcomes. We show that soft drink taxes have no relationship with mental health status, flu shot receipt, or exercise outcomes.

Finally, in Table 6, we examine the dynamic effects of soft drink taxation on weight status. Our results strongly suggest that nearly all of the effect of taxation on weight is short term. Specifically we estimate equation (1) but replace current soft drink tax rate variables with tax rates from previous periods (previous year, 2 years prior, and 3 years prior). Except for the results for the previous year, all estimates are small and not statistically significant. The previous year results are in most cases small, positive and statistically significant. These results could suggest that consumers overcompensate for their reduced soft drink consumption in the short term, but we have no direct evidence in determining the cause of this pattern. Overall, our results suggest little dynamic effects of soft drink taxes on weight, which indicate that individuals respond over time to increased soft drink taxes to keep their steady-state weight.[18]

Conclusion

In this study, we estimate the effects of current soft drinks taxes on weight outcomes for the US population. As the "obesity epidemic" has garnered considerable attention in the US in the last decade, we examine the usefulness of attempts to control population weight gain through taxation of undesirable consumption. In doing so, we make several important contributions to estimating the effects of taxation on weight changes in the US population. We use state, year, and quarter-of-year fixed effects, along with state-specific time trends in our baseline specification and find that a one percentage point increase in soft drink taxes decreases adult BMI by 0.003. While soft drink consumption is the single largest contributor of energy intake in the US in the past decade (Block 2004), it represents only 7 percent of total energy intake. Therefore, we should expect only modest changes in population weight through soft drink consumption responses to small tax increases. We verify the robustness of our results by including a variety of time-varying state characteristics in our estimation specifications. We also

[18] Substantial interstate mobility would also reduce the estimated lagged relationship.

perform falsification tests on variables that should not be affected directly by soft drink taxes (e.g. mental health status). Overall, our results are robust.

While our results suggest modest changes in weight as a result of soft drink taxation, we should note that soft drinks are currently taxed at a low rate and many states are proposing sizeable changes to the soft drink tax rate. Over the period of our data (1990-2006), we calculate the average incremental tax rate on soft drinks to be approximately 3 percent. Maine has recently increased its soft drink tax rate by approximately 20 percentage points. Our results suggest that a 20 percentage point change will lead to a decrease in BMI of 0.06 and that the impact could be larger for some demographic groups.

The tax rate of soft drinks is especially low compared to other consumption items like cigarettes. In New York City, smokers pay $0.39 per pack of cigarettes to the federal government, $1.50 to the state government, and $1.50 to the city (Kuchler et al., 2005), so that the price per pack is over $5.75 (Boonn, 2007). The average federal and state taxes on cigarettes across the US are $1.66 of the average retail price of $4.54 (Boonn, 2007)—these taxes are comparable to an ad valorem tax of nearly 58 percent. While a tax rate of 58 percent is nearly out of the support of our data, we perform a back-of-the-envelope calculation to estimate the effects of imposing a soft drink tax of a similar magnitude to current cigarette taxes in the US. Our results suggest that raising the soft drink tax to 58 percent would decrease the mean BMI in the US by 0.16 points.[19] In comparison, the average gain in BMI between 1990 and 2006 was more than 2.3 points. A similar calculation suggests that increasing the tax rate by 55 percentage points would decrease the proportion of the population who are obese or overweight by nearly 0.7 percentage points While increasing the tax rate on soft drinks to be comparable with

[19] We perform this calculation by multiplying the coefficients in Table 2 that represent the change in BMI for each 1 percentage point increase in soft drink tax rates by the proposed change in tax rates of 55 points.

cigarettes will not halt the obesity epidemic, the impact on population weight would likely be non-negligible.

Although the impact of soft drink taxes on population weight is small in magnitude, a more complete evaluation of the effectiveness of this policy would compare a wider array of outcomes to the costs of these taxes. Reducing soft drink consumption may lead to improvement in other areas of health, including dental health (WHO, 2003). Additionally, an increase in the soft drink tax of this size would likely raise considerable revenue for the federal and state governments. The downside of the policy of increasing taxes of soft drinks is the likelihood that the tax is regressive.

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Table 1. Summary Statistics (Means)

Variable	All	Men	Women
BMI (reported)	26.222	26.765	25.688
BMI (adjusted)	26.668	26.928	26.412
Obese	0.209	0.201	0.217
Overweight	0.577	0.641	0.514
Underweight	0.001	0.006	0.014
Age	45.307	43.912	46.675
Black	0.105	0.097	0.113
Hispanic	0.105	0.111	0.100
White	0.863	0.868	0.858
High school grad	0.866	0.867	0.865
College grad	0.272	0.296	0.249
Income < $10k	0.078	0.058	0.990
Income >= $10k & < $15k	0.070	0.059	0.817
Income >= $15k & < $20k	0.087	0.079	0.948
Income >= $20k & < $25k	0.104	0.101	0.108
Income >= $25k & < $35k	0.160	0.161	0.158
Income >= $35k & < $50k	0.183	0.193	0.174
Income >= $50k	0.317	0.349	0.285
N	2709441	1126334	1583107
N (education)	2705873	1124846	1581127
N (income)	2364604	1007149	1357455

Note: Means are weighted using the BRFSS survey weights.

Table 2: The Impact of Soft Drink Taxes on BMI, Obese, and Overweight

	BMI	BMI	Obese	Obese	Overweight	Overweight
Total Soft Drink Tax Rate	-0.0029***		-0.0001		-0.0001	
	[0.0007]		[0.0000]		[0.0001]	
Incremental Soft Drink Tax Rate		-0.0030***		-0.0001		0.000
		[0.0007]		[0.0001]		[0.0001]
Male	0.571***	0.571***	-0.014***	-0.014***	0.136***	0.136***
	[0.046]	[0.046]	[0.003]	[0.003]	[0.004]	[0.004]
Age	0.309***	0.309***	0.016***	0.016***	0.027***	0.027***
	[0.004]	[0.004]	[0.000]	[0.000]	[0.000]	[0.000]
Age Squared	-0.003***	-0.003***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Black	1.852***	1.852***	0.113***	0.113***	0.138***	0.138***
	[0.076]	[0.076]	[0.005]	[0.005]	[0.005]	[0.005]
Hispanic	1.085***	1.085***	0.058***	0.058***	0.108***	0.108***
	[0.158]	[0.158]	[0.010]	[0.010]	[0.016]	[0.016]
Observations	1353719	1353719	1353719	1353719	1353719	1353719
R-squared	0.08	0.08	0.04	0.04	0.08	0.08

Notes: Heteroskedasticity-robust standards errors in parentheses that allow for clustering within states. Additional variables include state, year, and quarter fixed effects and state-specific time trends. Observations are weighted using the BRFSS survey weights in all regressions.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3: The Impact of Incremental Soft Drink Taxes on BMI, Obese, and Overweight by Income Category

	BMI	Obese	Overweight	N
Income < $10k	-0.0154***	-0.0008***	-0.0010***	175751
	[0.0015]	[0.0001]	[0.0001]	
Income >= $10k & < $15k	-0.0134***	-0.0005***	-0.0006***	167220
	[0.0017]	[0.0001]	[0.0001]	
Income >= $15k & < $20k	-0.0102***	-0.0008***	0.0003***	208096
	[0.0018]	[0.0002]	[0.0001]	
Income >= $20k & < $25k	0.0115***	0.0000	0.0003**	253257
	[0.0014]	[0.0001]	[0.0001]	
Income >= $25k & < $35k	0.0032**	0.0002**	0.0006***	373025
	[0.0013]	[0.0001]	[0.0001]	
Income >= $35k & < $50k	-0.0056***	-0.0001	-0.0005***	429271
	[0.0012]	[0.0001]	[0.0001]	
Income >= $50k	-0.0081***	-0.0005***	-0.0008***	757970
	[0.0010]	[0.0001]	[0.0001]	

Notes: Heteroskedasticity-robust standards errors in parentheses that allow for clustering within states. Each cell represents a separate regression. Additional variables include male, age, age squared, black, Hispanic, state, year, and quarter fixed effects, and state-specific time trends. Observations are weighted using the BRFSS survey weights in all regressions.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: The Impact of Incremental Soft Drink Taxes on BMI, Obese, and Overweight by Demographic Category

	BMI	Obese	Overweight	N
Female	-0.0041***	0.0000	-0.0005***	1583097
	[0.0008]	[0.0001]	[0.0001]	
Male	-0.0010**	-0.0001	0.0001**	1126325
	[0.0004]	[0.0000]	[0.0000]	
Black	-0.0012	-0.0001	0.0001	235642
	[0.0017]	[0.0001]	[0.0001]	
White	-0.0030***	-0.0001	-0.0001	1205782
	[0.0008]	[0.0001]	[0.0001]	
Hispanic	-0.0176***	-0.0022***	-0.0022***	157002
	[0.0019]	[0.0002]	[0.0001]	
High School Graduate	-0.0019***	0.0000	0.0001	1194035
	[0.0007]	[0.0000]	[0.0001]	
College Graduate	-0.0076***	-0.0004***	-0.0004***	792385
	[0.0007]	[0.0001]	[0.0001]	
Married	-0.0045***	-0.0003***	-0.0005***	1481699
	[0.0006]	[0.0000]	[0.0001]	
Age > 65	-0.0041***	-0.0001	-0.0002*	553913
	[0.0010]	[0.0001]	[0.0001]	
Age 18-25	0.0020	0.0000	0.0001	236521
	[0.0014]	[0.0001]	[0.0001]	
Age 25-40	-0.0032***	0.0000	-0.0005***	740654
	[0.0006]	[0.0001]	[0.0001]	
Age 40-65	-0.0036***	0.0000	-0.0001	1178334
	[0.0005]	[0.0001]	[0.0001]	

Notes: Heteroskedasticity-robust standards errors in parentheses that allow for clustering within states. Each cell represents a separate regression. The White and High school graduate samples were estimated using a 50% random sample. Additional variables include male, age, age squared, black, Hispanic, state, year, and quarter fixed effects, and state-specific time trends. Observations are weighted using the BRFSS survey weights in all regressions.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Alternative Specifications and Falsification Tests for Incremental Taxes

	BMI	Obese	Overweight
Controlling for Lagged State Average BMI	-0.0026***	0.0000	0
	[0.0007]	[0.0000]	[0.0001]
N	1338680	1338680	1338680
Controlling for Lagged State Unemployment Rate	-0.0036***	-0.0001*	0
	[0.0007]	[0.0000]	[0.0001]
N	1315252	1315252	1315252
Controlling for Cigarette Taxes	-0.0030***	-0.0001	-0.0001
	[0.0007]	[0.0000]	[0.0001]
N	1353719	1353719	1353719

Falsification Tests	Mental Health	Flu Shot	Exercise
Incremental Soft Drink Tax Rate	0.0059	-0.0002	-0.0002
	[0.0040]	[0.0001]	[0.0002]
N	745896	1206462	829549

Notes: Heteroskedasticity-robust standards errors in parentheses that allow for clustering within states. Each cell represents a separate regression. Additional variables include male, age, age squared, black, Hispanic, state, year, and quarter fixed effects, and state-specific time trends. Observations are weight using the BRFSS survey weights in all regressions.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: The Dynamic Impact of Incremental Soft Drink Taxes on BMI, Obese, and Overweight

	BMI	Obese	Overweight	N
Baseline	-0.0029***	-0.0001	-0.0001	1353719
	[0.0007]	[0.0000]	[0.0001]	
Lag = 1 year	0.0013**	0.0002***	0.0001	1344394
	[0.0006]	[0.0000]	[0.0001]	
Lag = 2 years	0.0006	0.0000	0.0001	1335006
	[0.0005]	[0.0000]	[0.0001]	
Lag = 3 years	0.0001	0.0001	0.0000	1325607
	[0.0006]	[0.0000]	[0.0001]	

Notes: Heteroskedasticity-robust standards errors in parentheses that allow for clustering within states. Each cell represents a separate regression. The baseline results are the results reported in Table 2. Additional variables include male, age, age squared, black, Hispanic, state, year, and quarter fixed effects, and state-specific time trends. Observations are weighted using the BRFSS survey weights in all regressions.

* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix Table 1: The Impact of Soft Drink Taxes on BMI, Obese, and Overweight for the Sample of States with a Soft Drink Tax

	BMI	BMI	Obese	Obese	Overweight	Overweight
Total Soft Drink Tax Rate	-0.0031***		-0.0001		-0.0001	
	[0.0008]		[0.0001]		[0.0001]	
Incremental Soft Drink Tax Rate		-0.0033***		-0.0001		-0.0001
		[0.0008]		[0.0001]		[0.0001]
Male	0.524***	0.524***	-0.016***	-0.016***	0.131***	0.131***
	[0.050]	[0.050]	[0.003]	[0.003]	[0.005]	[0.005]
Age	0.312***	0.312***	0.016***	0.016***	0.028***	0.028***
	[0.005]	[0.005]	[0.000]	[0.000]	[0.000]	[0.000]
Age Squared	-0.003***	-0.003***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Black	1.843***	1.843***	0.114***	0.114***	0.137***	0.137***
	[0.086]	[0.086]	[0.006]	[0.006]	[0.005]	[0.005]
Hispanic	1.111***	1.111***	0.060***	0.060***	0.111***	0.111***
	[0.189]	[0.189]	[0.012]	[0.012]	[0.019]	[0.019]
Observations	991592	991592	991592	991592	991592	991592
R-squared	0.08	0.08	0.04	0.04	0.08	0.08

Notes: Heteroskedasticity-robust standards errors in parentheses that allow for clustering within states. The results in this table are based on specification similar to those from Table 2, except that the sample is restricted to individuals living in states with a positive soft drink tax rate. Additional variables include state, year, and quarter fixed effects and state-specific time trends. Results use a 50% random sample of observations. Observations are weighted using the BRFSS survey weights in all regressions.

* significant at 10%; ** significant at 5%; *** significant at 1%