THE UNEQUAL DISTRIBUTION OF BODY MASS INDEX: EXAMINING THE EFFECT OF STATE-LEVEL SOFT DRINK TAXES ON OBESITY INEQUALITY

by

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(Under the Direction of Susana Ferreira, and Gregory Colson)

ABSTRACT

Sugar-sweetened beverages have emerged as one of the primary targets in the battle against obesity. Understanding the differential impacts of soda taxes for different obesity categories (e.g., moderate vs. morbidly obese) is critical to assess their full potential to not only reduce obesity rates, but to target those individuals who have the most to gain from a reduction in caloric intake, i.e., the morbidly obese. In this thesis we test two interrelated hypotheses associated with the health and social impacts of soda taxes as a policy instrument to combat obesity in the US. First, using data from a large representative sample of US adults, we assess whether the responsiveness of individuals to soda taxes is related to their body mass index (BMI). Second, we build upon these results to assess the impact of soda taxes on the BMI inequality (i.e., the BMI gap between normal weight and obese people) using weight inequality measures. Results from the analysis indicate that higher soft drink taxes slightly reduce the BMI of the morbidly obese, but not obesity inequality.

INDEX WORDS: Body Mass Index, Soft Drink Taxation, Obesity, Morbid Obesity, Inequality Index, BRFSS

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# CHAPTER 1

## INTRODUCTION

### *1.1 Prevalence and Recent Trend of Obesity in the U.S.*

Currently, obesity[1] is the second largest cause of preventable death in the United States and a significant contributor to a variety of chronic illnesses. During the past 20 years there has been a remarkable increase in obesity rate among the US adult population (Flegal et al., 2010). Based on analyses from this thesis, obesity rates between 1984 and 2010 increased by 222% (from 9% to approximately 29% of the adult population) (table 1). Specifically, the proportion of people classified as class 3 (morbidly) obese is approximately 3.56% in 2011, reflecting an increase of 614% from 0.5% in 1984. Over the same time period the percentage of US adults that are class 2 and class 1 obese increased by a lesser degree, 295% and 172%, respectively (table 1 and figure 1). The prevalence of overweight and obesity among adults also differs in their demographic and socioeconomic status (SES). According to Flegal et al. (2012), African Americans and Hispanics, low income households, and men have relatively higher rates of being overweight or obese compared to other groups in the US.

[1] Throughout this thesis we adopt the definitions proposed by the International Obesity Task Force (IOTF) of the World Health Organization (WHO) in 1997. Overweight and obese are defined as a body mass index (BMI), which is measured as mass(kg)/height$^2$ (m$^2$), above 25 and 30, respectively. A person with BMI less than 18.50 is classified as underweight and from 18.50 to 24.99 as normal weight. Any BMI greater than 30.00 and less than 34.99, greater than 35.00 and less than 39.99, and greater than 40.00 is regarded as class 1 obesity, class 2 obesity, and class 3 obesity, respectively.

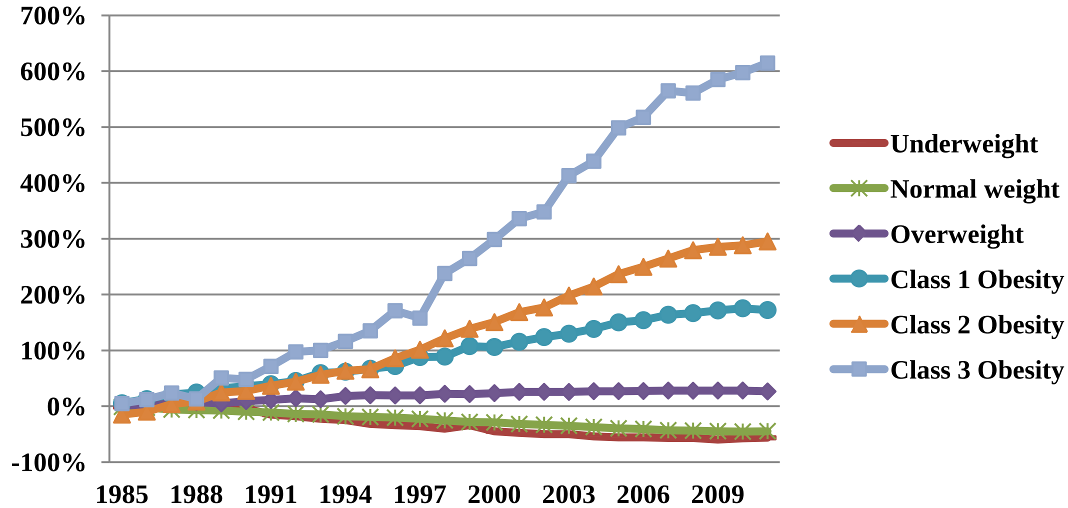


**Figure 1. Trends in Proportional Increase of Weight Categories, 1984-2011**

Figure 2 depicts the prevalence of overweight and obesity from the Behavioral Risk Factor Surveillance System (BRFSS) annual survey. From 1984 to 2010, the prevalence of overweight and obesity combined substantially increased from 38.2% to 66.5% in the adult population.

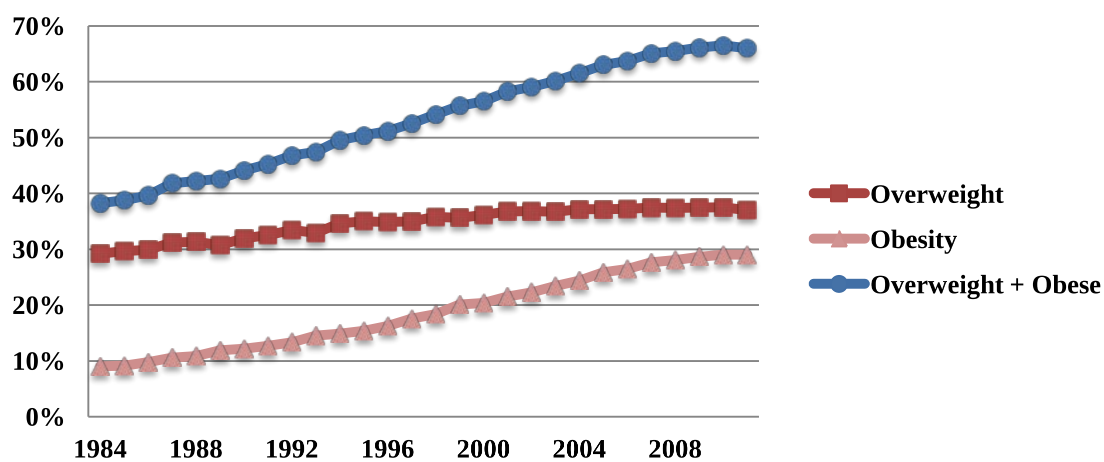


**Figure 2. Prevalence of Overweight and Obesity in the U.S., 1984-2011**

Although the prevalence of obesity or overweight and obesity combined among adults more than doubled between 1984 and 2011, the prevalence of overweight remained relatively stable during the same period (Fryar et al., 2012). It is also interesting to note that the recent increasing trend in obesity and overweight prevalence has leveled off (Flegal et al., 2012). In addition to the adult population, children and adolescent obesity has increased markedly in the last three decades as well (Capiro et al., 2008).

### *1.2 Public Health and Economic Problems related to Obesity*

Obesity increases the risk of a number of the most common chronic medical conditions in our society. An obese person is more likely to develop a range of chronic diseases such as type 2 diabetes mellitus, gallbladder disease, coronary heart disease (CHD), respiratory problems, high blood cholesterol level, high blood pressure, hypertension, and some kinds of cancer (breast, prostate, and colon) (Must et al., 1999; NHLBI Expert Panel, 1998; Wyatt et al., 2006). Psychiatric disorders that deteriorate individuals' quality of life such as depression and low self-esteem are also linked to chronic adolescent obesity (Mustillo et al., 2003).

Previous studies have attempted to estimate mortality and morbidity rate among US population attributable to being overweight or obese (Calle et al., 1999; Drenick et al., 1980; Fontaine et al., 2003; Mokdad et al., 2005). Specifically, Drenick et al. (1980) examined a group of morbidly obese men in a weight control program and reached a conclusion that a person's life expectancy is negatively correlated with the level of obesity. Taking a recent example that is estimated on US data, Mokdad et al. (2005) estimate mortality due to poor diet and physical inactivity to be 365,000 deaths in 2000 in the US. In addition to general associations between morbid health outcome and obesity, a direct correlation between increasing BMI and risk of specific disease was found in Calle et al. (1999) by studying one million individuals. Regardless of the actual cause of death, the most common cause of death among obese people was heart attack. For individuals with a BMI of 3 0 or above, mortality rates from all causes, and especially from cardiovascular disease, are generally increased by 50 to 100 percent above that of persons with BMIs in the rage of 20 to 25. Overall, mortality is also higher among the overweight and obese population, but the specific health risk of obesity varies with demographic and socioeconomic status (Paeratakul et al., 2002).

The social cost of obesity is, of course, the expected direct and indirect health care costs associated with obesity-related health problems. Direct health care costs refer to the expense of preventing, diagnosing and treating morbid health outcomes caused by overweight and obesity (for example, physician visits and hospital and nursing home care). According to Kuchler and Ballenger (2002), people who are overweight and obese in the US impose approximately $117 billion worth of social costs per year. They found that the direct cost of being overweight or obese in 2000 was about 4.7% of all U.S. health care expenditures. Indirect costs refer to expenses arising from current loss of workplace productivity from absenteeism and presenteeism, disability, premature mortality, life insurance expenses, and potential future earning loss due to obese weight status (Wolf and Colditz, 1998). For instance, a study on the effects of obesity on absence from work found that obesity is associated with 80% higher rate of absenteeism and 3.7 more days of absence from work than normal weight employees per year (Tsai et al., 2008). A national wide estimates of the obesity indirect cost is presented by Trogdon et al. (2008). They found that average cost of annual productivity losses caused by absenteeism attributable to obesity is approximately between $3.38 billion ($79 per obese individual) and $6.38 billion ($132 per obese individual).

Obesity also has an impact on labor market outcomes. Obesity is associated with wage penalties and reductions in hours of work (Mitchell and Burkhauser 1990; Bazzoli 1985). By examining National Longitudinal Survey of Youth (NLSY), Cawley (2004) found that higher BMI is significantly associated with lower wage rates for white females, but not for black females. Specifically, an increase in weight by two standard deviations (64 pounds) from mean among white female resulted in a 9 percent wage decrease. Also, weight and average intelligence test scores were positively correlated among black men. Averett and Korenman (1996) found that obese women tend to have lower family incomes than normal weight women, even after controlling for family background differences.

### *1.3 Soft Drink Tax to control Obesity*

A 'fat tax' on certain types of food has been adopted as a government intervention to control the recent obesity epidemic. It is a pigouvian tax type policy that aims to increase the price of specific foodstuffs to deter people from generating negative externalities by consuming them. Over the years, a number of research studies have linked the consumption of sugar-sweetened beverages (SSBs) with the increase in BMIs in the U.S. (Bray, 2010) and various chronic diseases (Must et al., 1999). To reduce the social cost of chronic diseases associated with obesity, the application of small sales taxes on food and sugar-sweetened beverages has been adopted by many local governments.

Currently, all U.S. states except for Alaska, Delaware, Montana, New Hampshire, and Oregon have state-wide general sales tax systems. All states levying a sales tax have exemption policies on certain types of goods. For instance, in the case of sales taxes on food items, sales of food for home consumption are normally exempted in most states[2] due to their potentially regressive nature, while sales of food in restaurants are generally taxable. In addition to general exemptions for food items, some states' definition of "food" category does not explicitly include soft drinks.[3] This initiative clearly aims to help individuals reduce soft drink consumption, diminish social cost of health care, and thus generate sufficient revenue to promote public health (Brownell et al., 2009).

The idea of taxing sugar-sweetened beverages in the battle against obesity was first introduced in the early 1990's and as of 2012, thirty-six states impose sales taxes on sodas (diet and nondiet sodas). The average tax rate is 3.645 percent and ranges from 1.225% in Missouri to 7.25% in California (table 2, 3, and 4). An increasing number of states have also implemented taxes on drinks sold by vending machines and non-sales taxes on manufacturers, distributors, wholesalers, or retailers of sodas. Most studies that have analyzed the relationship between sugar-sweetened beverage taxes and BMI have shown that there is a weak connection or no statistically significant effect (e.g., Powell et al., 2009; Sturm et al., 2010; Fletcher et al., 2009; 2010a).

### *1.4 Motivation and Statement of the Problem*

Building upon these earlier works, this paper provides causal evidence on the effects of statewide soda taxes on individual weight outcome and the distribution of population BMI using a variety of obesity classifications. Clinical evidence suggests that extremely obese people are

[2] For more details of current sales tax on food, see http://www.cbpp.org/cms/?fa=view&id=1230 (last accessed December 22, 2012) .

[3] A term, "soft drink" is normally defined as a non-alcoholic carbonated beverage with added sweeteners. The specific definition of taxable food or beverage items is different across states.

more prone to have serious chronic diseases (NHLBI Expert Panel, 1998). Since morbidly obese people normally undergo a surgical operation (bariatric surgery) to lose weight, the social health costs, on a per-individual basis, are most pronounced for those at the higher spectrums of the obesity scale. While there are significant individual and public benefits through reducing obesity rates, the benefits are the highest for those who are in the highest obesity classifications. This feature, coupled with the likelihood that severely obese individuals expend a greater proportion of their income on all foods, and in particular less healthy foods, raises the speculation that soda taxes could potentially have a significant impact on consumption among high BMI individuals. That is, if individuals with the highest BMI rates are more sensitive to food price changes, this could lead to significant individual and social benefits even if overall obesity rates change only to a minor degree.

So far, the effectiveness of soft drink taxes on obesity has not been fully considered by economists and policy makers before. A pioneering study of the potential of soda taxation policies for weight control (Fletcher et al., 2010a) found that increased price in soft drinks incurred by small flat-rate taxes would be associated with slightly lower obesity prevalence. In this thesis, we follow the same framework to verify whether (1) there is a statistically significant effect of soda taxes on individuals' BMI with more recent data, (2) individuals respond differently to various levels of soda taxes according to their BMI (i.e., the elasticity of demand for soda varies across individuals according to their BMI), and (3) soda taxes are associated with more equally distributed individuals' BMI. Although the overall magnitude of tax effects on average BMI is relatively minor (Fletcher et al., 2010a), we expect to verify that as the soda tax rate increases it lowers the BMI of extremely obese people more than that of less obese people.

Furthermore, using aggregated BRFSS and state-level data we also verify the hypotheses that this effect of soda taxes has the potential to reduce the inequality of individual BMI distribution.

Ultimately, our research aims to contribute to the growing body of research addressing the rapid growth of morbid obesity rates throughout the U.S., by shedding light on the ongoing debate over more stringent economic regulations targeting the obesity epidemic. In particular, we are concerned with the current lack of adequate empirical evidence concerning the effects of soda tax by respondent's weight.

Consequently, this thesis is focused upon (1) the verification of prior studies with more reasonable data handling method and recent data, and (2) the development and application of an appropriate analytic framework for revealing the hypothesized nonlinear effects of sugar-sweetened beverage tax, with a goal of evaluating the nature and extent of both the beneficial (decrease in obesity) and adverse effects (regressivity of food tax) of current soda taxation policies on obese people. Other contributions of this thesis include a comprehensive review of the existing literature on the economic effect of fat tax policy on obesity, detailed in Chapter 2. In addition, this thesis is one of only a handful of studies to examine both non-linear impact of soft drink tax (Auld and Powell, 2009), as well as its positive distributional impacts and labor market implications. Finally, both cross-sectional reduced form fixed effects models of individual BMI and longitudinal fixed effects models of state-level obesity inequality index are used, and the results from using these two different approaches to verify our arguments are provided for robustness, consistency, and cross-validation.

### *1.5 Hypotheses*

In spite of the national concern regarding obesity and the needs to assess the effectiveness of specific policy instruments used to fight the obesity epidemic, only few studies have analyzed the relationship between soda taxation and individual BMI in detail. This thesis verify prior studies with more recent data and presents critical evidence of a rarely studied by the literature – the responsiveness of individual weight outcomes to current soft drink taxes is different depending upon current BMI level. Specifically, the following hypotheses are tested:

Hypothesis 1a: Taxing soft drink taxes have statistically and economically significant effect on adults' BMI in the US.

Hypothesis 1b: The BMI of morbidly obese individuals is more responsive to changes in soft drink tax rates compared to less obese classes, other factors held constant.

Hypothesis 1c: An increase in the soft drink tax rate decreases the probability of individuals being morbidly obese, or obese, other factors held constant.

Hypothesis 2a: As the epidemiological literature points out, if the BMI level is affected by soda consumption and consumers are aware of changes in soda prices (or the presence of soda tax), the individual BMI should be more responsive to an incremental tax rate[4] than to the absolute level of the soft drink tax.

Hypothesis 2b: Not only does the incremental (or effective) soft drink tax rate better account for changes in individuals' weight status, the nonlinear effect can also be found in the same framework.

[4] Tefft (2008) defines incremental soft drink taxes as "taxes specifically on soft drinks net of other food taxes" and total soft drink taxes as "accounting for state's specific exclusions of soft drinks from the food exemptions to the sales tax".

Hypothesis 3a: If hypothesis 1b and 1c hold, we expect to verify that the degree of obesity inequality measured by a state-level inequality index in terms of BMI falls as the soda tax rate grows.

Overall, if the first set of hypotheses hold true, the intended benefit of such policy is actually larger than what previous literature found. The second hypothesis postulates that the benefits realized by taxation policy depend on the rate of incremental soft drink tax, which is the difference between the soda tax and food tax. This hypothesis will not hold if the actual weight gain is not associated with the growth in soft drink consumption or people are unaware of minor soda price changes due to infrequent change of sticker price. Finally, the third hypothesis refers to how soda taxation affects the whole distribution of individuals' BMI in each state by employing aggregated micro-level data. So far the distribution of individual BMI in each state has not been studied independently from previous studies. This distributional aspect of soda taxation with a specific focus on morbid obesity is particularly important since (1) most social costs associated with obesity come from morbidly obese people, not from the normal weight or moderately overweight groups, and (2) individual BMI is normally associated with wage rates in a negative way. Throughout this thesis, it is our goal to assess if taxing sugar-sweetened beverages not only reduces BMI on average, but also reduces the degree of inequality of obesity in a society.

*1.6 Thesis Outline*

Chapter 2 reviews the relevant theoretical literature, and provides a rationale for the effectiveness of soda tax policy on both economic and public health grounds. The strengths and weaknesses of the current soda taxation system and analytical approaches suggested by previous researchers are also presented, and insights of particular relevance to this thesis are discussed.

In chapter 3, we present the methodology. We first summarize the theoretical basis of individual utility maximization in the context of the relationship between BMI and food consumption and weight consideration. This chapter discusses what factors contribute to obesity as well as the economic reasoning as to how they affect obesity. For a detailed empirical study, we propose to use 4 different econometric models with the intention of comparing various modeling specifications, and highlighting various aspects of the obesity problem. The first model uses individual-level data from the Centers for Disease Control and Prevention (CDC) Behavioral Risk Factor Surveillance System (BRFSS). The models examine seventeen explanatory variables including individual covariates and state-level noneconomic and economic variables that are regressed on body mass index (BMI). Through model (2) and (3), we use probit model to estimate the probability of being obese under current soda taxation schemes. The fourth model is developed using state-level data which is aggregated from individual level data and uses ten explanatory variables which are regressed on state-level inequality index of BMI.

Chapter 4 describes the data. We combined an extensive individual-level data with detailed information on food, soft drink, and incremental tax rates at the state level. As well, state-level data and various inequality indices are developed for use in the ensuing empirical analysis. Chapter 5 presents the results and also contains detailed discussion of the choice of variables to be included in the analysis and the process of model selection. In Chapter 6 we present a comprehensive summary and policy implications of our empirical findings. Limitations to our modeling scheme, possible solutions, and suggestions for further research are discussed.

## CHAPTER 2

LITERATURE REVIEW

There exists a substantial number of empirical studies delving into various aspects of economic institutions associated with population weight. However, there is a paucity of research related to the effectiveness of soft drink taxation, providing additional justification for the empirical analysis contained later in this thesis. Throughout this chapter, we provide an extensive literature review with a specific focus on obesity prevalence associated with soft drink taxation policy. The methodological contributions presented by previous literature are critically reviewed, as are their specific empirical findings regarding the nature and extent of possible impacts of soda taxation.

### *2.1 Current U.S. Soft Drink Taxation System*

To help curb obesity prevalence and increase revenue that can be directed to the improvement of public health status, taxing sugar-sweetened beverages has been proposed and adopted across the U.S. states (Brownell and Frieden, 2009; Jacobson and Brownell, 2000). In contrast to European Union (EU) and Australia imposing taxes on food by value added tax (VAT) or general service tax (GST), no federal tax has placed on foods and beverages in the United States (Caraher and Cowburn, 2005; Leicester and Windmeijer, 2004). Instead, many county and state governments have placed a flat rate sales tax on foods and drinks mainly to achieve an objective of revenue generation for local governments, but not the improvement of public health in mind (Brownell et al., 2009). This local-level taxation policy has generally applied to a variety of food or drink categories as opposed to being based directly on the value of nutritional contents (Caraher and Cowburn, 2005). As a result, state governments are now taxing foods and drinks at flat rate, but the formal definition of taxable 'food' and 'sugar-sweetened beverage' items are different in each state as are the specific items exempted from the tax (Chriqui et al. 2008; Fletcher et al,. 2010a; Jacobson and Brownell 2000).[5] Additionally, excise taxes has placed upon components of soft drink and other beverage products such as bottles, syrup, powder or mix, and dispensing system.[6]

A study on current soda tax systems shows that state sales taxes on foods and sodas have remained at a stable level or even slightly declined since mid 1990's (Powell and Chriqui, 2011). Figure 3 shows the recent trend that more food items are being exempted from state sales taxes due to the regressive nature of such policy, so the average rate is decreasing. Specifically, the average food tax in the U.S. has declined from 1.29% in 1984 to 1.10% in 2012 (table 2). This trend results in inverted U-shaped curve for food and soft drink taxes except in the late 2000's soda tax, but the overall rate of sugar-sweetened beverage taxes is a bit higher than in 1984. Additionally, the difference between the soft drink tax and sales tax on normal food items is notable for its rising trend at the beginning of 2000's. The incremental tax, which represents the

[5] Definitions of taxable food products and soft drinks and related law citations in each state are available from Bridging the Gap Program at the University of Illinois at Chicago.
For more details see http://www.bridgingthegapresearch.org/_asset/71yw2g/Food-Definitions-2011-for-posting.pdf (last accessed March 15, 2013).

[6] As of 2009, legal citations related to license fees, privilege taxes, excise tax, and annual decal fees are found in Alabama, Arkansas, Rhode Island, Tennessee, Virginia, Washington, and West Virginia.
See http://www.bridgingthegapresearch.org/_asset/rc7kd6/HER_BTG_Brief_SSBtaxes-2009.pdf (last accessed April 3, 2013).

effective rate of tax on soft drinks, has increased approximately by 22.57% as compared to 1984, greater than 8.36% of soft drink (table 2).

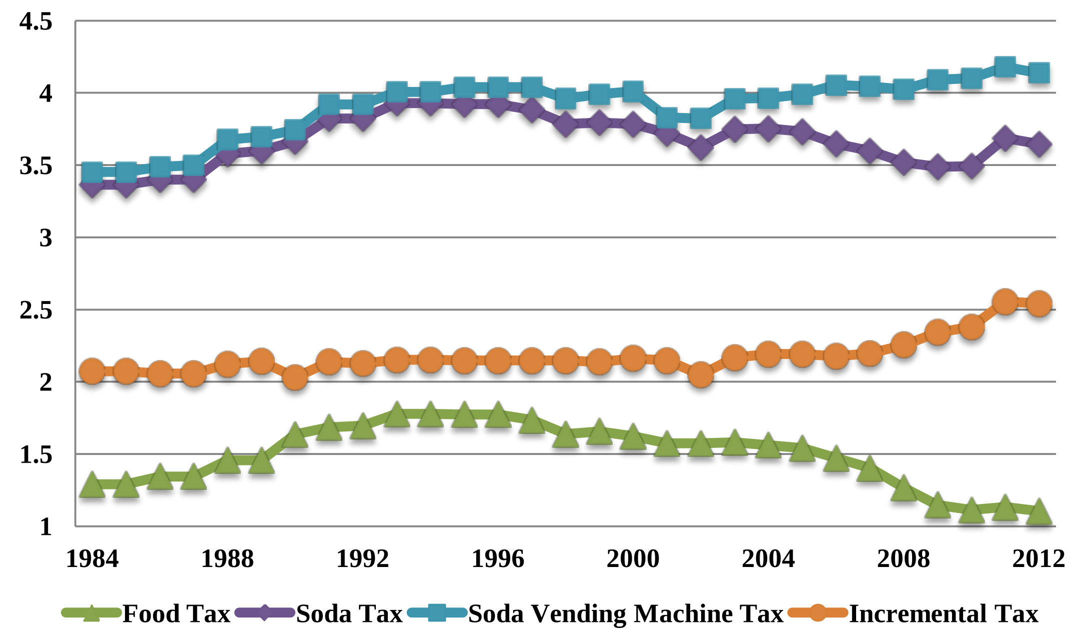


**Figure 3. Mean annual tax rates by certain types of tax**

*2.2 Impact of Food Price Changes on Body Weight*

As the main emphasis of this study is on soda taxation policy and the effect it has on individual weight loss, an in-depth look at the previous literature assessing the economic impact of food price changes on BMI will be provided in this subsection. Although there is no clear evidence on the price effect and the incidence of soft drink tax, it has gained wide support as a policy instrument to curb obesity prevalence by influencing relative price structures (Brownell et al., 2009; Powell and Chaloupka, 2009). Since the characteristics of adult weight is substantially different with that of adolescents, previous literature normally confined their interest to two subcategories: adult and adolescent, based upon their specific interests and hypotheses.

Much of the literature on food price changes is primarily concerned with the impact that such price changes have on individual weight level, and thus body mass index. In a widely cited and comprehensive study of the impact of food price changes, Chou, Grossman, and Saffer (2004) provide the first evidence of the potential effectiveness of soda taxation policy on adult weight outcome by utilizing cross-sectional data from 1984 to 1999. In this paper, the authors aim to estimate the impact of possible price changes on BMI based upon Behavioral Risk Factor Surveillance System (BRFSS) and American Chamber of Commerce Researchers Association (ACCRA) *Cost of Living Index*[7] data. The estimation results imply that a governmental policy that induces a relative increase in food prices can be used to reduce individual weight and curb the obesity prevalence, but the magnitude of BMI decrease is very minor unless the price increases are substantial. In response to this result, a great deal of literature has been devoted to the estimation of food price effects on adult BMI (Beydoun et al., 2008; Han and Powell, 2011; Powell and Han, 2011), and on adolescent weight outcomes (Auld and Powell, 2009; Powell et al., 2007; Powell, 2009; Powell and Chaloupka, 2009; Powell and Bao, 2009; Sturm and Datar, 2005; Sturm and Datar, 2008), based mostly on ACCRA price index data. The overall finding is that relatively high levels of fast food prices and low levels of fruit and vegetable prices is significantly associated with lower body mass index and obesity prevalence, but the absolute magnitude of effects is fairly small as compared to other factors in the model and in rare cases, the coefficients representing price indexes are not statistically significant. The implications of these studies is clear: that is, it is evident that any governmental policy that leads to a rise in the

[7] The Council for Community and Economic Research (C2ER) produces the Cost of Living Index (COLI) by collecting price data for highly specified items representing each Metropolitan Statistical Area (MSA)'s specific consumption pattern. Currently, the Cost of Living Indexes in grocery, housing, transportation, utilities, health care, and miscellaneous items are available for region-to-region comparisons.
For more details of index see http://www.coli.org/ (last accessed April 4, 2013).

price of energy-dense food can negatively affect population weight by reducing caloric intake, but imposing such policies is relatively costly due to regressivity problems, as compared to the potential welfare gain that can be achieved (Chouinard et al., 2007).

According to these studies, the question is not only whether the overall price level measured by cost of living influences food consumption behavior, dietary pattern, and thus body mass index level, but also whether it deters individuals from being obese or overweight. Specifically, a number of recent studies also employed measures representing the probability of being overweight or obese as primary health outcomes to understand how much food price increases affect individuals' food and soda consumption decision (Auld and Powell, 2009; Beydoun et al., 2008; Chou et al., 2004; Chou et al., 2008; Miljkovic and Nganje, 2008; Miljkovic et al., 2008; Powell et al., 2007; Powell et al., 2009). Despite the fact that an increase in the price of fast food leads to a slight decrease in the probability of being overweight or obese, its actual effect on individuals' obesity status is very minor as well.

Specifically, Powell et al. (2009) found evidence that raising fast food price is a particularly favorable measure to increase vegetable consumption since it affects individuals' consumption patterns and weight outcomes by adjusting relative price structure. Using reduced form models of BMI and overweight/obesity status, they estimated that a 10% increase in the price of a fast food meal leads to a 3.0% increase in the probability of frequent fruit and vegetable consumption, a 0.4% decrease in BMI, and a 5.9% decrease in prevalence of overweight. They also found that overweight individuals are more responsive to changes in prices than normal or underweight individuals. A similar negative effect of food price increases on BMI or the probability of being overweight was found by Auld and Powell (2009). In line with the previous results, this research also found a negative impact of an increase in food price on BMI, but a positive effect of vegetable price in opposite way. Since the authors employed quantile regressions for policy implications, the nonlinear effects of fruit and vegetable price and fast food meal price on individual BMI depending upon weight status can be estimated. In their research, the coefficient estimates of price measures at the 90th or 95th quantile are approximately three to five times greater than OLS estimates in a full-sample model.

While most of these studies only employ a regionally aggregated index of food price, there is a reoccurring concern that models employing food price indexes is not appropriate due to the possible threats of such indexes. For instance, as Koo et al. (2000) pointed out, empirical studies using ACCRA index is subject to a number of potential weaknesses in the ACCRA data due to sampling error, sampling bias, aggregation bias, and substitution bias. The inconsistency of lists of regions subject to the survey also limits researchers' ability to investigate time trends of indexes. Furthermore, the survey weights are significantly different from the consumer price indexes and include far less detail. They also exclude state and local taxes - a potentially major omission.

Despite the fact that ACCRA data offers the price index of "Coke", it is nearly impossible to assume that the price level of specific soda product can represent the overall price level of soft drinks. Following states' law citations on food and beverages there is no consistent definition of "Soft drink" across US states due to the presence of healthful beverages such as organic fruit juice and milk. Although artificial sweeteners and other sugar substitutes have more been used in a variety of beverages marketed as "sugar-free" or "diet", but not sure whether those products are, in fact, positively related to obesity is uncertain. Furthermore, even if we confine our interests to sugary drinks sold through grocery stores, estimating price indexes representing a variety of beverages is very challenging and costly. In addition to all these weaknesses of "Coke" index in ACCRA data, the absolute level of soda price is extremely small and does not vary sufficiently by states,[8] which justifies the employment of soft drink tax rates as a proxy variable to capture the effect of soda consumption on BMI.

### *2.3 Empirical Evidence of Fat Taxes on Body Weight*

Early evaluations of policies taxing sugary drinks as a control for obesity include Caraher and Cowburn (2005), Jacobson and Brownell (2000), Kim and Kawachi (2006), and Schroeter et al. (2008). Jacobson and Brownell (2000) is the first research to evaluate state and local taxation systems for soft drinks with a specific perspective of its usefulness as a potential method to increase public revenue. The authors claim that even a small raise in soft drink and snack food taxes would substantially increase public revenue. Specifically, based on the authors' calculation, a national tax of 1 cent per 12-oz soft drink would raise $1.5 billion in tax revenue and a national tax of 1 cent per pound of candy, chips, and other snack foods, or fats and oils, would raise about $70 million, $54 million, and $190 million, respectively. Another study involving policy analysis of food taxes was undertaken by Caraher and Cowburn (2005). In this paper, they sought to determine whether small tax initiatives are likely to be an effective policy to reduce individual BMI. By reviewing previous literature, they conclude that a stand-alone food taxation scheme would not be successful because individuals respond to the relative price changes, not to the price of energy-dense food alone. In particular, the authors claim that taxing food is likely to have an impact once it is considered within isolated systems such as schools and the workplace. Although a small tax would be enough to reduce soft drink consumption and individual BMI, a

[8] Based on the sample data of ACCRA Cost of Living Index in the second quarter of 2008, the geographical variation in Coke price in Alabama is quite stable within the range of $1.08 to $1.58.

larger tax should be imposed to have more effect on individual weight control and for visible health improvement (Kuchler et al., 2005).

Following Serdula et al. (1993), since obese children are more likely to become obese adults[9], the diseases associated with obesity and subsequent health care costs are likely to increase even more in the future given current trends. As a result, existing literature on soft drink taxation and its impact on population weight have concentrated almost exclusively on children and adolescents, due in large part to the particular importance of childhood obesity (Fletcher et al., 2010b; Powell et al., 2009; Sturm et al., 2010). In contrast to other research that found statistically significant relationships between soda taxes and individual obesity status, Powell et al. (2009) in their analysis of Monitoring The Future (MTF) data found no statistically significant association among adolescents between 13 and 19 years of age. However, they found that adolescent BMI among teens at risk of being overweight is significantly associated with taxes on soda sold through vending machine, but only minimally. Specifically, the authors estimated that a one percentage point increase in the vending machine tax rate reduces individual BMI of adolescents at risk of being overweight by $0.006\, kg/m^2$.

More direct evidence of the effectiveness of soft drink taxes among youth samples is presented in Fletcher et al. (2010b). In this paper, the authors examined the impact of state-level tax rates on child and adolescent sugar-sweetened beverage (SSB) consumption and BMI using more detailed 24-hour dietary recall data and objectively measured BMI in the National Health and Nutrition Examination Surveys (NHANES). Overall they found soda taxes had no effect on BMI or the probability that a youth would consume soda, although they found that a 1 percent increase in the tax rate is associated with approximately 8 fewer calories from soda consumed

[9] In particular, the authors found interesting result that (1) the obesity classification of nearly one-third of preschool children was unchanged over time, and (2) children who were obese at school-age become obesity in adulthood.

($p<.05$), an approximate 6% reduction. However, the authors noted that this decrease was offset by an increase from whole milk ($p<0.01$), resulting in no net changes in total calories consumed. They also found no substitution to diet drinks in this population.

Finally, several studies have drawn on existing state-level food and beverage sales taxes to examine the tax sensitivity of adult weights, with a specific focus on soda taxes. A study using aggregated individual-level data at the state level from the BRFSS and state soda and snack sales taxes by Kim and Kawachi (2006) found no difference in obesity rates between states with positive soft drink tax rates and states without soda taxation. However, they found that states repealing a soft-drink or snack-food tax had an increase in obesity prevalence. In order to have a closer examination and make broader claims, Fletcher et al. (2010a) pooled individual-level BRFSS data from 1990 to 2006 with state-level soda tax rates to estimate how much 1% rise in soft drink tax lowers individual BMI. Interestingly, it was hypothesized that the effective soda tax rate (incremental tax rate), defined as the soft drink tax less food tax, has a statistically significant effect on weight status and obesity prevalence. As a result, they found that a 1 percentage point increase in the state soft drink tax was associated with a 0.0029 unit reduction in adult BMI, a 0.01 percentage point decrease in adult obesity prevalence, and a 0.02 percentage point decrease in the probability of overweight, respectively. It is also important to note the amount of soda consumption is affected by the difference between soft drink tax and food tax rates since a unit increase in incremental tax rate has nearly the same level of impact on individual weight reduction and probability of being obese or overweight. This is clear evidence that increasing food or soda prices induced by current taxation scheme is significantly associated with lower individual BMI and reduced obesity rate, but the magnitude of this impact is still considerably small.

These findings of minimal effects of state-level soda sales taxes on weight outcomes are not surprising. Following Chouinard et al. (2007), even relatively large levels of taxes on soft drink would not be associated with the large reduction of soda consumption. First of all, we need to point out that the price elasticity of soft drink demand is relatively elastic compared to other foods and beverages. By reviewing 14 previous studies, Andreyeva et al. (2010) demonstrates the mean price elasticity of soft drink is 0.79, which is higher than juice (0.76), milk (0.59), and sugars (0.34). These elasticity estimates imply a possibility that the effective incidence of soft drink taxes would not be on consumers. This explains why previous studies delved into the effectiveness of soda taxation policies at best found very minor impact on individual weight. Another reason is that soda sales taxes are generally small and infrequently changed, whereas BMI has been consistently growing. Generally, these taxes are levied on the entire product class rather than on specific items, giving consumers limited incentive to substitute within the category (e.g., regular to diet soda). Furthermore, these taxes are usually in the form of post-purchase sales taxes, rather than reflected in shelf prices. Due to these reasons, the evidence suggests that a majority of consumers do not take sales taxes into account when making purchase. In fact, consumers may be unaware of the tax and unresponsive to a sales tax increase when making retail purchases (Chetty et al., 2009).

## CHAPTER 3

METHODS

*3.1 Conceptual Framework*

In this chapter, we present a simple behavioral model considering individual weight outcome. Following Philipson and Posner (1999) who include terms related to individuals' decision making on weight status as an argument in the utility function, we assume that individual utility is a function of weight. We also introduce the state-level indexes utilized to measure obesity inequality. We finally present the empirical models and methods used in the regression analysis to estimate the effect of state soft drink tax on body mass index.

*3.1.1 A Model of Individual Soda Consumption*

Previous studies have modeled economic decision in terms of soda and food consumption in a simple individual utility maximization framework, in which individual weight outcomes is an argument in the utility function. As in Asfaw (2007), Fletcher et al. (2010), Philipson and Posner (1999), Lakdawalla and Philipson (2002), and Schroeter et al. (2008), we assume a non-monotonic utility function that has an inverted U-shape in weight (*W*). To address the effect of an increase in the soft drink tax, we assume an economic agent who maximizes utility by consuming soft drink (*S*), non-soda food items (*NS*), and other composite goods (*O*). Therefore, an individual utility function can be represented as follows:

$$U = U(S, NS, O, W)\,, \tag{1}$$

where $\partial U / \partial S, \partial U / \partial NS, \partial U / \partial O > 0$ and $\partial^2 U / \partial S^2, \partial^2 U / \partial NS^2, \partial^2 U / \partial O^2 < 0$.

To incorporate a taxation policy effect into our model, we define the demand for soft drinks as a function of the price of soda ($P_S$), non-soda foods ($P_{NS}$), and other goods ($P_O$), and individual income ($I$). Since the main interest of our research is in estimating the effects of a soft drink tax on soda consumption and weight outcomes, soda price is affected by the state sales tax rate ( $\tau$ ) in equations below.

$$S = f(P_S(\tau), P_{NS}, P_O, I) \tag{2}$$

$$NS = g(P_S(\tau), P_{NS}, P_O, I) \tag{3}$$

$$O = h(P_S(\tau), P_{NS}, P_O, I) \tag{4}$$

The weight function ($W(\bullet)$) is defined as a function of the amount of soda and food consumed, and the level of physical activity ($A$).

$$W = W(S, NS, A) \tag{5}$$

A representative agent's budget constraint with a tax on soft drinks may then be specified as

$$P_S(\tau) \cdot S + P_{NS} \cdot NS + P_O \cdot O \le I, \tag{6}$$

where $\tau$ denotes the rate of soft drink tax, and $P_S$, $P_{NS}$, and $P_O$ represent the prices of soft drink, non-soda food items, and composite goods, respectively. Subject to their budget constraint, individuals maximize their utility by choosing the amount of consumption of each goods and the level of physical activity such as

$$\underset{S,NS,O,A}{Max} \; U = U(S, NS, O, W(S, NS, A))$$

$$\text{s.t. } P_S(\tau) \cdot S + P_{NS} \cdot NS + P_O \cdot O \le I \tag{7}$$

The model used in this thesis is very similar to a model suggested in Asfaw (2007) and Schroeter et al. (2008), which also assumed that the utility function is concave, continuous and twice differentiable. Finally, individual demand functions for soft drink and other non-soft drink food items and corresponding weight outcomes can be obtained by maximizing the utility with respect to the budget constraints.

$$S^* = f(P_S(\tau), P_{NS}, P_O, I) \tag{8}$$

$$NS^* = g(P_S(\tau), P_{NS}, P_O, I) \tag{9}$$

$$O^* = h(P_S(\tau), P_{NS}, P_O, I) \tag{10}$$

$$W^* = W(f(P_S(\tau), P_{NS}, P_O, I), g(P_S(\tau), P_{NS}, P_O, I), A) \tag{11}$$

Following Schroeter et al. (2005), it is interesting to note that the optimal weight derived from this optimization problem can be different from the ideal weight mainly because utility is an inverted U-shaped function in terms of weight status. An important testable implication of the theoretical model is that $S^*$ is a decreasing function of the soda tax rate, which implies that an increase in soda taxes reduces the weight of individuals (*W*) by reducing soda consumption.

*3.1.2 Inequality Indexes Revisited*

Previous literature has found a statistically significant, although very small, effect of soft drink taxation on curbing obesity prevalence. However, most of the studies have analyzed the impact of soda taxes on average BMI outcomes, ignoring the potential different effects of the policy on the distribution of individual BMI. A notable exception is the study by Auld and Powell (2009), who find that for adolescents any type of food price increase lowers the BMI level of the morbidly obese more than of normal or underweight people. From this finding, it is likely that similar results can be found in terms of soda tax rates. One objective of this thesis is estimating the impact of a 1% increase in the soda tax rate on obesity inequality. .

In addition to individual-level regressions that use BMI for different weight categories as the dependent variable, to verify the robustness of our empirical framework and for cross-validity, we perform state-level regressions that use BMI inequality indexes as the dependent variable. We use two alternative inequality indicators: Gini coefficient and generalized entropy, constructed by aggregating BRFSS individual-level data at the state level.

The Gini coefficient is the most widely used measure of income inequality (Allison, 1978). Applied to obesity, we calculated the obesity inequality in state *j* at time *t* as:

$$Gini_{jt} = 1 - \sum_{i=1}^{N} (x_{ijt} - x_{i-1jt})(y_{ijt} + y_{i-1jt}) \tag{12}$$

Based on our calculation, obesity inequality in the United States according to the Gini coefficient is on an upward trend (figure 4).

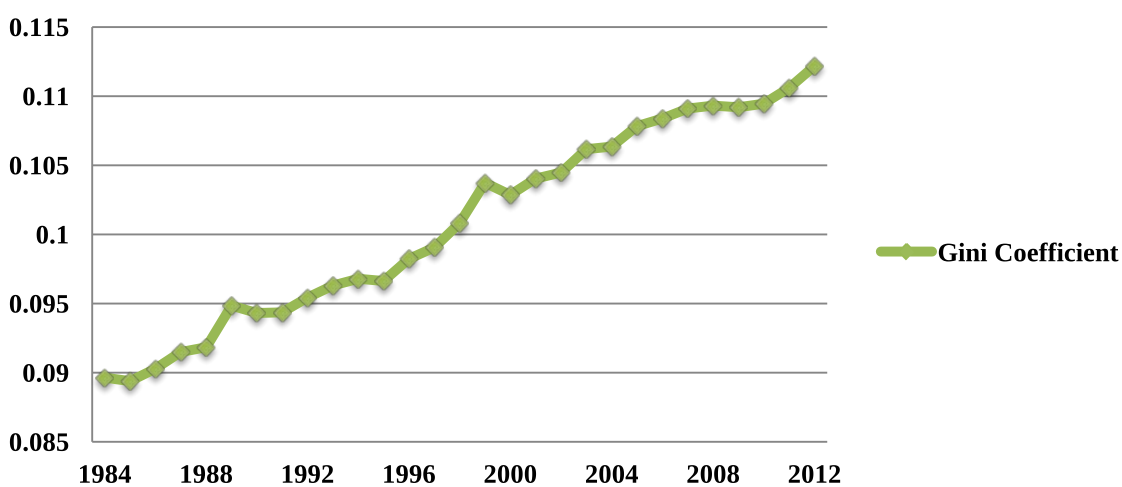


**Figure 4. Degree of Inequality in BMI distribution**

Although the Gini coefficient has some desirable properties,[10] we consider alternative inequality indexes to check the robustness of our analyses. The Theil index is one type of generalized entropy inequality measures whose general formula is given by:

$$GE(\lambda)_{jt} = \frac{1}{\lambda(\lambda-1)}\left[\frac{1}{N}\sum_{i=1}^{N}\left(\frac{y_{ijt}}{\bar{y}_{jt}}\right)^{\lambda} - 1\right] \tag{13}$$

The parameter $\lambda$ in the GE class represents the weight given to distances between incomes at different parts of the income distribution, and can take any real value. In practice of inequality studies, four GE measures, GE(–1), GE(0), GE(1) and GE(2), have normally been used. For lower values of $\lambda$, GE is more sensitive to changes in the lower tail of the distribution, and for higher values GE is more sensitive to changes that affect the top of the BMI distribution. That is, if we calculate GE(2) index in terms of individual BMI, it gives more weight to the right-end of BMI distribution which leads to overestimated inequality index. Since the effect of soft drink tax on individual BMI is expected to be very small in general, we compare the effect on GE(2) index to Gini coefficient to check whether there is a remarkable difference in regression results. If $\lambda$ is equal to 2 as in this thesis,

$$GE(2)_{jt} = \frac{1}{2}\left[\frac{1}{N}\sum_{i=1}^{N}\left(\frac{y_{ijt}}{\bar{y}_{jt}}\right)^{2} - 1\right] \tag{14}$$

In STATA, 'ineqdeco' command estimates a range of inequality indexes including members of the single parameter Generalized Entropy (Theil) class GE($\lambda$) for $\lambda$ = -1, 0, 1, 2, in addition to the Gini coefficient. Table 5 and figure 4 show that the absolute level of obesity inequality, estimated by GE(2) and the Gini coefficient are worsening across the U.S.

[10] The desirable properties of Gini coefficients are (1) mean independence, (2) population size dependence, (3) symmetry, and (4) Pigou-Dalton Transfer sensitivity (World Bank Institute, 2005).

*3.2 Empirical Models and Estimation Methodology*

In this chapter we present the empirical models that we use to study the effect of state soft drink tax on body mass index and BMI inequality. Our model specifications are based on those in previous literature (e.g. Auld and Powell, 2009; Fletcher et al., 2010a; Fletcher et al., 2010b). Since the cross-sectional estimates of state-dependent relationship may be subject to omitted variables bias, we include state fixed effects as well as time fixed effects to correct for it. Throughout this thesis, we also adopt cluster-robust standard errors to control for clustering in regression to prevent underestimated OLS standard errors.

*3.2.1 Fixed Effects Model of individual Body Mass Index*

We use a reduced form two-way fixed effects models to test our hypothesis. Briefly, we assume that $W_{ijmt}$ be the BMI of individual *i* who lives in state *j* at month-of year *m* and year *t*, and $X_{ijmt}$, $Z_{jt}$, $T_{jt}$, be a vector of individual-level covariates from Behavioral Risk Factor Surveillance System (BRFSS), economic and non-economic state-level variables that is expected to affect individual BMI, and soft drink tax rates, respectively. Once concern with this model construction is that coefficient estimates may be subject to potential omitted variables bias caused by state or time-related unobserved characteristics (Fletcher et al., 2010a; Fletcher et al., 2010b). Specifically, the particular concern is that unobserved state-specific characteristic affecting the recent rise in obesity prevalence or other state-level heterogeneity may be correlated with the level of the tax rate itself in a particular state, while simultaneously having an independent effect on BMI. It is also important to note that unobserved effect of time dependent factor also can affect individual BMI. By incorporating these terms representing fixed effects (grouped dummies), the model controls for the average differences across states, months, and years in any observable or unobservable predictors, and greatly reduces the threat of omitted variable bias. If we assume that $\mu_j$, $\sigma_m$ , $\delta_t$ denote state fixed effects, month-of year fixed effects, and year fixed effects, then an econometric model relating individual BMI to soda taxes and other covariates would be:

$$W_{ijmt} = \alpha + \beta X_{ijmt} + \phi Z_{jt} + \lambda T_{jt} + \mu_j + \sigma_m + \delta_t + \varepsilon_{ijt} \tag{15}$$

All reported standard errors are clustered by state of residence to allow for non-independence of observations within the same state. This model is particularly important since we wish to compare the absolute value of the coefficients of soda tax rate estimated in different subsamples depending upon their current obesity classifications[11] and verify which groups of people are being more affected by soft drink taxation. This should give insight into how much individual body mass is affected by proposed taxes and how much it is affected by current BMI.

In addition to analyses incorporating the level of soft drink taxes, we also follow the same modeling strategy to verify and compare the effect of "pure" soft drink taxation, so-called "incremental" soft drink taxation, on obesity prevalence. The concept of incremental soft drink tax, which is defined by total soft drink tax rate less the level of food tax, was first introduced by Fletcher et al. (2010a) to reveal the effectiveness of proposed policy measures. This analysis is designed to compare the results with a fixed-effects model estimated with soft drink taxes specified as

$$W_{ijmt} = \nu + \eta X_{ijmt} + \psi Z_{jt} + \gamma I_{jt} + \xi_j + \varsigma_m + \upsilon_t + e_{ijt}, \tag{16}$$

[11] It has been claimed that overweight is not associated with increased risk of morbidity and mortality (Faeh et al., 2011). As a result, normal weight category in this thesis also includes overweight individuals.

where $I_{jt}$ represents incremental soda tax rate in state *j* at time *t*. Since the main objective of this thesis is to show whether consumers' consumption pattern of energy-dense food and following weight status is being affected by an economic policy inducing relative price increase in high calorie diets, we hypothesize that only incremental tax rate would have statistically significant effect on individuals' weight outcomes.

*3.2.2 Probit and Ordered Probit Models of Obesity and Overweight status*

Based on the previous literature that found very weak or statistically insignificant associations between soda taxation and BMI, we examine the problem from another angle by assessing if imposing a soda tax influences the probability of individuals being obese. To estimate the impact of taxing sugar-sweetened beverages on reducing the probability of being morbidly obese, or moderately obese, we employ probit regression models with a dichotomous dependent variable equal to 1 if the individual is class 3 obese, or obese and 0 otherwise. It is important to note that the status of individuals being class 3 obese is also utilized as a dependent variable in this model to reveal the effect of tax measures on extremely obese individuals. By comparing two different types of models proposed here, we also can explore how much the price rise in soft drinks caused by soda taxes affects the probability of individuals being obese. The specific modeling strategies are

$$\Pr(W_{ijmt} > x_k) = \Phi(\alpha + \beta X_{ijmt} + \phi Z_{jt} + \lambda T_{jt} + \mu_j + \sigma_m + \delta_t), \quad (17)$$

where $x_k$ , $k = 1$ represents a threshold classifying class 3 obese group and non-morbidly obese group, and $k = 2$ denotes a cut point distinguishing obese people from non-obese individuals. All other modeling specifications are the same as in equation (15) and (16).

As we can see from table 1, the relative distribution of BMI substantially varies at the higher end of the distribution due to the nature of exponential increases in obesity. To control for this variation at high BMI levels and around the threshold, we also employ an ordered probit model where the dependent variable denotes ordinal categories representing 5 different groups of individuals depending on their BMI level. Furthermore, given that BMI has pre-established thresholds indicating increased health risks associated with obesity, it makes more sense to use the known threshold values to determine the relationship between soft drink taxation and the probability of being overweight or obese.

Specifically, using an ordered probit model provides more detailed information on the association between a unit change in a given variable and the probability of being in the next higher obesity classification - in this case, the probability of changing from normal to class 1 obese, or class 1 obese to class 2 obese. The ordered probit analysis allows the preservation of order in the obesity classifications depending upon current BMI, so normal weight is "higher" than underweight and obese is "higher" than normal weight. An ordered probit model with 5 obesity categories can be expressed as

$$Y^{*} = \Psi(x_k - (\alpha + \beta X_{ijmt} + \phi Z_{jt} + \lambda T_{jt} + \mu_j + \sigma_m + \delta_t + \varepsilon_{ijt})) \quad (18)$$

$$Y = \begin{cases} 0 & if \quad Y^* \leq x_1 \\ 1 & if \quad Y^* \leq x_2 \\ 2 & if \quad Y^* \leq x_3 \\ 3 & if \quad Y^* \leq x_4 \\ 4 & if \quad Y^* \leq x_5 \end{cases},$$

where $x_k$ represents the threshold point for category k, and $\Psi(\bullet)$ denotes the standard normal distribution function. Specifically, $Y^*$ is equal to 0 if individual *i*'s BMI level is less than 18.5, 1 if individual *i*'s BMI level is greater than or equal to 18.5 and less than 30.0, 2 if individual *i*'s

BMI level is greater than or equal to 30.0 and less than 35.0, 3 if individual *i*'s BMI level is greater than or equal to 30.0 and less than 35.0, 4 if individual *i*'s BMI level is greater than or equal to 40.0. It has been implied by Courtemanche (2011) that including underweight and class 3 obese people that have quite distinct characteristics in the analysis cause potential problems of smoothing coefficient estimate of soda tax rate. However, since the aim of this study is to figure out whether the economic impact of soda taxation on extremely obese people is different across obesity classes, we conduct additional analysis based on the sample without underweight individuals. To verify if there is a clear difference between a model estimated with the entire and censored sample, we estimate and compare these two ordered probit models in chapter 4.

### *3.2.3 Fixed Effects Model of State-level Inequality Index*

In a second step, we calculate a variety of concentration indexes in terms of individuals' BMI, a measure of the extent of obesity inequalities in state *j* at time *t*. Based on the evidence from BRFSS survey, we can make inferences that since the share of the morbidly obese in the entire population has remarkably increased, the shape of BMI distribution is more negatively skewed as compared to the previous periods. In this thesis we also assume that the level of obesity inequality of each state can be explained by aggregated individual covariates, state-level noneconomic policy variables, and state-level economic variables including soft drink taxation. The main objective of this analysis is first to calculate the inequality indices in terms of BMI revealing the recent upward trend in inequality and second to examine whether soft drink taxation has a positive impact on reducing inequality. The relationship between the inequality index and other variables including the tax rate is described by the longitudinal regression of the form

$$C_{jt} = \nu + \eta S_{jt} + \psi Z_{jt} + \gamma I_{jt} + \xi_j + \upsilon_t + e_{jt}, \tag{19}$$

where $C_{jt}$ is an inequality measure of state *j* at time *t*, $S_{jt}$ is a vector of aggregated individual characteristics, $\delta_t$ and $\mu_j$ denote state fixed effects, and year fixed effects, respectively. Using state and year fixed-effects completely controls for any fixed differences across states between years, which means that our identification strategy relies only on within-state variation in soda taxes. In this framework a weak negative relationship is expected between soda tax rates and the inequality indexes.

# CHAPTER 4

## SAMPLE SELECTION AND DATA DESCRIPTION

The independent variables included in the regressions were classified into four categories: (1) individual characteristics, (2) state-level non-economic factors, (3) state-level economic variables, and (4) state-level variables related to food, soft drink, and incremental tax rates. Table 6 lists the variables used in the analysis and their definitions. These variables were included because they were theoretically expected to affect individual food consumption decisions. A total of 33 independent variables were used in various combinations to estimate the three regression models proposed in the previous section: (a) Fixed effects models of individual BMI, (b) Probit models of obesity and overweight status, and (c) Fixed effects models of state-level obesity inequality index.

### *4.1 Individual Characteristics*

The data on individual characteristics were collected from the Behavioral Risk Factor Surveillance System (BRFSS) Annual Survey Data established by the Centers for Disease Control and Prevention (CDC).[12] The BRFSS is a cross-sectional, random digit dialed telephone survey of the United States adult population eighteen years or older reporting the present state of chronic diseases and demographic and socioeconomic status. As it is a telephone survey and people self-report critical data, it is important to note that it is subject to recall bias (Malone et al.,

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[12] The original BRFSS data files are available at http://www.cdc.gov/brfss/annual_data/annual_data.htm (last accessed April 6, 2013)

2008).[13] The first survey was conducted in 1984 in fifteen states.[14] Since then BRFSS data provides self-reported weight and height of each respondent, which are slightly under- and over-reported.

The dataset utilized in this thesis includes 3,151,285 individual observations that span 50 states and the District of Columbia from 1991 and 2010. Although for the analysis it would be desirable to include variables representing caloric intake behavior from consuming energy-dense food or fruits and vegetables, these data were not available for the period considered . Our sample does not include observations with miscoded values, missing values or no response. Furthermore, since the main interest of this paper is to examine how differences in soft drink tax rate affect individual BMI and population weight distribution, we also eliminate respondents who were pregnant at the time of the survey whenever that information is available. To control for the role of physical activity in weight control, we explicitly include in our econometric analysis responses to the question: "During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?". It is worth noting that none of the previous literature considered this variable due to the vagueness in the definition of physical activities or exercises and the relatively long time span (1 month).

Biases in self-reported health data have long been discussed by epidemiologic and economic researchers. Several studies have pointed out that self-reported anthropometric variables employing unadjusted height, weight, and BMI are susceptible to systematic bias (Kuczmarski et al., 2001; Wang et al., 2002). Specifically, Wang et al. (2002) found a systematic

[13] The responses are less precise for questions that require respondents to precisely report or recall numeric values over a longer period of time.

[14] For a list of states participating in surveillance system see http://www.cdc.gov/brfss/technical_infodata/surveydata/all_years/states_data.htm (last accessed March 30, 2013).

underreporting of weight and overreporting of height in self-reported data by older adolescents (15–19 years). This bias, however, does not remarkably change the coefficient estimates unless the dependent variable is obesity status since the correlation coefficient between corrected and uncorrected BMI is very close to 1 (Cawley, 1999; Chou et al., 2004; Lakdawalla and Philipson, 2002). To minimize the effects of self-reported bias, we follow the method suggested by Cawley (1999). Since the National Health and Nutrition Examination Survey III (NHANES III, 1988-1994)[15] contains physically measured weight and height data of selected respondents in addition to self-reported weight and height, the author proposes to regress actual height/weight on reported height/weight and the square of reported height/weight to find the relationship in order to control for bias. Since each ethnic group and gender combination normally has different weight distributions (Cawley, 1999), these regressions are estimated separately for eight groups: White male non-Hispanics, White female non-Hispanics, Black male non-Hispanics, Black female non-Hispanics, Hispanic males, Hispanic females, other males, and other females.[16] The coefficient estimates of these regressions are employed to generate calibrated values in weight and height of BRFSS data.

In addition to self-report bias, BRFSS data contains a relatively large number of outliers especially in weight and height, such as a respondent with a height of 8 ft 9 in or less than 3 ft in height. Following Chou, Grossman, and Saffer (2004), as the first criterion I eliminated the observations with an uncorrected BMI of <11 or >140 $kg/m^2$ to deal with the potential problems of extreme BMI. Although there is no theoretical basis for truncating both ends of the weight

[15] The NHANES III includes a partial sample of respondents reporting self-rated, and physically examined weight and height at the same time.

[16] The other races in NHANES III include Asians, Native Hawaiians or Pacific Islanders, American Indians, and Alaska Natives.

distribution, it appears to be a good technique to eliminate extreme outliers. Secondly, based on the assumption that people answered correctly, I excluded respondents that can be considered a group suffering from disease such as "dwarfism" or respondents taller than the tallest person (7 ft 8⅓ in) in the United States.[17]

*4.2 State-level Non-Economic Characteristics*

Although it is obvious that any information representing unseen statewide factors would at best have relatively minor effects on individual weight outcome, we included a variety of state-level controls to (1) provide more practical and detailed information to policy makers on potential public policies with impacts on obesity outcomes and (2) mitigate potential risks of omitted variable bias. We expect most state-level non-economic variables to have very small coefficient estimates compared to individual characteristics and state-level economic variables.

There is limited research on the link between access to transportation and weight outcomes. Previous literature analyzing how the built environment affects obesity prevalence in adults has produced mixed results. A recent review concluded that there are inconsistent associations of smart growth factors (representing the effects of built environment) with obesity-related outcomes (Durand et al., 2011). In our models, we control for the number of private and commercial autos per capita, state funding for public transit per capita, and annual vehicle miles traveled per capita, with data from Highway Statistics.[18] We hypothesize that when states invest

[17] Little People of America (LPA) defines Dwarfism as abnormally short stature that results from various genetic, medical, and nutritional problems. Dwarfism is normally defined as an adult height of 4 feet 10 inches or less, among both men and women.

[18] For more details of data source see http://www.fhwa.dot.gov/policyinformation/statistics.cfm (last accessed November 24, 2012) .

more on public transit, people rely less on cars and tend to more actively engage in outdoor activities.

In light of the potential of state parks to increase physical activity, we control for we state park operating expenditures per capita with data from the Annual Information Exchange, published by The National Association of State Park Directors (NASPD). Gordon-Larson et al. (2006) show that parks and other outdoor recreation resources are closely related to individual weight outcomes. Despite the fact that a state-level proxy variable of state park availability might have only a minor effect on the dependent variable due to the lack of consideration of individual choices, we hypothesize that having better-managed (and/or more) state parks offers more opportunities to residents to actively take part in outdoor activities. In the opposite direction, it is possible to consider a negative factor deterring people from participating in physical activities such as regional security. It is interesting to note that even though living in a dangerous place can reduce the level of physical activity, there is still no research that supports this theory. In this thesis, we include the violent crime rate of each U.S. state to control for state security effects using the annual Uniform Crime Reporting Statistics (UCR) of the Federal Bureau of Investigation (FBI). Again, this is very weak hypothesis since we are postulating a situation based on state-level data.

It has been claimed that Medicaid and the Children's Health Insurance Program (CHIP) have had a great influence on controlling individuals' weight participating in the program.[19] Following Finkelstein et al. (2003), in the United States approximately half of participants' direct medical spending associated with overweight and obesity is financed from federal and state governments in the form of Medicare and Medicaid. Furthermore, about 7% of Medicare

[19] For more details see http://www.medicaid.gov/Medicaid-CHIP-Program-Information/By-Topics/Quality-of-Care/Quality-of-Care-Obesity.html (last accessed April 4, 2013).

expenditure and 11% of adult Medicaid expenditures are attributable to obesity-related medical problems (Finkelstein et al., 2004). For instance, approximately 81% of New York and 28% of Georgia's adult obesity-attributable medical expenditures are financed through Medicaid and Medicare.[20][21] To reveal the substantial effect of Medicaid expenditure on obesity control, we need to have individual-level information of body mass index, chronic diseases, and program participation. This is not the objective of this thesis, but as a rough approach and to control for this effect, we employ historical data of Medicaid Per Enrollee State Estimates by State of Residence from 1991 to 2010, reported by Centers for Medicare & Medicaid Services.

*4.3 State-level Economic Variables*

The number of fast-food and full-service restaurants in each state is calculated using information from the 1987, 1992, 1997, 2002, and 2007 Census of Retail Trade (Bureau of the Census, 1989, 1994, 2000, 2004, 2009). In the Census of Retail Trade, the specific number of fast-food and full-service restaurants are coded based on Standard Industrial Classification (SIC) before 1997 and North American Industry Classification System (NAICS) after then. Since the census is conducted every 5 years since 1972, [22] to estimate data for other years we adopt the methodology proposed by Chou et al. (2004) that suggests interpolating or extrapolating depending upon state-specific logarithmic time trends. We merged fast-food with full-service restaurant data because, as Chou et al. (2004) points out, it is difficult to figure out differences

[20] For more detailed obesity statistics in New York see http://www.health.ny.gov/prevention/obesity/statistics_and_impact/ (last accessed March 15, 2013).

[21] For more details see http://www.georgiahealthnews.com/2012/03/obesity-expensive-problem-video/ (last accessed March 15, 2013).

[22] For a description of how Census of Retail Trade is conducted see http://www.census.gov/econ/overview/re0100.html (last accessed March 15, 2013).

between those. In particular, many full-service restaurants serve the type of high-caloric and inexpensive food that is offered by fast-food restaurants.

As mentioned in the literature review, in our analysis we do not control for the Cost of Living Index published by American Chamber of Commerce Researchers Association (ACCRA). In addition to data reliability issues, aggregating the prices of all fast-foods and fruits and vegetables may obscure important information on differences in the consumption and caloric patterns of households. However, to prevent omitted variable bias we do control for some economic variables that may influence food consumption behavior: distilled spirit tax rate ($ per gallon), cigarette tax rate ($ per pack), weighted average cigarette price ($ per pack).

Although there is no clear causal relationship between alcohol consumption and obesity, there are associations between habitual drinking and obesity and these are heavily influenced by lifestyle, genetic and social factors (National Obesity Observatory, 2012). Due to the fact that many people are not aware of the calories contained in alcoholic drinks, alcohol consumption can lead to a substantial increase in caloric intake. Interestingly, the effects of alcohol on body weight may be more pronounced in overweight and obese people (National Obesity Observatory, 2012).

In contrast to the effect of drinking on obesity, heavy smoking is also associated with lower weight. Smoking and subsequent nicotine intake temporarily increase energy expenditure and could reduce appetite, which may explain why smokers tend to have lower body weight than nonsmokers and why smoking cessation is frequently followed by weight gain (Chiolero et al., 2008). To reveal the relationship between economic factors related to smoking and obesity outcomes, two price measures, weighted average cigarette price and cigarette tax rate by state, are taken from Tax Burden on Tobacco.

In addition to variables representing transportation infrastructures, we extend our set of economic variables to include gasoline prices and taxes in each state. It is reasonable to assume that individual weight outcomes are in part subject to the changes in calories consumed due to transportation costs. Previous literature has found evidence that approximately 7% and 10% reduction in overweight and obesity is attributable to 1$ increase in gasoline price (Courtemanche, 2008). In our analysis we include average gas prices and tax rates by state from 1991 to 2010, taken from Independent Statistics & Analysis of US Energy Information Administration.

*4.4 Soft Drink Taxation*

Currently, Bridging The Gap (BTG) program (supported by Robert Wood Johnson Foundation) distributes data of general sales taxes and excise taxes on food, soft drink and snack and related statutory law citations of each state.[23] The detailed data sets include (1) sales tax rates for each of the 50 states and the District of Columbia for foods, sodas and selected snack products sold through grocery stores and vending machines and (2) state definitions of food and food Products. Since there are differences in specific tax rates of each state between data provided by Bridging The Gap and Fletcher et al. (2010a), we follow the strategy proposed by Chriqui et al. (2007), Fletcher et al. (2010a), and Tefft (2008) to construct data regarding soft drink taxes that allows our analysis to yield more reliable results.

First of all, in order to obtain sales tax rate and specific exemption information we refer to the Book of the States (The Council of State Governments, 1990-2011), published annually by the Council of State Governments (CSG, 1990–2011). Because "The Federation of Tax

[23] For a complete description of the current soft drink taxation system see http://www.bridgingthegapresearch.org/research/sodasnack_taxes/ (last accessed April 5, 2013).

Administrators" does not keep historical record of state-sale tax rates, we refer to this text which has a considerable amount of information about US tax systems. Tax rates in odd years from 1985 to 2001 cannot be gathered from "The Book of the States", so we refer to "All States Tax Handbook" just for odd year tax rates. Some states' food sales tax rate, such as (LA, NC, GA, AR, UT, WV) are subject to local sales tax. In this case, we calculate the average value of minimum and maximum local sales tax on food products, which is accessed by the LexisNexis academic search engine. If a state imposes state sales tax along with local tax, we sum up these two rates to represent the effective rate. If a tax rate changes on July 1 of a certain year, we divide the given rate by 2 to get the effective rate. Since sales of food for consumption other than meals sold by restaurant are tax-exempt, we incorporate this exemption information with general sales tax rate by setting net food / soft drink taxes as zero when exempted (Fletcher et al., 2010a).

Table 2 shows the average annual tax rates across all states for 1984 through 2012. The average soft drink tax rate varies between 3.364 and 3.929 percent during this period. The number of states with any tax on soft drinks in each year also varies between 34 and 38. However, it is interesting to note that the overall level of our total and incremental soft drink tax estimates (table 2) are slightly higher than tax rates estimated by Fletcher et al. (2010a). Particularly, they show that the average incremental and total soda tax in 1993 and 1994 was relatively higher than other study years, but we cannot find any states' law citations associated with this hike in tax rates. As a result, we carefully re-verify the reliability of sources used in this thesis and found no systematic error that biases our tax estimates.

# CHAPTER 5

## RESULTS

*5.1 Descriptive Statistics*

Table 7 reports descriptive statistics of individual characteristics from BRFSS, and other state-level variables. The overall mean of individual BMI in the sample is approximately 27.25, which is slightly greater than in previous literature due to the inclusion of more recent data. Although the magnitude of the difference is minor as compared to the absolute value of individual BMI, including more recent data has particular importance in explaining the recent sudden rise in obesity that has started from late 1990 and reached a peak around the late-2000s (Ogden et al., 2012). The average age of respondents is 50.66, ranging from 18 to 99. In contrast to Beydoun et al. (2008) who eliminated respondents older than 65 from the sample to ensure that only healthy individuals were included, we do not employ this criteria due to the arbitrariness of the threshold.

In this thesis an approach developed by Cawley (1999) calibrating the error of unadjusted BMI is employed to control for this measurement error. Using National Health and Nutrition Examination Survey III (NHANES III) data, we estimate linear regression models of actual BMI as a function of self-reported BMI and its squared terms depending upon gender and race characteristics to adjust self-reported data (table 8 and 9). As expected, table 10 shows that adjusted BMI is larger than unadjusted BMI since individuals tend to underreport their weight and overreport height. Our analysis also found a very strong correlation ( $\rho = 0.999$ ) between the corrected and uncorrected figures. Interestingly, the differences between unadjusted and adjusted BMI decrease over time indicating that individuals are more correctly reporting their BMI in recent years. Specifically, the percentage error has dropped from 1% of in 1984 to 0.485% in 2011 (table 10). This result may be due to (1) the improvement of digital scaling devices, (2) the increased awareness of weight status of the public, and (3) overall rise in absolute weight. The fact that this difference between actual and self-reported BMI is subject to a time trend implies that controlling for self-report bias might be a crucial part to achieve correct coefficient estimates when we deal with long time-series data.

As discussed in Chapter 4, the BRFSS is limited by the use of telephone survey methods, which may result in undersampling of disadvantaged ethnic groups who are less likely to have telephones (Diez-Roux et al. 1999; Coughlin and Uhler, 2002). As of 2010, the U.S. population is composed of approximately 72.4% White and 12.6% Black or African American people.[24] But, as shown in table 7, about 7.24%, 5.52% and 5.20% of our sample are Blacks, Hispanics, and other races, respectively. If we consider the fact that Blacks and Hispanics are 51% and 21% more likely to have higher obesity rates compared to the White population (CDC, 2009), the under sampling of these groups may lead to underestimate the impacts of soft drink taxation in previous studies as well as in our analysis.

The majority of respondents (75.29%) in the BRFSS sample reported that they were engaged in physical activity during the past 30 days (table 7). Due to the ambiguous meaning of the “physical activity”, this usually has not been included as a proxy variable representing the level of physical activeness in previous studies. Incorporating this variable into our model would slightly overestimate individuals’ exercise frequency as well as intensity. As expected, our

[24] Detailed statistics on demographic composition in the U.S. is available at http://www.census.gov/prod/cen2010/briefs/c2010br-02.pdf (last accessed March 15, 2013).

descriptive statistics also indicate that most respondents (75.29%) have been involved in exercise during the past month. Despite the potential measurement error, we decided to include this variable since exercising might be the most effective way to control one's weight.

The BRFSS survey includes a question regarding the employment status of respondents. About 62% of individuals in the sample are reportedly engaged in business or study. Approximately 38% of respondents do not belong to this group, which includes individuals currently unemployed, homemakers, and those retired or unable to work. The rationale of incorporating this variable into our model is to control for the physical activity associated with being employed or a student. We expect to find a significant negative effect of employment status on individual BMI and obesity prevalence.

*5.2 Fixed Effects Model of individual Body Mass Index*

The estimation results of equation (15) for 3,151,285 adult respondents from 1991 to 2010 are reported in table 11. Four different models were estimated to find the best fitting model explaining variations in the dependent variable. Throughout this thesis, cluster-robust standard errors are reported in parentheses under the coefficients since ignoring clustering effects in a model underestimates OLS standard errors and overestimates t statistics (Moulton, 1986; Bertrand et al., 2004). All the regressions include state, month-of-year, and year fixed effects.[25] State fixed effects account for unobserved state-level sentiment towards obesity or other state-level heterogeneity that may possibly be correlated with the level of soft drink taxes in a particular state, while simultaneously having an independent effect in other states.

[25] We could not find any noticeable difference in regression results with region fixed effects or season fixed effects.

Table 11 offers evidence that higher total soft drink taxes do not reduce individual BMI and obesity prevalence. As a baseline specification, model (1) regresses BMI on soft drink taxation including no covariates other than state, month and year fixed effects. The specifications of model (2), (3), and (4) are augmented by adding variables related to individual-level characteristics, state-level economic and noneconomic variables, respectively. In model (2) we add the individual covariates whose coefficients are expected to be highly statistically significant in most cases. In line with previous studies, age, gender, race (especially Black and Hispanic), education, marriage status, and income have the expected sign. Despite the fact that the survey question related to physical activity was not easily understandable, it explains a greater portion of variation in individuals' BMI than other variables in the model, suggesting that incorporating a variable representing physical activity is critical for modeling obesity prevalence and mitigating the risk of omitted variable bias. Overall, the coefficients on total soft drink taxes are negative, but not statistically significant in all four different specifications.

To figure out the effectiveness of increasing relative price of soft drink compared to food price, as we explained in equation (16) we apply the same framework and methodologies to incremental tax rates (table 12). The estimation result shows incremental soft drink tax is not significantly associated with individuals' BMI throughout the specifications in the entire sample. Based on the previous studies delved into the price elasticities of soft drink demand, this result is quite obvious because most increases in soda price will not be absorbed by final consumers. In contrast to Fletcher et al. (2010) that reported 1 percentage point rise in total and incremental soda tax rates are associated with a decrease in BMI of 0.0029 and 0.0028 points, our analysis does not provides any statistical evidence that soda taxes are important factors in determining weight outcomes.

This significant difference in the assessment of the impact of soda taxes is in part due to employing different criterion to handle extreme BMI values in the sample. For instance, Fletcher et al. (2010) adopt stricter, but relatively arbitrary standards to exclude several observations considered as outliers.[26] Since most negative effects of soda taxation on individual BMI come from obese people and underweight or normal weight individuals are not as responsive to soda price changes, dropping more observations with extremely low levels of BMI could lead to statistically significant parameter estimates in their research. Furthermore, a threshold distinguishing outliers from the sample should be applied to the adjusted BMI, not directly to the self-reported data.

Another possible explanation of this contradictory result can be found in the period of study. Specifically, adult obesity rate in the US has consistently increased at a lower rate since the mid 2000’s, so the inclusion of more recent data would lead to less significant coefficient estimates of soft drink taxes. In addition to the difference in individual level data, we also have to focus more on the wide discrepancies in soda tax rates especially in 1993 and 1994. If we consider the fact that the problem of obesity was not so severe at the beginning of 1990’s, this discrepancy could also lead to a further increase in the magnitude of tax effects.

The presence of statistically significant and meaningful effects of soft drink taxation on obesity presented by Fletcher et al. (2010) could reflect omitted variable bias from the exclusion of critical determinants explaining individual weight outcomes. Table 11 and 12 clearly shows that individuals more involved with any physical activity have sufficiently lower BMI, which implies the possibility of omitted variable bias in the previous study. To correct this problem we also included state-level variables that have relevant associations with government policies.

[26] Specifically, the authors exclude respondents with calculated BMI less than 13 or greater than 70 (0.02% of the remaining sample), based on individuals’ unadjusted self reports of height and weight.

It is possible that endogeneity may cause a serious problem with this model since we did not control for this issue in the analysis. It is likely that states with relatively high obesity rates direct more funding towards anti-obesity policies and campaigns. It is also possible that states might also raise soft drink and food taxes in response to recent rises in obesity rates. However, we do not believe that endogeneity poses a problem for our estimates. The data on state tax rates and legal terms related to obesity policy indicates that most southeastern states, which are those that are most significantly suffering from obesity prevalence (e.g. Mississippi), already had relatively high tax rates on food and soda items before 1984.

Turning to state-level covariates, as we expected in chapter 3, model (3) and (4) of table 11 and 12 show most state-level covariates are not statistically associated with individual BMI. In contrast to Courtemanche (2011), our results do not support the claim that a rise in gasoline price leads to the reduction of obesity prevalence. This contradicting result is robust to using either gas taxes or price.

### *5.2.1 Nested F-Test on State-level Non-Economic Variables*

We conducted an F-test on state-level noneconomic variables to evaluate if the state-level economic or non-economic variables have jointly significant effects on individual weight outcomes. The null hypothesis is that all slope coefficients of these variables are simultaneously equal to zero. In order to conduct this statistical test, we need to estimate two different models: an unrestricted model (equation 20) that includes all possible explanatory variables and a restricted model (equation 21) that omits variables being tested:

$$W_{ijmt} = \alpha + \beta X_{ijmt} + \phi Z_{jt} + \lambda T_{jt} + \mu_j + \sigma_m + \delta_t + \varepsilon_{ijt} \quad (20)$$

$$W_{ijmt} = \alpha' + \beta' X_{ijmt} + \lambda' T_{jt} + \mu_j' + \sigma_m' + \delta_t' + u_{ijt} \quad (21)$$

The test statistic follows a F distribution with *q* degrees of freedom in the numerator and *N-k-r-q-1* degrees of freedom in the denominator.

$$F = \frac{(R_{UR}^2 - R_R^2)/q}{(1-R_{UR}^2)/(N-k-r-q-1)} \sim F_{q,N-k-r-q-1}, \tag{22}$$

where $R_{UR}^2$ and $R_R^2$ denote the R-squares of the unrestricted and restricted model, respectively (Bremmer, 2003).

In the first regression results of total soft drink tax (table 11), our analysis indicates the effect of state-level non-economic and economic variables are not jointly significant, which fails to reject the null hypothesis at a 5% significance level, meaning that exogenous variables in the unrestricted model add no significant explanatory power to the restricted model. That is, the hypothesized state-level variables representing possible policy measures do not systematically affect individual weight outcomes. In the same way, these variables are not jointly significant in models with incremental soft drink taxes (table 12). Thus, in the subsequent analysis the restricted model only including statistically significant state-level variables (public transit investment per capita, vehicle miles traveled per capita, and Medicaid expenditure per enrollee) is chosen over a model with all possible explanatory variables.

### *5.3 Differential Impact of Soft Drink Taxes by Obesity Categories*

In order to investigate the potential different impact of soda taxes on BMI for different obesity categories, we estimated equation (15) and (16) for five subsamples defined according to a 5-category obesity classification using the total and incremental (or effective) soda tax rates as independent variables. This approach allows us to check hypothesis 1b and 1c in the BRFSS data (table 13 and 14). As a result, only morbidly obese people are weakly responsive (statistically significant at 10% level) to exogenous soda price changes incurred by incremental taxes.

Specifically, among extremely obese (class 3 obese) individuals a one percent increase in the incremental soda tax leads to a reduction in individual BMI approximately by 0.0709 units (table 14). Although incremental soda tax rates still negatively affects extremely obese respondents' BMI level, the effect of total soda tax which represents the absolute rate of soft drink taxes is not statistically significant across all obesity classifications (table 13). This finding is consistent with previous research that found similar effect of soft drink price effects on morbidly obese adolescents' BMI using quantile regression analysis (Auld and Powell, 2009). Another interesting finding for underweight sample supports claims by epidemiologic studies that engaging in physical activity increases the weight of underweight individuals (Gleeson et al., 1990).

Based on our tax rate data, it is interesting to note that 11 states have had no taxes on soft drinks since 1984.[27] It is obvious that the consumption pattern of residents in these states was not affected by soft drink taxation policy, so should not be included in our analyses. In table 15 and 16, we verify that our estimation results in a subsample of states with positive soda taxes do not substantially vary. The results demonstrate that small price rise caused by incremental or total soft drink taxes are associated only with morbidly obese individuals' weight outcome, but the effect is still minor relative to the current BMI. Specifically, we found that one percent increase in the incremental and total soda tax rate leads to a decreased BMI by 0.0847 and 0.0514, respectively. Based on the magnitude of coefficient estimates and statistical significance, table 15 and 16 clearly shows a possibility that a rise in incremental taxes is likely to achieve a greater reduction in soda consumption of the morbidly obese. Even after controlling for differential

[27] These states are Arizona, Delaware, Massachusetts, Michigan, Montana, Nebraska, New Hampshire, Nevada, Oregon, and Vermont.

impacts depending upon current BMI, the effect of taxing sugary drinks on individual BMI level is not only statistically insignificant but also economically unclear.

Applying OLS regression models to censored data sometimes lead to substantial downward bias in the estimate of coefficients since we cannot observe information about a certain segment in the population. To check the robustness of the regression results estimated with censored sample, we conduct further analysis using truncated regression (table A1 and A2). Specifically, the truncated and OLS regression results with total and incremental soft drink tax depending upon each subsample are compared each other to verify if there is a remarkable difference in coefficient estimates or statistical significance. As we see from table A1 and A2, coefficient estimates of truncated regression models are not significantly different from the OLS estimates, which reconfirm the robustness of our estimation.

*5.4 Probit and Ordered Probit Model of Obesity status*

Table 17 and 18 shows the results from the estimation of the probit models according to the general form in individual level analysis, with dichotomous variables representing class 3 obesity and obesity status as dependent variables. As the results indicate, increasing the current incremental (or effective) tax rate on soft drinks leads to a decrease in the predicted probability of being class 3 obese (table 18). According to this analysis, as people gain higher BMIs they are more likely to change their soda consumption pattern even if soda prices increase only a small amount. For instance, the results of the marginal effects analyses indicate that, for two hypothetical individuals with average values on other independent variables, the predicted probability of being class 3 obese is 0.08% lower for an individual living in a state with a one percentage point higher effective soft drink tax rate. However, in the same vein, a one percent increase in total soft drink tax does not explain the probability of individual being class 3 obese or obese (table 17). In table 19 and 20, as in chapter 5.3 we apply the same framework to a subsample excluding states that have had no taxes on soft drinks. Again, the overall results are consistent with previous estimates from full sample, but the effect of incremental soft drink tax on the probability of being class 3 obese is slightly larger. Although we identify the reducing effect of morbid obesity prevalence according to soda taxes, the given policy is proven to be ineffective in weight control due to minuscule impact and little statistical significance.

In this section we also use ordered probit models with the pre-established BMI classifications as an ordered categorical outcome. The estimated coefficients and corresponding marginal effects from the ordered probit regression models are presented in table 21 and 22. Our analysis reports that a one percent increase in total or incremental soft drink taxes is not statistically associated with the chance that individuals are classified as each obesity category. Interestingly, non-Hispanic blacks are 3.111% more likely to report that they are in the class 3 obesity group which agrees with most previous findings. Most state-level variables are not statistically significant at the 10% level except for Medicaid expenditure.

### *5.5 Fixed Effects Model of State-level Inequality Index*

This thesis presents new evidence of a claim rarely hypothesized in the literature - that the recent obesity epidemic has gradually increased the inequality in the distribution of BMI within the population. The analysis demonstrates that the degree of inequality in BMI measured by widely-employed inequality indexes such as the Gini coefficient and the Generalized entropy index is growing rapidly (figure 4), leading to potential problems of individual productivity disparity and subsequent rising income inequality. Specifically, the degree of obesity inequality measured by the Gini coefficient has grown by 23.38% in the past 26 years across the U.S. at an average rate of 0.79% since 1984 (table 5). This is partly because (1) obese adolescents as well as adults normally tend to stay obese and (2) a growing number of people are suffering from obesity while less heavy individuals keep their BMI at healthy levels.

Based on the individual-level analysis results, we first expect that an increase in incremental soft drink taxes will slightly reduce the inequality of BMI distribution in a given state. Since this taxation policy affects the weight outcome of morbidly obese people, a one percentage point rise in the soft drink tax would be associated with decreasing obesity inequality. Table 23 reports regression results for the estimation of equation (19) with an indicator of BMI inequality as a dependent variable. All the models incorporate three squared terms to capture true nonlinear relationship between an obesity inequality index and average age, number of restaurants, and cigarette taxes because the scatter plot of inequality indexes against tax reveals a weak nonlinear association.

First of all, using a state-level fixed effects model our study estimated the effect of incremental soda tax and other aggregated covariates on the obesity inequality in each state. As expected, a rise in incremental soda tax does not relate to the level of obesity inequality measured by Gini coefficient (table 23). In addition to the analyses on Gini coefficient, we also estimate the obesity inequality by Generalized Entropy (GE) index to check the robustness of our models (table 24). Although GE index at $\lambda = 2$ gives more weight on the right-end of BMI distribution, the results indicate that the effect of incremental soda taxes on obesity inequality measured by GE index is not statistically significant, or significant at 10% level with very minor effects.

However, there is clearly a problem with autocorrelation since the degree of BMI inequality in a state at a given period will be highly correlated with previous periods' distribution. Detecting serial correlation has particular importance in panel data analysis because parameter estimates are no longer efficient and standard error estimates are incorrect on average. To mitigate this problem we estimate a fixed effects regression with AR(1) disturbances, presented in table 25. Since we do not have any prior knowledge whether state effects are uncorrelated with other explanatory variables, we estimate fixed and random effects first order autoregressive model at the same time depending upon two obesity inequality indexes. To verify if random effect would be a more effective specification than fixed effects AR(1) model, we perform a Hausman test to compare the fixed versus random effects, with the null hypothesis that there is no systematic difference between these two models and the alternative hypothesis that there is a difference. While the fixed effects model is consistent under both hypotheses, the random effects model is not consistent under the alternative hypothesis. We compute a chi-squared value of 299.70 in regression results with Gini coefficient and 149.44 with GE index, which reject the null hypothesis at the 1% level. This means that the random effects model is inconsistent, so we do not employ it to model and interpret this relationship anymore. In fixed effects models (model (1) and (3) in table 25), the incremental soft drink tax is not statistically associated with obesity inequality, which leads to a conclusion that incremental soft drink tax has no effect on individuals' BMI distribution of each state.

## CHAPTER 6

## DISCUSSION AND CONCLUSION

### *6.1 Conclusions and Policy Implications*

In this thesis, we have examined the effects of soft drink taxation on individual weight outcomes and population weight distribution, using the CDC's Behavioral Risk Factor Surveillance System (BRFSS) merged with state-level economic/noneconomic variables and soft drink tax rates. The main objective of this study is to show if (1) current flat-rate soft drink taxation has had significantly greater influence on the weight outcome of morbidly obese individuals than others, (2) incremental (or effective) tax rates better explain the weight variation of the morbid obese, and (3) this taxation system has acted in ways that are effective to reduce obesity inequality among respondents. These additional social benefits of soft drink taxation have not been thoroughly studied by previous studies.

Using two-way fixed effects models, we first examine whether taxes on soft drinks are negatively correlated with soft drink consumption, and individual weight outcomes. As we see in table 11 and 12, we first reached the conclusion that it is difficult to reduce population weight by imposing small taxes on sugary beverages, in light of the current low level of soft drink taxes. The estimation results in subsequent individual-level analyses reveal that the effect of soft drink price changes has been overestimated in previous studies. Our results show that the morbidly obese tend to be more responsive even to a very minor change in food or soda price which could be explained by (1) the excessive amount of consumption and (2) the proportion of income spent on food items being much greater than for non-obese people. This finding implies that policies aimed to decrease the negative economic and social effects of obesity could consider increasing overall tax rates of soft drinks regardless of type of product and nutrient contents because most social costs are associated with extreme obesity. It also signals that morbidly obese individuals are well aware of the existence of soft drink sales taxes even if it is generally small and infrequently changed. A recent evidence on beverage consumption behavior also supports this claim by showing approximately 78% of residents in New York correctly perceive the presence of soft drink taxes (Zheng et al., 2012). It is obvious to assume that extremely obese individuals would have higher awareness rate than the non-obese. However, these evidences partly contrast with Chetty et al. (2009) that claimed consumers may be unaware of such taxes and are unresponsive to a sales tax increase.

In addition to the responsiveness of morbidly obese individuals, we find that BMI-lowering effect of taxing sugary drinks does not appear to exist for the moderately obese and non-obese. This result implies that these respondents normally do not pay attention to their weight status and energy-dense food consumption. In fact, this result is obvious and straightforward if we compare the (elastic) price elasticity of soft drink demand to other less energy-dense foods. As we discussed in Chapter 2, prior studies imply that government policies imposing taxes and fees on soft drinks will not be fully passed along to consumers in the form of higher prices. In another aspect, if we consider the fact that heavier people tend to be more addicted to the sweet taste in foods and drinks, they would have relatively inelastic price elasticities compared to less obese people, so tax incidence falls more on the class 3 obese.

The analysis incorporating incremental or effective soft drink resulted in similar coefficient estimates, but with greater impact on morbidly obese respondents. The results suggest that (1) raising the incremental soda tax rate would be more effective in reducing the BMI level of extremely obese individuals, (2) people being classified as morbidly obese pay more attention to relative price changes of soda with respect to other food items than less obese individuals, and (3) soda consumption is actually making people more obese. This research confirms what most people already know, that is taxation schemes raising the relative price of energy-dense, but low nutritional value foods would be successful in reducing morbid obesity rates.

Similarly, the probit regressions explaining the probability of being in a specific obesity category illustrate that imposing incremental tax on sugar-sweetened beverages would lead to a small reduction in class 3 obesity prevalence, but the impact is very close to zero. The probit regression results reaffirm the fact that soda taxation policies would not be an effective way to curb obesity.

The empirical evidence reviewed in this thesis does not found statistically significant effect of soda taxes on weight suggesting that even large taxes will not be effective to have a marked effect on individual soda consumption behavior and related weight outcomes. However, considering the fact that most social costs of obesity are caused by morbidly obese individuals, a hike in the soft drink tax rate can be sufficiently justified.

Not to mention that taxing soft drink would be associated with individual weight outcome, we also hypothesized that additional benefits of this policy come from a reduction in obesity inequality among adults. This thesis presents the first empirical evidence of the recent rise in obesity inequality at the state level and whether unequal distributions of population weight are associated with potential price changes in soft drink incurred by taxation. In line with the individual-level analysis, our results for the state level analysis does not find any evidence that taxing sugary drinks is associated with obesity inequality in each state. This result is not surprising since current low level of soft drink taxes and elastic price elasticities of soda demand would not have any deterrent effect on rising individual weight.

In conclusion, our analyses indicate that economic policies raising relative price in soft drink would not achieve a substantial reduction in obesity rate and obesity inequality, but can be employed to reduce morbid obesity prevalence. In addition, this study does not confirm if substantial increase in soft drink taxes would lead to less severe obesity status since we do not have sufficient evidence whether our result is estimated due to the current light tax rate or elastic price elasticity of soda demand.

### *6.2 Limitations and Extensions*

The main limitation of this research is the use of BRFSS data relying on random digit dialed telephone survey, which has been shown to undersample ethnic minorities. Given the association between ethnicity and the probability of being obese, our study has potentially underestimated the impact of soft drink taxes.

Other limitations of this thesis are the lack of information on specific food/soda consumption behavior that could be elicit with questions regarding fruits and vegetables or fast-food consumption. Since individuals may substitute to other non-taxed sugary drinks of related food items in response to taxes, analyzing factors representing individuals' consumption behavior and subsequent substitution effects would be a natural extension of this research.

As we see from the comparison of our results and Fletcher et al. (2010a), employing valid criterion to exclude outliers from the sample is practically important issue for more reliable estimates. Our analyses imply a possibility that extremely heavy individuals or underweight people have relatively different food consumption pattern, so excluding these respondents regarded as outliers or miscoded values could lead to incorrect coefficient estimates of soft drink tax. Therefore, a set of sensitivity analyses on how much coefficient estimates of soft drink taxes be affected by different criterion excluding observations in the lower and upper tail should be conducted to show the importance of extreme values in obesity research.

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**Table 1. Population Weight Distribution by Obesity Category, 1984-2011**

| Year | Under weight | Normal weight | Over weight | Class 1 Obesity | Class 2 Obesity | Class 3 Obesity | Obesity[a] | At risk of Overweight[b] |
|---|---|---|---|---|---|---|---|---|
| 1984 | 2.60% | 59.17% | 29.23% | 6.66% | 1.85% | 0.50% | 9.01% | 18.62% |
| 1985 | 2.57% | 58.64% | 29.67% | 7.03% | 1.57% | 0.52% | 9.12% | 19.41% |
| 1986 | 2.63% | 57.71% | 29.90% | 7.52% | 1.67% | 0.56% | 9.75% | 19.97% |
| 1987 | 2.45% | 55.73% | 31.22% | 8.06% | 1.92% | 0.62% | 10.60% | 21.78% |
| 1988 | 2.56% | 55.24% | 31.33% | 8.31% | 2.00% | 0.56% | 10.88% | 22.21% |
| 1989 | 2.75% | 54.65% | 30.74% | 8.82% | 2.31% | 0.75% | 11.87% | 22.95% |
| 1990 | 2.49% | 53.40% | 31.93% | 9.08% | 2.36% | 0.74% | 12.18% | 23.91% |
| 1991 | 2.21% | 52.56% | 32.54% | 9.30% | 2.52% | 0.85% | 12.68% | 24.39% |
| 1992 | 2.13% | 51.08% | 33.45% | 9.69% | 2.66% | 0.98% | 13.33% | 25.71% |
| 1993 | 2.01% | 50.57% | 32.91% | 10.62% | 2.89% | 1.00% | 14.51% | 26.68% |
| 1994 | 1.95% | 48.52% | 34.64% | 10.79% | 3.02% | 1.08% | 14.89% | 28.01% |
| 1995 | 1.78% | 47.83% | 35.01% | 11.14% | 3.07% | 1.17% | 15.39% | 28.89% |
| 1996 | 1.71% | 47.14% | 34.90% | 11.46% | 3.44% | 1.35% | 16.25% | 29.59% |
| 1997 | 1.67% | 45.80% | 34.99% | 12.54% | 3.72% | 1.28% | 17.54% | 31.37% |
| 1998 | 1.56% | 44.30% | 35.78% | 12.60% | 4.10% | 1.68% | 18.37% | 32.69% |
| 1999 | 1.72% | 42.58% | 35.64% | 13.85% | 4.41% | 1.82% | 20.07% | 35.01% |
| 2000 | 1.44% | 42.07% | 36.14% | 13.74% | 4.63% | 1.99% | 20.36% | 35.06% |
| 2001 | 1.37% | 40.37% | 36.77% | 14.36% | 4.96% | 2.17% | 21.49% | 36.83% |
| 2002 | 1.30% | 39.62% | 36.81% | 14.92% | 5.12% | 2.23% | 22.27% | 37.65% |
| 2003 | 1.31% | 38.57% | 36.74% | 15.32% | 5.51% | 2.55% | 23.39% | 38.83% |
| 2004 | 1.20% | 37.27% | 37.15% | 15.89% | 5.81% | 2.68% | 24.38% | 40.31% |
| 2005 | 1.15% | 35.82% | 37.16% | 16.68% | 6.22% | 2.98% | 25.88% | 42.13% |
| 2006 | 1.15% | 35.16% | 37.22% | 16.94% | 6.46% | 3.08% | 26.47% | 42.80% |
| 2007 | 1.12% | 33.80% | 37.45% | 17.59% | 6.73% | 3.31% | 27.63% | 44.46% |
| 2008 | 1.13% | 33.41% | 37.39% | 17.78% | 7.01% | 3.29% | 28.08% | 44.91% |
| 2009 | 1.05% | 32.84% | 37.47% | 18.10% | 7.12% | 3.41% | 28.64% | 45.54% |
| 2010 | 1.11% | 32.40% | 37.49% | 18.36% | 7.17% | 3.47% | 29.01% | 45.91% |
| 2011 | 1.13% | 32.86% | 37.01% | 18.15% | 7.30% | 3.56% | 29.01% | 45.61% |
| Percentage Increase | -56.38% | -44.47% | 26.62% | 172.37% | 295.17% | 614.53% | 221.98% | 145.03% |

Note: [a] Obesity denotes Class 1, Class 2, and Class 3 Obesity.
[b] At Risk of Overweight denotes adult males and females with BMI > 27.8, 27.3 respectively.

**Table 2. Average Food, Total, and Incremental Soda Tax Rates, 1984-2012**

| Year | Food Tax | Total Soda Tax | Soda Vending Machine Tax | Incremental Soda Tax |
|---|---|---|---|---|
| 1984 | 1.290 | 3.364 | 3.452 | 2.074 |
| 1985 | 1.290 | 3.364 | 3.452 | 2.074 |
| 1986 | 1.344 | 3.400 | 3.489 | 2.056 |
| 1987 | 1.344 | 3.400 | 3.499 | 2.056 |
| 1988 | 1.456 | 3.579 | 3.677 | 2.123 |
| 1989 | 1.456 | 3.598 | 3.696 | 2.142 |
| 1990 | 1.636 | 3.665 | 3.744 | 2.029 |
| 1991 | 1.686 | 3.823 | 3.921 | 2.137 |
| 1992 | 1.696 | 3.823 | 3.921 | 2.127 |
| 1993 | 1.777 | 3.929 | 4.007 | 2.152 |
| 1994 | 1.777 | 3.929 | 4.007 | 2.152 |
| 1995 | 1.775 | 3.922 | 4.039 | 2.147 |
| 1996 | 1.775 | 3.922 | 4.039 | 2.147 |
| 1997 | 1.735 | 3.882 | 4.039 | 2.147 |
| 1998 | 1.637 | 3.784 | 3.961 | 2.147 |
| 1999 | 1.657 | 3.794 | 3.990 | 2.137 |
| 2000 | 1.623 | 3.784 | 4.010 | 2.162 |
| 2001 | 1.574 | 3.721 | 3.828 | 2.147 |
| 2002 | 1.574 | 3.623 | 3.824 | 2.049 |
| 2003 | 1.581 | 3.748 | 3.959 | 2.167 |
| 2004 | 1.562 | 3.753 | 3.964 | 2.191 |
| 2005 | 1.540 | 3.731 | 3.991 | 2.191 |
| 2006 | 1.471 | 3.648 | 4.054 | 2.176 |
| 2007 | 1.402 | 3.599 | 4.045 | 2.196 |
| 2008 | 1.265 | 3.520 | 4.025 | 2.255 |
| 2009 | 1.148 | 3.488 | 4.091 | 2.341 |
| 2010 | 1.113 | 3.493 | 4.101 | 2.380 |
| 2011 | 1.133 | 3.687 | 4.180 | 2.554 |
| 2012 | 1.103 | 3.645 | 4.138 | 2.542 |
| Percentage Increase | -14.50% | 8.35% | 19.87% | 22.57% |
| Average Rate | 1.497 | 3.676 | 3.901 | 2.179 |

Note: Incremental soda tax (or effective soda tax) is defined as an effective tax rate on soft drink which is equal to soft drink tax less food tax.

**Table 3. Number of U.S. States taxing Food and Soft Drink, 1984-2012**

| Year | Food Tax | Total Soda Tax | Soda Vending Machine Tax |
|---|---|---|---|
| 1984 | 17 | 37 | 38 |
| 1985 | 17 | 37 | 38 |
| 1986 | 17 | 37 | 38 |
| 1987 | 17 | 37 | 38 |
| 1988 | 17 | 37 | 38 |
| 1989 | 17 | 37 | 38 |
| 1990 | 20 | 38 | 39 |
| 1991 | 20 | 38 | 39 |
| 1992 | 20 | 38 | 39 |
| 1993 | 20 | 38 | 39 |
| 1994 | 20 | 38 | 39 |
| 1995 | 20 | 38 | 39 |
| 1996 | 20 | 38 | 39 |
| 1997 | 20 | 38 | 39 |
| 1998 | 20 | 38 | 39 |
| 1999 | 19 | 37 | 39 |
| 2000 | 19 | 37 | 39 |
| 2001 | 19 | 37 | 38 |
| 2002 | 19 | 36 | 38 |
| 2003 | 19 | 37 | 39 |
| 2004 | 18 | 36 | 38 |
| 2005 | 18 | 36 | 38 |
| 2006 | 18 | 36 | 39 |
| 2007 | 18 | 36 | 39 |
| 2008 | 18 | 36 | 39 |
| 2009 | 16 | 34 | 39 |
| 2010 | 16 | 34 | 39 |
| 2011 | 16 | 36 | 40 |
| 2012 | 16 | 36 | 40 |

**Table 4. Level of Tax Rates by U.S. States, as of January 1, 2012**

| State | Food Tax (%) | Total Soda Tax (%) | Soda Vending Machine Tax (%) | Incremental Soda Tax (%) |
|---|---|---|---|---|
| Alabama | 4.00 | 4.00 | 4.00 | 0.00 |
| Alaska | 0.00 | 0.00 | 0.00 | 0.00 |
| Arizona | 0.00 | 0.00 | 0.00 | 0.00 |
| Arkansas | 1.50 | 1.50 | 1.50 | 0.00 |
| California | 0.00 | 7.25 | 7.25 | 7.25 |
| Colorado | 0.00 | 2.90 | 2.90 | 2.90 |
| Connecticut | 0.00 | 6.35 | 6.35 | 6.35 |
| Delaware | 0.00 | 0.00 | 0.00 | 0.00 |
| District of Columbia | 0.00 | 6.00 | 6.00 | 6.00 |
| Florida | 0.00 | 6.00 | 6.00 | 6.00 |
| Georgia | 3.00 | 3.00 | 4.00 | 0.00 |
| Hawaii | 4.00 | 4.00 | 4.00 | 0.00 |
| Idaho | 6.00 | 6.00 | 6.00 | 0.00 |
| Illinois | 1.00 | 6.25 | 6.25 | 5.25 |
| Indiana | 0.00 | 7.00 | 7.00 | 7.00 |
| Iowa | 0.00 | 6.00 | 6.00 | 6.00 |
| Kansas | 6.30 | 6.30 | 6.30 | 0.00 |
| Kentucky | 0.00 | 6.00 | 6.00 | 6.00 |
| Louisiana | 0.00 | 0.00 | 0.00 | 0.00 |
| Maine | 0.00 | 5.00 | 5.00 | 5.00 |
| Maryland | 0.00 | 6.00 | 6.00 | 6.00 |
| Massachusetts | 0.00 | 0.00 | 0.00 | 0.00 |
| Michigan | 0.00 | 0.00 | 0.00 | 0.00 |
| Minnesota | 0.00 | 6.88 | 6.88 | 6.88 |
| Mississippi | 7.00 | 7.00 | 8.00 | 0.00 |
| Missouri | 1.23 | 1.23 | 1.23 | 0.00 |
| Montana | 0.00 | 0.00 | 0.00 | 0.00 |
| Nebraska | 0.00 | 0.00 | 5.50 | 0.00 |
| Nevada | 0.00 | 0.00 | 0.00 | 0.00 |
| New Hampshire | 0.00 | 0.00 | 0.00 | 0.00 |
| New Jersey | 0.00 | 7.00 | 7.00 | 7.00 |
| New Mexico | 0.00 | 0.00 | 5.13 | 0.00 |
| New York | 0.00 | 4.00 | 4.00 | 4.00 |
| North Carolina | 2.00 | 4.75 | 4.75 | 2.75 |
| North Dakota | 0.00 | 5.00 | 5.00 | 5.00 |
| Ohio | 0.00 | 5.50 | 5.50 | 5.50 |
| Oklahoma | 4.50 | 4.50 | 4.50 | 0.00 |
| Oregon | 0.00 | 0.00 | 0.00 | 0.00 |
| Pennsylvania | 0.00 | 6.00 | 6.00 | 6.00 |
| Rhode Island | 0.00 | 7.00 | 7.00 | 7.00 |
| South Carolina | 0.00 | 0.00 | 6.00 | 0.00 |
| South Dakota | 4.00 | 4.00 | 4.00 | 0.00 |

| | | | | |
|---|---|---|---|---|
| Tennessee | 5.50 | 5.50 | 5.50 | 0.00 |
| Texas | 0.00 | 6.25 | 6.25 | 6.25 |
| Utah | 1.75 | 1.75 | 1.75 | 0.00 |
| Vermont | 0.00 | 0.00 | 0.00 | 0.00 |
| Virginia | 2.50 | 2.50 | 5.00 | 0.00 |
| Washington | 0.00 | 6.50 | 6.50 | 6.50 |
| West Virginia | 2.00 | 6.00 | 6.00 | 4.00 |
| Wisconsin | 0.00 | 5.00 | 5.00 | 5.00 |
| Wyoming | 0.00 | 0.00 | 4.00 | 0.00 |
| Average | 1.10 | 3.65 | 4.14 | 2.54 |

**Table 5. Trends in Obesity Inequality among U.S. adults, 1984-2011**

| Year | Self-report bias adjusted sample | | Self-report bias unadjusted sample | |
|---|---|---|---|---|
| | Gini Coefficient | Generalized Entropy | Gini Coefficient | Generalized Entropy |
| 1984 | 0.0896 | 0.0139 | 0.0929 | 0.0149 |
| 1985 | 0.0894 | 0.0138 | 0.0926 | 0.0148 |
| 1986 | 0.0903 | 0.0141 | 0.0935 | 0.0152 |
| 1987 | 0.0915 | 0.0146 | 0.0946 | 0.0157 |
| 1988 | 0.0918 | 0.0145 | 0.0950 | 0.0155 |
| 1989 | 0.0949 | 0.0157 | 0.0982 | 0.0169 |
| 1990 | 0.0943 | 0.0154 | 0.0976 | 0.0166 |
| 1991 | 0.0944 | 0.0156 | 0.0977 | 0.0168 |
| 1992 | 0.0954 | 0.0160 | 0.0988 | 0.0171 |
| 1993 | 0.0963 | 0.0161 | 0.1001 | 0.0175 |
| 1994 | 0.0968 | 0.0163 | 0.1004 | 0.0176 |
| 1995 | 0.0966 | 0.0165 | 0.1006 | 0.0181 |
| 1996 | 0.0982 | 0.0170 | 0.1019 | 0.0183 |
| 1997 | 0.0991 | 0.0169 | 0.1024 | 0.0182 |
| 1998 | 0.1008 | 0.0179 | 0.1048 | 0.0194 |
| 1999 | 0.1037 | 0.0192 | 0.1073 | 0.0204 |
| 2000 | 0.1029 | 0.0186 | 0.1068 | 0.0201 |
| 2001 | 0.1040 | 0.0190 | 0.1079 | 0.0205 |
| 2002 | 0.1045 | 0.0193 | 0.1084 | 0.0207 |
| 2003 | 0.1062 | 0.0199 | 0.1103 | 0.0215 |
| 2004 | 0.1064 | 0.0199 | 0.1107 | 0.0217 |
| 2005 | 0.1078 | 0.0205 | 0.1121 | 0.0222 |
| 2006 | 0.1084 | 0.0208 | 0.1128 | 0.0226 |
| 2007 | 0.1091 | 0.0210 | 0.1135 | 0.0228 |
| 2008 | 0.1093 | 0.0210 | 0.1138 | 0.0229 |
| 2009 | 0.1092 | 0.0210 | 0.1137 | 0.0228 |
| 2010 | 0.1095 | 0.0211 | 0.1140 | 0.0230 |
| 2011 | 0.1106 | 0.0215 | 0.1152 | 0.0234 |
| Percentage Increase | 23.38% | 54.74% | 24.00% | 57.64% |

Note: $\lambda$ of Generalized Entropy is assumed to be equal to 2 in this analysis to be more sensitive at upper tail.

**Table 6. Variable Descriptions**

| Variable | Definition | Expected Effect |
|---|---|---|
| Body Mass Index | Weight in kilograms divided by the square of the height in meters | |
| Underweight | Binary variable that equals one if BMI is less than 18.5 $kg/m^2$ | |
| Normal weight | Binary variable that equals one if BMI is greater than or equal to 18.5 $kg/m^2$ and less than 25.0 $kg/m^2$ | |
| Overweight | Binary variable that equals one if BMI is greater than or equal to 25.0 $kg/m^2$ and less than 30.0 $kg/m^2$ | |
| Class 1 obese | Binary variable that equals one if BMI is greater than or equal to 30.0 $kg/m^2$ and less than 35.0 $kg/m^2$ | |
| Class 2 obese | Binary variable that equals one if BMI is greater than or equal to 35.0 $kg/m^2$ and less than 40.0 $kg/m^2$ | |
| Class 3 obese | Binary variable that equals one if BMI is greater than or equal to 40.0 $kg/m^2$ | |
| Age | Age of respondent | + / - |
| Male | Binary variable that equals one if respondent is male | + |
| Non-Hispanic black | Binary variable that equals one if respondent is non-Hispanic black | + |
| Hispanic | Binary variable that equals one if respondent is Hispanic | + |
| Other races | Binary variable that equals one if respondent's race is other than white, black, or Hispanic | - |
| Some high school | Binary variable that equals one if respondent completed at least 9 years but less than 12 years of formal education | - |
| High school graduate | Binary variable that equals one if respondent completed exactly 12 years of formal education | - |
| Some college | Binary variable that equals one if respondent completed at least 13 years but less than 16 years of formal education | - |
| College graduate | Binary variable that equals one if respondent completed college education | - |
| Married | Binary variable that equals one if respondent is married | - |
| Divorced | Binary variable that equals one if respondent is divorced or separated | - |
| Widowed | Binary variable that equals one if respondent is widowed | - |
| Employed | Binary variable that equals one if respondent is employed or student | - |
| Physical activity | Binary variable that equals one if respondent participated any physical activity during the past 30 days | - |
| Household income | Real household income in constant 1984 dollars or eight-level binary variable | - |
| Violent crime rate | State-level violent crime rate per 100,000 population (number of violent crime per 100,000 population) | + |
| Medicaid expenditure | Medicaid per enrollee state estimates by state of residence ($ per enrollee) | - |
| Number of vehicles | Number of registered private and commercial autos per capita (number of motor vehicles per capita) | + |
| Public transit investment | Public transit investment per capita ($ per capita) | - |
| Vehicle miles traveled | Annual vehicle miles traveled per capita (miles per capita) | + |
| Restaurants | Total number of restaurant (full-service and fast-food) by state (number of restaurants per capita) | + |
| State park investment | Expenditure on state park operation ($ per capita) | - |
| Alcohol tax rate | Distilled spirit tax rate ($ per gallon) | - |
| Cigarette tax rate | Cigarette tax rate ($ per pack) | ? |
| Gasoline tax rate | Gasoline tax rate ($ per gallon) | - |
| Soft drink tax rate | Soft drink tax rate (%) | - |

**Table 7. Descriptive Statistics of Variables**

| Variables | Mean | Standard Error | Range (Min) | Range (Max) |
|---|---|---|---|---|
| Body Mass Index | 27.2497 | 5.4932 | 11.0074 | 137.3566 |
| Underweight | 0.0128 | 0.1125 | 0 | 1 |
| Normal weight | 0.3749 | 0.4841 | 0 | 1 |
| Overweight | 0.3676 | 0.4822 | 0 | 1 |
| Class 1 obese | 0.1590 | 0.3657 | 0 | 1 |
| Class 2 obese | 0.0585 | 0.2347 | 0 | 1 |
| Class 3 obese | 0.0271 | 0.1624 | 0 | 1 |
| Obese | 0.2446 | 0.4299 | 0 | 1 |
| Age | 50.6619 | 16.6805 | 18 | 99 |
| Male | 0.4153 | 0.4928 | 0 | 1 |
| Non-Hispanic black | 0.0724 | 0.2591 | 0 | 1 |
| Hispanic | 0.0552 | 0.2284 | 0 | 1 |
| Other races | 0.0520 | 0.2219 | 0 | 1 |
| Some high school | 0.0612 | 0.2396 | 0 | 1 |
| High school graduate | 0.3012 | 0.4588 | 0 | 1 |
| Some college | 0.2762 | 0.4471 | 0 | 1 |
| College graduate | 0.3340 | 0.4716 | 0 | 1 |
| Married | 0.5696 | 0.4951 | 0 | 1 |
| Divorced | 0.1666 | 0.3726 | 0 | 1 |
| Widowed | 0.1069 | 0.3090 | 0 | 1 |
| Employed | 0.6262 | 0.4838 | 0 | 1 |
| Physical activity | 0.7529 | 0.4313 | 0 | 1 |
| Household Income < $10k | 0.0574 | 0.2326 | 0 | 1 |
| Household Income >= $10k and <$15k | 0.0607 | 0.2388 | 0 | 1 |
| Household Income >= $15k and <$20k | 0.0791 | 0.2699 | 0 | 1 |
| Household Income >= $20k and <$25k | 0.0996 | 0.2995 | 0 | 1 |
| Household Income >= $25k and <$35k | 0.1406 | 0.3476 | 0 | 1 |
| Household Income >= $35k and <$50k | 0.1733 | 0.3785 | 0 | 1 |
| Household Income >= $50k and <$75k | 0.1710 | 0.3765 | 0 | 1 |
| Household Income >= $75K | 0.2183 | 0.4131 | 0 | 1 |
| Violent crime rate | 426.7768 | 189.3609 | 65.4 | 1207.2 |
| Medicaid expenditure | 3478.2080 | 901.3832 | 0 | 9026.49 |
| Number of vehicles | 0.8330 | 0.1367 | 0.2845 | 1.2716 |
| Public transit investment | 16.0076 | 22.6648 | 0 | 115.2961 |
| Vehicle miles traveled | 10.2714 | 1.7991 | 5.962 | 18.3446 |
| Restaurants | 21.2738 | 5.1222 | 11.3210 | 48.6203 |
| State park investment | 4.1489 | 2.4001 | 0 | 18.2761 |
| Alcohol tax rate | 1.1100 | 1.0218 | 0 | 4.9618 |
| Cigarette tax rate | 0.7262 | 0.4066 | 0 | 2.5524 |
| Gasoline tax rate | 0.1244 | 0.0549 | 0 | 0.5882 |
| Soft drink tax rate | 3.9392 | 2.5863 | 0 | 8.25 |

**Table 8. OLS Regression of Actual Height on Reported Height**

| | White Male | White Female | Black Male | Black Female | Hispanic Male | Hispanic Female | Other Male | Other Female |
|---|---|---|---|---|---|---|---|---|
| Height | -1.6081 | -3.0084 | 0.9161 | -0.1954 | -0.6413 | -1.0662 | -1.4505 | -3.3775 |
| Height squared | 0.7324 | 1.1966 | -0.0963 | 0.1868 | 0.3840 | 0.4767 | 0.6758 | 1.3204 |
| Constant | 2.3103 | 3.3536 | 0.4170 | 1.4484 | 1.6654 | 2.0683 | 2.2169 | 3.6156 |
| Number of Observation | 224 | 279 | 334 | 378 | 316 | 324 | 48 | 54 |
| F | 605.78 | 567.94 | 308.91 | 174.08 | 333.99 | 85.45 | 56.04 | 85.19 |
| R-squared | 0.8457 | 0.8045 | 0.6511 | 0.4814 | 0.6809 | 0.3474 | 0.7135 | 0.7696 |
| Adjusted R-Squared | 0.8443 | 0.8031 | 0.649 | 0.4787 | 0.6789 | 0.3433 | 0.7008 | 0.7606 |

**Table 9. OLS Regression of Actual Weight on Reported Weight**

| | White Male | White Female | Black Male | Black Female | Hispanic Male | Hispanic Female | Other Male | Other Female |
|---|---|---|---|---|---|---|---|---|
| Weight | 0.8231 | 1.0965 | 0.4909 | 2.0073 | 1.8970 | 1.3691 | 0.5407 | 1.5870 |
| Weight squared | 0.0006 | -0.0006 | 0.0034 | -0.0073 | -0.0071 | -0.0028 | 0.0042 | -0.0055 |
| Constant | 8.4588 | -1.9707 | 18.0209 | -31.5558 | -26.2060 | -10.4877 | 10.8666 | -14.9343 |
| Number of Observation | 194 | 251 | 276 | 334 | 259 | 264 | 42 | 45 |
| F | 490.94 | 663.17 | 1016.16 | 540.96 | 390.61 | 517.44 | 90.48 | 119.32 |
| R-squared | 0.8372 | 0.8425 | 0.8816 | 0.7657 | 0.7532 | 0.7986 | 0.8227 | 0.8503 |
| Adjusted R-Squared | 0.8354 | 0.8412 | 0.8807 | 0.7643 | 0.7513 | 0.797 | 0.8136 | 0.8432 |

**Table 10. Calibration Results of Individual BMI**

| Year | Unadjusted BMI | Adjusted BMI | Difference | Percentage Error |
|---|---|---|---|---|
| 1984 | 24.280 | 24.537 | 0.256 | 1.056% |
| 1985 | 24.353 | 24.611 | 0.258 | 1.060% |
| 1986 | 24.454 | 24.694 | 0.240 | 0.980% |
| 1987 | 24.661 | 24.902 | 0.241 | 0.978% |
| 1988 | 24.683 | 24.930 | 0.246 | 0.998% |
| 1989 | 24.773 | 25.025 | 0.252 | 1.017% |
| 1990 | 24.902 | 25.147 | 0.246 | 0.987% |
| 1991 | 25.050 | 25.282 | 0.232 | 0.926% |
| 1992 | 25.208 | 25.435 | 0.228 | 0.904% |
| 1993 | 25.328 | 25.540 | 0.213 | 0.839% |
| 1994 | 25.490 | 25.711 | 0.221 | 0.867% |
| 1995 | 25.588 | 25.814 | 0.225 | 0.881% |
| 1996 | 25.744 | 25.953 | 0.209 | 0.812% |
| 1997 | 25.867 | 26.096 | 0.228 | 0.882% |
| 1998 | 26.102 | 26.306 | 0.204 | 0.781% |
| 1999 | 26.289 | 26.514 | 0.225 | 0.855% |
| 2000 | 26.410 | 26.610 | 0.200 | 0.757% |
| 2001 | 26.619 | 26.809 | 0.189 | 0.711% |
| 2002 | 26.738 | 26.925 | 0.187 | 0.698% |
| 2003 | 26.923 | 27.102 | 0.179 | 0.666% |
| 2004 | 27.076 | 27.257 | 0.182 | 0.671% |
| 2005 | 27.313 | 27.481 | 0.168 | 0.615% |
| 2006 | 27.418 | 27.579 | 0.161 | 0.587% |
| 2007 | 27.595 | 27.759 | 0.164 | 0.593% |
| 2008 | 27.663 | 27.813 | 0.151 | 0.545% |
| 2009 | 27.752 | 27.900 | 0.148 | 0.533% |
| 2010 | 27.801 | 27.948 | 0.147 | 0.530% |
| 2011 | 27.804 | 27.938 | 0.135 | 0.485% |

Note: The fifth column shows the percentage point of difference (error) in unadjusted BMI.

**Table 11. Fixed Effects Regression Results for the Effect of Total Soft Drink Tax on BMI**

| Variables | Dependent Variable: BMI | | | |
|---|---|---|---|---|
| | Model (1) | Model (2) | Model (3) | Model (4) |
| Age | | 0.3345*** (0.0041) | 0.3345*** (0.0041) | 0.3345*** (0.0041) |
| Age squared | | -0.0032*** (0.0001) | -0.0032*** (0.0001) | -0.0032*** (0.0001) |
| Male | | 0.4274*** (0.0423) | 0.4273*** (0.0423) | 0.4274*** (0.0423) |
| Non-Hispanic black | | 2.3405*** (0.0532) | 2.3403*** (0.0533) | 2.3394*** (0.0534) |
| Hispanic | | 0.8061*** (0.0514) | 0.8060*** (0.0513) | 0.8060*** (0.0513) |
| Other races | | -0.1984 (0.1372) | -0.1987 (0.1373) | -0.1996 (0.1374) |
| Some high school | | -0.0115 (0.0372) | -0.0118 (0.0373) | -0.0126 (0.0370) |
| High school graduate | | -0.1054*** (0.0412) | -0.1055*** (0.0412) | -0.1062*** (0.0409) |
| Some college | | -0. 2908 (0.0437) | -0. 0031 (0.0437) | -0. 0036 (0.0434) |
| College graduate | | -0.7588*** (0.0512) | -0.7587*** (0.0511) | -0.7590*** (0.0510) |
| Married | | -0.1073*** (0.0296) | -0.1070*** (0.0296) | -0.1069*** (0.0296) |
| Divorced | | -0.4599*** (0.0312) | -0.4596*** (0.0312) | -0.4594*** (0.0312) |
| Widowed | | -0.0857*** (0.0302) | -0.0856*** (0.0302) | -0.0855*** (0.0302) |
| Employed | | -0.2626*** (0.0177) | -0.2623*** (0.0177) | -0.2622*** (0.0177) |
| Physical activity | | -1.2533*** (0.0297) | -1.2532*** (0.0297) | -1.2536*** (0.0296) |
| Household Income >= $10k and <$15k | | -0.0070 (0.0223) | -0.0072 (0.0224) | -0.0078 (0.0224) |
| Household Income >= $15k and <$20k | | -0.2243*** (0.0228) | -0.2245*** (0.0229) | -0.2252*** (0.0230) |
| Household Income >= $20k and <$25k | | -0.3592*** (0.0289) | -0.3595*** (0.0289) | -0.3602*** (0.0288) |
| Household Income >= $25k and <$35k | | -0.4510*** (0.0290) | -0.4514*** (0.0291) | -0.4523*** (0.0291) |
| Household Income >= $35k and <$50k | | -0.5231*** (0.0349) | -0.5239*** (0.0349) | -0.5249*** (0.0349) |
| Household Income >= $50k and <$75k | | -0.6778*** (0.0438) | -0.6791*** (0.0437) | -0.6804*** (0.0436) |
| Household Income >= $75K | | -1.2744*** (0.0541) | -1.2750*** (0.0541) | -1.2754*** (0.0540) |
| Violent crime rate | | | | -0.0002 (0.0004) |
| Violent crime rate squared | | | | 0.0000 (0.0000) |
| Public transit investment | | | | -0.0036** (0.0018) |
| Public transit investment squared | | | | 0.0000 (0.0000) |
| Vehicle miles traveled | | | | 0.0527** (0.0201) |
| Medicaid expenditure | | | | 0.0001 (0.0001) |
| Medicaid expenditure squared | | | | 0.0000 (0.0000) |
| State park investment | | | | -0.0109 (0.0079) |
| Restaurants | | | -0.1002 (0.1104) | -0.1092 (0.1005) |
| Restaurants squared | | | 0.0029 (0.0035) | 0.0031 (0.0033) |
| Alcohol tax | | | 0.0566 (0.2007) | -0.0877 (0.1822) |
| Alcohol tax squared | | | -0.0059 (0.0342) | 0.0143 (0.0340) |
| Cigarette tax | | | 0.0359 (0.1104) | 0.0795 (0.1205) |
| Cigarette tax squared | | | -0.0457 (0.0377) | -0.0527 (0.0412) |
| Gasoline tax | | | 0.0327 (0.5960) | 0.1949 (0.5310) |
| Gasoline tax squared | | | 0.2020 (1.0433) | -0.0287 (0.9318) |
| **Total soft drink tax** | **-0.0135 (0.0172)** | **-0.0121 (0.0128)** | **-0.0101 (0.0128)** | **-0.0090 (0.0122)** |
| Constant | 25.2774*** (0.0833) | 19.0438*** (0.1130) | 19.7893*** (0.8955) | 16.3846*** (0.8375) |
| Number of Observations | 3151285 | 3151285 | 3151285 | 3151285 |
| R-squared | 0.0172 | 0.0854 | 0.0854 | 0.0854 |

Note: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 12. Fixed Effects Regression Results for the Effect of Incremental Soft Drink Tax on BMI**

| **Variables** | **Dependent Variable: BMI** | | | |
|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (4)** |
| Age | | 0.3345*** (0.0041) | 0.3345*** (0.0041) | 0.3345*** (0.0041) |
| Age squared | | -0.0032*** (0.0000) | -0.0032*** (0.0000) | -0.0032*** (0.0000) |
| Male | | 0.4274*** (0.0423) | 0.4273*** (0.0423) | 0.4274*** (0.0424) |
| Non-Hispanic black | | 2.3406*** (0.0535) | 2.3403*** (0.0536) | 2.3394*** (0.0536) |
| Hispanic | | 0.8058*** (0.0514) | 0.8057*** (0.0513) | 0.8058*** (0.0512) |
| Other races | | -0.1983 (0.1372) | -0.1987 (0.1373) | -0.1996 (0.1374) |
| Some high school | | -0.0115 (0.0372) | -0.0119 (0.0373) | -0.0125 (0.0371) |
| High school graduate | | -0.1054** (0.0412) | -0.1056** (0.0412) | -0.1062** (0.0409) |
| Some college | | -0.0031 (0.0437) | -0.0032 (0.0437) | -0.0036 (0.0434) |
| College graduate | | -0.7590*** (0.0512) | -0.7589*** (0.0511) | -0.7591*** (0.0510) |
| Married | | -0.1073*** (0.0296) | -0.1071*** (0.0296) | -0.1069*** (0.0296) |
| Divorced | | -0.4598*** (0.0311) | -0.4596*** (0.0311) | -0.4594*** (0.0311) |
| Widowed | | -0.0856*** (0.0302) | -0.0856*** (0.0302) | -0.0855*** (0.0302) |
| Employed | | -0.2626*** (0.0177) | -0.2624*** (0.0177) | -0.2622*** (0.0177) |
| Physical activity | | -1.2534*** (0.0297) | -1.2532*** (0.0297) | -1.2536*** (0.0296) |
| Household Income >= $10k and <$15k | | -0.0070 (0.0233) | -0.0071 (0.0224) | -0.0078 (0.0225) |
| Household Income >= $15k and <$20k | | -0.2241*** (0.0229) | -0.2243*** (0.0230) | -0.2251*** (0.0231) |
| Household Income >= $20k and <$25k | | -0.3589*** (0.0288) | -0.3593*** (0.0289) | -0.3600*** (0.0289) |
| Household Income >= $25k and <$35k | | -0.4507*** (0.0292) | -0.4512*** (0.0292) | -0.4522*** (0.0292) |
| Household Income >= $35k and <$50k | | -0.5227*** (0.0350) | -0.5237*** (0.0351) | -0.5248*** (0.0350) |
| Household Income >= $50k and <$75k | | -0.6774*** (0.0439) | -0.6789*** (0.0438) | -0.6802*** (0.0437) |
| Household Income >= $75K | | -1.2739*** (0.0542) | -1.2747*** (0.0542) | -1.2752*** (0.0540) |
| Violent crime rate | | | | -0.0002 (0.0004) |
| Violent crime rate squared | | | | 0.0000 (0.0000) |
| Public transit investment | | | | -0.0034* (0.0018) |
| Public transit investment squared | | | | 0.0000 (0.0000) |
| Vehicle miles traveled | | | | 0.0521** (0.0206) |
| Medicaid expenditure | | | | 0.0001* (0.0001) |
| Medicaid expenditure squared | | | | 0.0000 (0.0000) |
| State park investment | | | | -0.0104 (0.0079) |
| Restaurants | | | -0.1071 (0.1104) | -0.1178 (0.1013) |
| Restaurants squared | | | 0.0030 (0.0036) | 0.0032 (0.0034) |
| Alcohol tax | | | 0.0378 (0.2010) | -0.1077 (0.1816) |
| Alcohol tax squared | | | -0.0042 (0.0344) | 0.0165 (0.0338) |
| Cigarette tax | | | 0.0269 (0.1143) | 0.0700 (0.1244) |
| Cigarette tax squared | | | -0.0424 (0.0393) | -0.0486 (0.0429) |
| Gasoline tax | | | -0.0276 (0.6222) | 0.1464 (0.5627) |
| Gasoline tax squared | | | 0.2978 (1.0910) | 0.0502 (0.9898) |
| **Incremental soft drink tax** | **0.0193 (0.0211)** | **0.0103 (0.0168)** | **0.0096 (0.0163)** | **0.0092 (0.0155)** |
| Constant | 25.9221*** (0.0421) | 19.1065*** (0.0923) | 19.8346*** (0.8888) | 19.3098*** (0.8239) |
| Number of Observations | 3151285 | 3151285 | 3151285 | 3151285 |
| R-squared | 0.0235 | 0.0885 | 0.0885 | 0.0885 |

Note: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 13. The Effect of Total Soft Drink Tax on BMI by selected Obesity Categories: Full sample**

| Variables | Class 3 obese | Class 2 obese | Class 1 obese | Normal weight | Underweight |
|---|---|---|---|---|---|
| Age | 0.1886*** (0.0117) | 0.0175*** (0.0015) | 0.0215*** (0.0009) | 0.1300*** (0.0012) | -0.0060*** (0.0019) |
| Age squared | -0.0023*** (0.0001) | -0.0002*** (0.0000) | -0.0002*** (0.0000) | -0.0011*** (0.0000) | 0.0000 (0.0000) |
| Male | 0.8219*** (0.1007) | 0.0338*** (0.0091) | -0.1895*** (0.0088) | 0.8634*** (0.0157) | -0.1138*** (0.0213) |
| Non-Hispanic black | 0.0688 (0.1163) | 0.0047 (0.0100) | 0.1193*** (0.0102) | 1.1213*** (0.0174) | -0.1940*** (0.0241) |
| Hispanic | -1.4986*** (0.0792) | 0.0030 (0.0257) | -0.2038*** (0.0102) | 1.0997*** (0.0317) | -0.1577*** (0.0424) |
| Other races | 1.9626*** (0.1834) | 0.0333* (0.0176) | -0.0283** (0.0126) | -0.1268* (0.0672) | -0.1105*** (0.0214) |
| Some high school | -0.3980*** (0.1389) | 0.0234 (0.0251) | -0.0179 (0.0153) | 0.0038 (0.0211) | 0.1092*** (0.0336) |
| High school graduate | -0.2723** (0.1257) | -0.0085 (0.0204) | -0.0459*** (0.0143) | 0.0236 (0.0202) | 0.1214*** (0.0337) |
| Some college | -0.0802 (0.1290) | 0.0152 (0.0219) | -0.0349** (0.0155) | -0.0191 (0.0218) | 0.1270*** (0.0339) |
| College graduate | -0.0573 (0.1240) | 0.0002 (0.0206) | -0.0643*** (0.0139) | -0.3563*** (0.0275) | 0.1639*** (0.0340) |
| Married | -0.9370*** (0.0725) | -0.0610*** (0.0112) | -0.0557*** (0.0057) | 0.2740*** (0.0111) | 0.0304* (0.0176) |
| Divorced | -0.8193*** (0.0813) | -0.0545*** (0.0103) | -0.0567*** (0.0073) | 0.0068 (0.0104) | 0.0153 (0.0201) |
| Widowed | -0.8057*** (0.0915) | -0.0856*** (0.0132) | -0.0442*** (0.0078) | 0.2819*** (0.0108) | -0.0169 (0.0243) |
| Employed | -1.0314*** (0.0439) | -0.0562*** (0.0082) | -0.0493*** (0.0051) | 0.0942*** (0.0076) | 0.1294*** (0.0134) |
| Physical activity | -1.0177*** (0.0427) | -0.1245*** (0.0082) | -0.1195*** (0.0044) | -0.1181*** (0.0081) | 0.1502*** (0.0123) |
| Household Income >= $10k and <$15k | -0.0483 (0.0927) | -0.0110 (0.0189) | 0.0024 (0.0117) | 0.0634*** (0.0120) | 0.0209 (0.0201) |
| Household Income >= $15k and <$20k | -0.4116*** (0.1015) | -0.0566*** (0.0167) | -0.0279*** (0.0096) | 0.0585*** (0.0127) | 0.0712*** (0.0194) |
| Household Income >= $20k and <$25k | -0.6041*** (0.0855) | -0.0772*** (0.0166) | -0.0392*** (0.0106) | 0.0553*** (0.0144) | 0.0785*** (0.0224) |
| Household Income >= $25k and <$35k | -0.7055*** (0.0807) | -0.1079*** (0.0153) | -0.0428*** (0.0102) | 0.0939*** (0.0132) | 0.1388*** (0.0206) |
| Household Income >= $35k and <$50k | -0.9017*** (0.0747) | -0.1168*** (0.0174) | -0.0636*** (0.0089) | 0.1290*** (0.0127) | 0.1399*** (0.0223) |
| Household Income >= $50k and <$75k | -1.0590*** (0.0784) | -0.1359*** (0.0178) | -0.0820*** (0.0113) | 0.1178*** (0.0162) | 0.1420*** (0.0214) |
| Household Income >= $75K | -1.3396*** (0.1071) | -0.1682*** (0.0180) | -0.1219*** (0.0103) | -0.0489*** (0.0172) | 0.1788*** (0.0260) |
| Public transit investment | -0.0083 (0.0056) | -0.0010 (0.0008) | 0.0001 (0.0004) | -0.0002 (0.0008) | 0.0013 (0.0013) |
| Public transit investment squared | 0.0001** (0.0001) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.1489** (0.0604) | 0.0085 (0.0070) | 0.0065 (0.0052) | 0.0150* (0.0085) | -0.0255** (0.0120) |
| Medicaid expenditure | 0.0000 (0.0003) | 0.0001 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0001 (0.0000) |
| Medicaid expenditure squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000* (0.0000) |
| **Total soft drink tax** | **-0.0469 (0.0325)** | **-0.0002 (0.0041)** | **-0.0017 (0.0024)** | **-0.0014 (0.0028)** | **0.0054 (0.0069)** |
| Constant | 41.8871*** (0.8198) | 36.5729*** (0.1401) | 31.7912*** (0.0659) | 20.1193*** (0.1202) | 17.3611*** (0.1496) |
| Number of Observations | 85479 | 184330 | 501134 | 2339916 | 40426 |
| R-squared | 0.0507 | 0.0075 | 0.0150 | 0.0761 | 0.0430 |

Note: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 14. The Effect of Incremental Soft Drink Tax on BMI by selected Obesity Categories: Full sample**

| Variables | Class 3 obese | Class 2 obese | Class 1 obese | Normal weight | Underweight |
|---|---|---|---|---|---|
| Age | 0.1886*** (0.0117) | 0.0175*** (0.0015) | 0.0215*** (0.0009) | 0.1300*** (0.0012) | -0.0060*** (0.0019) |
| Age squared | -0.0023*** (0.0001) | -0.0002*** (0.0000) | -0.0002*** (0.0000) | -0.0011*** (0.0000) | 0.0000 (0.0000) |
| Male | 0.8223*** (0.1007) | 0.0338*** (0.0091) | -0.1895*** (0.0088) | 0.8634*** (0.0157) | -0.1139*** (0.0214) |
| Non-Hispanic black | 0.0700 (0.1163) | 0.0047 (0.0100) | 0.1194*** (0.0101) | 1.1214*** (0.0174) | -0.1941*** (0.0241) |
| Hispanic | -1.4985*** (0.0793) | 0.0030 (0.0257) | -0.2038*** (0.0102) | 1.0997*** (0.0316) | -0.1573*** (0.0425) |
| Other races | 1.9620*** (0.1833) | 0.0333* (0.0176) | -0.0283** (0.0126) | -0.1268* (0.0672) | -0.1105*** (0.0214) |
| Some high school | -0.3976*** (0.1389) | 0.0234 (0.0251) | -0.0179 (0.0153) | 0.0038 (0.0211) | 0.1089*** (0.0336) |
| High school graduate | -0.2725** (0.1256) | -0.0085 (0.0204) | -0.0458*** (0.0143) | 0.0236 (0.0202) | 0.1211*** (0.0336) |
| Some college | -0.0800 (0.1289) | 0.0152 (0.0219) | -0.0349** (0.0155) | -0.0191 (0.0218) | 0.1267*** (0.0338) |
| College graduate | -0.0569 (0.1240) | 0.0002 (0.0206) | -0.0643*** (0.0139) | -0.3565*** (0.0276) | 0.1636*** (0.0340) |
| Married | -0.9372*** (0.0725) | -0.0610*** (0.0112) | -0.0557*** (0.0057) | 0.2739*** (0.0111) | 0.0305* (0.0176) |
| Divorced | -0.8194*** (0.0813) | -0.0545*** (0.0103) | -0.0567*** (0.0073) | 0.0068 (0.0104) | 0.0152 (0.0201) |
| Widowed | -0.8055*** (0.0914) | -0.0856*** (0.0132) | -0.0442*** (0.0078) | 0.2819*** (0.0108) | -0.0169 (0.0242) |
| Employed | -1.0312*** (0.0439) | -0.0562*** (0.0082) | -0.0493*** (0.0051) | 0.0942*** (0.0076) | 0.1295*** (0.0134) |
| Physical activity | -1.0179*** (0.0427) | -0.1245*** (0.0082) | -0.1195*** (0.0044) | -0.1181*** (0.0081) | 0.1502*** (0.0123) |
| Household Income >= $10k and <$15k | -0.0481 (0.0926) | -0.0110 (0.0189) | 0.0024 (0.0117) | 0.0634*** (0.0120) | 0.0208 (0.0201) |
| Household Income >= $15k and <$20k | -0.4116*** (0.1014) | -0.0566*** (0.0167) | -0.0278*** (0.0096) | 0.0586*** (0.0127) | 0.0712*** (0.0194) |
| Household Income >= $20k and <$25k | -0.6044*** (0.0856) | -0.0772*** (0.0166) | -0.0392*** (0.0106) | 0.0554*** (0.0144) | 0.0785*** (0.0224) |
| Household Income >= $25k and <$35k | -0.7056*** (0.0807) | -0.1079*** (0.0153) | -0.0428*** (0.0102) | 0.0939*** (0.0132) | 0.1388*** (0.0206) |
| Household Income >= $35k and <$50k | -0.9018*** (0.0747) | -0.1168*** (0.0174) | -0.0636*** (0.0089) | 0.1290*** (0.0127) | 0.1398*** (0.0223) |
| Household Income >= $50k and <$75k | -1.0591*** (0.0784) | -0.1359*** (0.0178) | -0.0820*** (0.0113) | 0.1178*** (0.0162) | 0.1419*** (0.0214) |
| Household Income >= $75K | -1.3396*** (0.1071) | -0.1682*** (0.0180) | -0.1218*** (0.0103) | -0.0488*** (0.0172) | 0.1787*** (0.0260) |
| Public transit investment | -0.0074 (0.0054) | -0.0010 (0.0008) | 0.0001 (0.0005) | -0.0002 (0.0008) | 0.0012 (0.0013) |
| Public transit investment squared | 0.0001** (0.0001) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.1534** (0.0598) | 0.0086 (0.0071) | 0.0067 (0.0052) | 0.0151* (0.0086) | -0.0257** (0.0122) |
| Medicaid expenditure | 0.0001 (0.0003) | 0.0001* (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0001 (0.0000) |
| Medicaid expenditure squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| **Incremental soft drink tax** | **-0.0709* (0.0382)** | **-0.0015 (0.0045)** | **-0.0031 (0.0038)** | **-0.0028 (0.0058)** | **0.0040 (0.0076)** |
| Constant | 41.6287*** (0.8614) | 36.5749*** (0.1251) | 31.7833*** (0.0673) | 20.1152*** (0.1125) | 17.3897*** (0.1472) |
| Number of Observations | 85479 | 184330 | 501134 | 2339916 | 40426 |
| R-squared | 0.0484 | 0.0074 | 0.0149 | 0.0760 | 0.0428 |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 15. The Effect of Total Soft Drink Tax on BMI by selected Obesity Categories: States with Positive Soft Drink Tax**

| Variables | Class 3 obese | Class 2 obese | Class 1 obese | Normal weight | Underweight |
|---|---|---|---|---|---|
| Age | 0.1856*** (0.0135) | 0.0169*** (0.0017) | 0.0213*** (0.0010) | 0.1311*** (0.0014) | -0.0047** (0.0022) |
| Age squared | -0.0023*** (0.0001) | -0.0002*** (0.0000) | -0.0002*** (0.0000) | -0.0011*** (0.0000) | 0.0000 (0.0000) |
| Male | 0.9399*** (0.1112) | 0.0390*** (0.0104) | -0.1888*** (0.0104) | 0.8576*** (0.0180) | -0.0981*** (0.0246) |
| Non-Hispanic black | -0.0514 (0.1206) | 0.0016 (0.0110) | 0.1213*** (0.0110) | 1.1307*** (0.0182) | -0.1769*** (0.0235) |
| Hispanic | -1.4976*** (0.0920) | 0.0144 (0.0308) | -0.2105*** (0.0116) | 1.1041*** (0.0366) | -0.1364*** (0.0490) |
| Other races | 1.8303*** (0.2241) | 0.0312 (0.0221) | -0.0349** (0.0147) | -0.1620** (0.0776) | -0.1227*** (0.0225) |
| Some high school | -0.5261*** (0.1487) | 0.0174 (0.0275) | -0.0189 (0.0177) | 0.0006 (0.0244) | 0.1018*** (0.0331) |
| High school graduate | -0.3619** (0.1404) | -0.0031 (0.0223) | -0.0487*** (0.0162) | 0.0237 (0.0233) | 0.1255*** (0.0373) |
| Some college | -0.1686 (0.1443) | 0.0215 (0.0243) | -0.0364** (0.0179) | -0.0193 (0.0247) | 0.1251*** (0.0354) |
| College graduate | -0.1338 (0.1392) | 0.0143 (0.0211) | -0.0635*** (0.0160) | -0.3475*** (0.0303) | 0.1587*** (0.0349) |
| Married | -0.9542*** (0.0794) | -0.0584*** (0.0127) | -0.0520*** (0.0064) | 0.2825*** (0.0133) | 0.0255 (0.0204) |
| Divorced | -0.8873*** (0.0830) | -0.0527*** (0.0116) | -0.0543*** (0.0084) | 0.0127 (0.0119) | 0.0145 (0.0235) |
| Widowed | -0.8308*** (0.0994) | -0.0766*** (0.0141) | -0.0418*** (0.0087) | 0.2861*** (0.0115) | -0.0182 (0.0277) |
| Employed | -1.0343*** (0.0520) | -0.0612*** (0.0095) | -0.0473*** (0.0058) | 0.0977*** (0.0093) | 0.1323*** (0.0150) |
| Physical activity | -0.9835*** (0.0486) | -0.1317*** (0.0089) | -0.1194*** (0.0051) | -0.1122*** (0.0091) | 0.1571*** (0.0138) |
| Household Income >= $10k and <$15k | -0.1004 (0.1083) | -0.0126 (0.0215) | -0.0011 (0.0122) | 0.0524*** (0.0129) | 0.0211 (0.0223) |
| Household Income >= $15k and <$20k | -0.4681*** (0.1139) | -0.0605*** (0.0183) | -0.0294*** (0.0108) | 0.0489*** (0.0144) | 0.0742*** (0.0215) |
| Household Income >= $20k and <$25k | -0.6473*** (0.0964) | -0.0943*** (0.0171) | -0.0461*** (0.0120) | 0.0591*** (0.0164) | 0.0684*** (0.0228) |
| Household Income >= $25k and <$35k | -0.7229*** (0.0907) | -0.1139*** (0.0165) | -0.0528*** (0.0111) | 0.0943*** (0.0150) | 0.1464*** (0.0216) |
| Household Income >= $35k and <$50k | -0.9357*** (0.0855) | -0.1263*** (0.0195) | -0.0687*** (0.0100) | 0.1293*** (0.0154) | 0.1271*** (0.0251) |
| Household Income >= $50k and <$75k | -1.1266*** (0.0892) | -0.1392*** (0.0200) | -0.0899*** (0.0124) | 0.1129*** (0.0193) | 0.1276*** (0.0239) |
| Household Income >= $75K | -1.4440*** (0.1173) | -0.1781*** (0.0204) | -0.1263*** (0.0116) | -0.0591*** (0.0205) | 0.1946*** (0.0265) |
| Public transit investment | -0.0133** (0.0050) | -0.0008 (0.0009) | 0.0001 (0.0004) | -0.0005 (0.0009) | 0.0006 (0.0013) |
| Public transit investment squared | 0.0002*** (0.0001) | 0.0000 (0.0000) | 0.0000* (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.2150*** (0.0662) | 0.0076 (0.0089) | 0.0068 (0.0060) | 0.0210* (0.0113) | -0.0130 (0.0146) |
| Medicaid expenditure | -0.0002 (0.0003) | 0.0001 (0.0001) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0001* (0.0001) |
| Medicaid expenditure squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| **Total soft drink tax** | **-0.0514* (0.0301)** | **-0.0007 (0.0039)** | **-0.0012 (0.0025)** | **-0.0012 (0.0030)** | **0.0057 (0.0072)** |
| Constant | 41.8282*** (0.8440) | 36.5924*** (0.1601) | 31.7932*** (0.0684) | 20.0172*** (0.1192) | 17.2301*** (0.1655) |
| Number of Observations | 69066 | 150818 | 407137 | 1870555 | 33164 |
| R-squared | 0.0474 | 0.0080 | 0.0155 | 0.0770 | 0.0455 |

Note: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 16. The Effect of Incremental Soft Drink Tax on BMI by selected Obesity Categories: States with Positive Soft Drink Tax**

| Variables | Class 3 obese | Class 2 obese | Class 1 obese | Normal weight | Underweight |
|---|---|---|---|---|---|
| Age | 0.1856*** (0.0135) | 0.0169*** (0.0017) | 0.0213*** (0.0010) | 0.1311*** (0.0014) | -0.0047** (0.0022) |
| Age squared | -0.0023*** (0.0001) | -0.0002*** (0.0000) | -0.0002*** (0.0000) | -0.0011*** (0.0000) | 0.0000 (0.0000) |
| Male | 0.9406*** (0.1113) | 0.0390*** (0.0104) | -0.1888*** (0.0104) | 0.8576*** (0.0180) | -0.0981*** (0.0246) |
| Non-Hispanic black | -0.0498 (0.1207) | 0.0016 (0.0110) | 0.1214*** (0.0109) | 1.1307*** (0.0181) | -0.1772*** (0.0235) |
| Hispanic | -1.4976*** (0.0923) | 0.0144 (0.0308) | -0.2105*** (0.0116) | 1.1041*** (0.0366) | -0.1360*** (0.0491) |
| Other races | 1.8297*** (0.2240) | 0.0312 (0.0222) | -0.0349** (0.0147) | -0.1619** (0.0776) | -0.1226*** (0.0225) |
| Some high school | -0.5259*** (0.1485) | 0.0174 (0.0275) | -0.0189 (0.0177) | 0.0006 (0.0244) | 0.1015*** (0.331) |
| High school graduate | -0.3624** (0.1404) | -0.0031 (0.0223) | -0.0487*** (0.0162) | 0.0237 (0.0233) | 0.1252*** (0.0372) |
| Some college | -0.1686 (0.1443) | 0.0214 (0.0243) | -0.0364** (0.0179) | -0.0193 (0.0247) | 0.1248*** (0.0354) |
| College graduate | -0.1334 (0.1393) | 0.0143 (0.0211) | -0.0634*** (0.0160) | -0.3475*** (0.0303) | 0.1583*** (0.0348) |
| Married | -0.9546*** (0.0794) | -0.0584*** (0.0127) | -0.0521*** (0.0064) | 0.2825*** (0.0133) | 0.0256 (0.0203) |
| Divorced | -0.8875*** (0.0829) | -0.0527*** (0.0116) | -0.0543*** (0.0084) | 0.0127 (0.0119) | 0.0145 (0.0235) |
| Widowed | -0.8306*** (0.0994) | -0.0766*** (0.0141) | -0.0418*** (0.0087) | 0.2861*** (0.0115) | -0.0180 (0.0276) |
| Employed | -1.0340*** (0.0521) | -0.0612*** (0.0094) | -0.0473*** (0.0058) | 0.0978*** (0.0093) | 0.1323*** (0.0150) |
| Physical activity | -0.9837*** (0.0486) | -0.1317*** (0.0089) | -0.1194*** (0.0051) | -0.1122*** (0.0091) | 0.1571*** (0.0138) |
| Household Income >= $10k and <$15k | -0.0999 (0.1082) | -0.0126 (0.0215) | -0.0011 (0.0122) | 0.0524*** (0.0129) | 0.0210 (0.0223) |
| Household Income >= $15k and <$20k | -0.4683*** (0.1138) | -0.0605*** (0.0183) | -0.0294*** (0.0108) | 0.0489*** (0.0144) | 0.0741*** (0.0215) |
| Household Income >= $20k and <$25k | -0.6479*** (0.0965) | -0.0943*** (0.0171) | -0.0461*** (0.0120) | 0.0591*** (0.0164) | 0.0684*** (0.0228) |
| Household Income >= $25k and <$35k | -0.7232*** (0.0908) | -0.1139*** (0.0165) | -0.0528*** (0.0111) | 0.0943*** (0.0150) | 0.1464*** (0.0216) |
| Household Income >= $35k and <$50k | -0.9358*** (0.0855) | -0.1263*** (0.0195) | -0.0686*** (0.0100) | 0.1293*** (0.0154) | 0.1270*** (0.0251) |
| Household Income >= $50k and <$75k | -1.1266*** (0.0893) | -0.1392*** (0.0200) | -0.0899*** (0.0124) | 0.1129*** (0.0193) | 0.1275*** (0.0238) |
| Household Income >= $75K | -1.4441*** (0.1173) | -0.1781*** (0.0204) | -0.1263*** (0.0116) | -0.0591*** (0.0205) | 0.1945*** (0.0264) |
| Public transit investment | -0.0125** (0.0050) | -0.0008 (0.0008) | 0.0001 (0.0005) | -0.0005 (0.0009) | 0.0005 (0.0013) |
| Public transit investment squared | 0.0001*** (0.0001) | 0.0000 (0.0000) | 0.0000* (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.2186*** (0.0655) | 0.0076 (0.0090) | 0.0069 (0.0060) | 0.0211* (0.0114) | -0.0131 (0.0150) |
| Medicaid expenditure | -0.0001 (0.0003) | 0.0001 (0.0001) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0001 (0.0001) |
| Medicaid expenditure squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000* (0.0000) | 0.0000 (0.0000) |
| **Incremental soft drink tax** | **-0.0847** (0.0409)** | **-0.0006 (0.0046)** | **-0.0028 (0.0042)** | **-0.0037 (0.0058)** | **0.0056 (0.0078)** |
| Constant | 41.5468*** (0.8786) | 36.5870*** (0.1423) | 31.7893*** (0.0689) | 20.0171*** (0.1116) | 17.2605*** (0.1625) |
| Number of Observations | 69066 | 150818 | 407137 | 1870555 | 33164 |
| R-squared | 0.0437 | 0.0080 | 0.0154 | 0.0769 | 0.0451 |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 17. Probit Regression Results for the Effect of Total Soft Drink Tax on Percentage Obese: Full Sample**

| Variables | Dependent Variable: Binary variable depending upon classification | | | |
|---|---|---|---|---|
| | Class 3 Obese | | Obese | |
| | **Coefficient** | **Marginal effect** | **Coefficient** | **Marginal effect** |
| Age | 0.0772*** (0.0015) | 0.0037*** (0.0001) | 0.0689*** (0.0007) | 0.0210*** (0.0002) |
| Age squared | -0.0008*** (0.0000) | 0.0000*** (0.0000) | -0.0007*** (0.0000) | -0.0002*** (0.0000) |
| Male | -0.1219*** (0.0217) | -0.0057*** (0.0010) | -0.0675*** (0.0079) | -0.0204*** (0.0024) |
| Non-Hispanic black | -0.0917*** (0.0112) | -0.0040*** (0.0005) | 0.5450*** (0.0110) | 0.1898*** (0.0042) |
| Hispanic | -0.2440*** (0.0166) | -0.0094*** (0.0005) | 0.1150*** (0.0127) | 0.0363*** (0.0041) |
| Other races | -0.0296 (0.0210) | -0.0014 (0.0010) | 0.0187 (0.0264) | 0.0057 (0.0081) |
| Some high school | -0.0227 (0.0195) | -0.0011 (0.0009) | -0.0166* (0.0096) | -0.0050* (0.0029) |
| High school graduate | -0.0376* (0.0195) | -0.0018** (0.0009) | -0.0564*** (0.0098) | -0.0170*** (0.0029) |
| Some college | 0.0263 (0.0191) | 0.0013 (0.0009) | -0.0346*** (0.0109) | -0.0105*** (0.0033) |
| College graduate | -0.1017*** (0.0199) | -0.0047*** (0.0009) | -0.2050*** (0.0125) | -0.0607*** (0.0036) |
| Married | -0.1658*** (0.0099) | -0.0081*** (0.0005) | -0.0339*** (0.0069) | -0.0103*** (0.0021) |
| Divorced | -0.1699*** (0.0085) | -0.0072*** (0.0003) | -0.1004*** (0.0060) | -0.0298*** (0.0017) |
| Widowed | -0.1319*** (0.0114) | -0.0057*** (0.0004) | -0.0179*** (0.0063) | -0.0054*** (0.0019) |
| Employed | -0.1508*** (0.0057) | -0.0075*** (0.0003) | -0.0550*** (0.0039) | -0.0168*** (0.0012) |
| Physical activity | -0.3712*** (0.0070) | -0.0218*** (0.0004) | -0.2868*** (0.0061) | -0.0916*** (0.0020) |
| Household Income >= $10k and <$15k | -0.0014 (0.0077) | -0.0001 (0.0004) | -0.0072 (0.0055) | -0.0022 (0.0017) |
| Household Income >= $15k and <$20k | -0.0736*** (0.0073) | -0.0033*** (0.0003) | -0.0488*** (0.0054) | -0.0146*** (0.0016) |
| Household Income >= $20k and <$25k | -0.1139*** (0.0095) | -0.0050*** (0.0004) | -0.0817*** (0.0061) | -0.0242*** (0.0018) |
| Household Income >= $25k and <$35k | -0.1585*** (0.0082) | -0.0068*** (0.0003) | -0.1117*** (0.0067) | -0.0330*** (0.0019) |
| Household Income >= $35k and <$50k | -0.2021*** (0.0094) | -0.0085*** (0.0003) | -0.1321*** (0.0080) | -0.0389*** (0.0023) |
| Household Income >= $50k and <$75k | -0.2626*** (0.0099) | -0.0106*** (0.0003) | -0.1666*** (0.0094) | -0.0486*** (0.0026) |
| Household Income >= $75K | -0.4202*** (0.0137) | -0.0161*** (0.0004) | -0.3015*** (0.0110) | -0.0857*** (0.0029) |
| Public transit investment | -0.0001 (0.0004) | 0.0000 (0.0000) | -0.0002 (0.0003) | -0.0001 (0.0001) |
| Public transit investment squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.0035 (0.0060) | 0.0002 (0.0003) | 0.0036 (0.0033) | 0.0011 (0.0010) |
| Medicaid expenditure | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Medicaid expenditure squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| **Total soft drink tax** | **-0.0048 (0.0032)** | **-0.0002 (0.0002)** | **-0.0037 (0.0027)** | **-0.0011 (0.0008)** |
| Number of Observations | 3151285 | | 3151285 | |
| R-squared | 0.0759 | | 0.0607 | |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 18. Probit Regression Results for the Effect of Incremental Soft Drink Tax on Percentage Obese: Full Sample**

| Variables | Dependent Variable: Binary variable depending upon classification | | | |
|---|---|---|---|---|
| | Class 3 Obese | | Obese | |
| | Coefficient | Marginal effect | Coefficient | Marginal effect |
| Age | 0.0772*** (0.0015) | 0.0037*** (0.0001) | 0.0689*** (0.0007) | 0.0210*** (0.0002) |
| Age squared | -0.0008*** (0.0000) | 0.0000*** (0.0000) | -0.0007*** (0.0000) | -0.0002*** (0.0000) |
| Male | -0.1219*** (0.0217) | -0.0057*** (0.0010) | -0.0675*** (0.0079) | -0.0204*** (0.0024) |
| Non-Hispanic black | -0.0917*** (0.0113) | -0.0040*** (0.0005) | 0.5450*** (0.0111) | 0.1898*** (0.0042) |
| Hispanic | -0.2440*** (0.0166) | -0.0094*** (0.0005) | 0.1150*** (0.0126) | 0.0363*** (0.0041) |
| Other races | -0.0296 (0.0210) | -0.0014 (0.0010) | 0.0187 (0.0264) | 0.0057 (0.0081) |
| Some high school | -0.0226 (0.0195) | -0.0011 (0.0009) | -0.0166* (0.0096) | -0.0050* (0.0029) |
| High school graduate | -0.0376* (0.0195) | -0.0018** (0.0009) | -0.0564*** (0.0098) | -0.0170*** (0.0029) |
| Some college | 0.0263 (0.0191) | 0.0013 (0.0009) | -0.0346*** (0.0109) | -0.0105*** (0.0033) |
| College graduate | -0.1017*** (0.0199) | -0.0047*** (0.0009) | -0.2050*** (0.0125) | -0.0608*** (0.0036) |
| Married | -0.1658*** (0.0099) | -0.0081*** (0.0005) | -0.0339*** (0.0069) | -0.0103*** (0.0021) |
| Divorced | -0.1699*** (0.0085) | -0.0072*** (0.0003) | -0.1004*** (0.0060) | -0.0298*** (0.0017) |
| Widowed | -0.1319*** (0.0114) | -0.0057*** (0.0004) | -0.0179*** (0.0063) | -0.0054*** (0.0019) |
| Employed | -0.1508*** (0.0057) | -0.0075*** (0.0003) | -0.0550*** (0.0039) | -0.0168*** (0.0012) |
| Physical activity | -0.3712*** (0.0070) | -0.0218*** (0.0004) | -0.2869*** (0.0061) | -0.0917*** (0.0020) |
| Household Income >= $10k and <$15k | -0.0014 (0.0077) | -0.0001 (0.0004) | -0.0072 (0.0055) | -0.0022 (0.0017) |
| Household Income >= $15k and <$20k | -0.0736*** (0.0073) | -0.0033*** (0.0003) | -0.0488*** (0.0054) | -0.0146*** (0.0016) |
| Household Income >= $20k and <$25k | -0.1138*** (0.0095) | -0.0050*** (0.0004) | -0.0816*** (0.0061) | -0.0242*** (0.0018) |
| Household Income >= $25k and <$35k | -0.1585*** (0.0082) | -0.0068*** (0.0003) | -0.1117*** (0.0067) | -0.0330*** (0.0019) |
| Household Income >= $35k and <$50k | -0.2021*** (0.0094) | -0.0085*** (0.0003) | -0.1320*** (0.0080) | -0.0389*** (0.0023) |
| Household Income >= $50k and <$75k | -0.2625*** (0.0099) | -0.0106*** (0.0003) | -0.1665*** (0.0094) | -0.0486*** (0.0026) |
| Household Income >= $75K | -0.4201*** (0.0137) | -0.0161*** (0.0004) | -0.3014*** (0.0110) | -0.0857*** (0.0029) |
| Public transit investment | 0.0000 (0.0004) | 0.0000 (0.0000) | -0.0001 (0.0003) | 0.0000 (0.0001) |
| Public transit investment squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.0033 (0.0062) | 0.0002 (0.0003) | 0.0036 (0.0034) | 0.0011 (0.0010) |
| Medicaid expenditure | 0.0000** (0.0000) | 0.0000** (0.0000) | 0.0000* (0.0000) | 0.0000* (0.0000) |
| Medicaid expenditure squared | 0.0000* (0.0000) | 0.0000* (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| **Incremental soft drink tax** | **-0.0027* (0.0016)** | **-0.0008* (0.0005)** | **-0.0014 (0.0046)** | **-0.0004 (0.0014)** |
| Number of Observations | 3151285 | | 3151285 | |
| R-squared | 0.0759 | | 0.0607 | |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

Table 19. Probit Regression Results for the Effect of Total Soft Drink Tax on Percentage Obese: States with Positive Soft Drink Tax

| Variables | Dependent Variable: Binary variable depending upon classification | | | |
|---|---|---|---|---|
| | Class 3 Obese | | Obese | |
| | Coefficient | Marginal effect | Coefficient | Marginal effect |
| Age | 0.0767*** (0.0017) | 0.0037*** (0.0001) | 0.0685*** (0.0008) | 0.0210*** (0.0003) |
| Age squared | -0.0008*** (0.0000) | 0.0000*** (0.0000) | -0.0007*** (0.0000) | -0.0002*** (0.0000) |
| Male | -0.1070*** (0.0256) | -0.0051*** (0.0012) | -0.0672*** (0.0092) | -0.0205*** (0.0028) |
| Non-Hispanic black | -0.0954*** (0.0121) | -0.0042*** (0.0005) | 0.5488*** (0.0117) | 0.1917*** (0.0045) |
| Hispanic | -0.2538*** (0.0193) | -0.0097*** (0.0006) | 0.1117*** (0.0146) | 0.0354*** (0.0048) |
| Other races | -0.0356 (0.0250) | -0.0017 (0.0011) | 0.0028 (0.0302) | 0.0009 (0.0093) |
| Some high school | -0.0290 (0.0218) | -0.0014 (0.0010) | -0.0170 (0.0108) | -0.0052 (0.0033) |
| High school graduate | -0.0405* (0.0222) | -0.0019* (0.0010) | -0.0560*** (0.0109) | -0.0170*** (0.0033) |
| Some college | 0.0245 (0.0214) | 0.0012 (0.0011) | -0.0330*** (0.0121) | -0.0100*** (0.0037) |
| College graduate | -0.1002*** (0.0222) | -0.0047*** (0.0010) | -0.2008*** (0.0126) | -0.0600*** (0.0037) |
| Married | -0.1564*** (0.0113) | -0.0077*** (0.0006) | -0.0298*** (0.0082) | -0.0091*** (0.0025) |
| Divorced | -0.1618*** (0.0096) | -0.0070*** (0.0004) | -0.0993*** (0.0070) | -0.0297*** (0.0020) |
| Widowed | -0.1265*** (0.0134) | -0.0055*** (0.0005) | -0.0183** (0.0075) | -0.0056** (0.0023) |
| Employed | -0.1465*** (0.0063) | -0.0073*** (0.0003) | -0.0503*** (0.0042) | -0.0155*** (0.0013) |
| Physical activity | -0.3672*** (0.0080) | -0.0216*** (0.0005) | -0.2819*** (0.0069) | -0.0905*** (0.0023) |
| Household Income >= $10k and <$15k | -0.0026 (0.0082) | -0.0001 (0.0004) | -0.0106* (0.0061) | -0.0032* (0.0019) |
| Household Income >= $15k and <$20k | -0.0738*** (0.0080) | -0.0033*** (0.0003) | -0.0503*** (0.0061) | -0.0152*** (0.0018) |
| Household Income >= $20k and <$25k | -0.1109*** (0.0097) | -0.0049*** (0.0004) | -0.0825*** (0.0069) | -0.0247*** (0.0020) |
| Household Income >= $25k and <$35k | -0.1546*** (0.0090) | -0.0067*** (0.0003) | -0.1128*** (0.0075) | -0.0335*** (0.0022) |
| Household Income >= $35k and <$50k | -0.2021*** (0.0107) | -0.0085*** (0.0004) | -0.1333*** (0.0093) | -0.0395*** (0.0027) |
| Household Income >= $50k and <$75k | -0.2615*** (0.0104) | -0.0106*** (0.0003) | -0.1688*** (0.0111) | -0.0496*** (0.0031) |
| Household Income >= $75K | -0.4254*** (0.0147) | -0.0163*** (0.0004) | -0.3049*** (0.0124) | -0.0873*** (0.0033) |
| Public transit investment | -0.0001 (0.0005) | 0.0000 (0.0000) | -0.0002 (0.0004) | -0.0001 (0.0001) |
| Public transit investment squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.0025 (0.0082) | 0.0001 (0.0004) | 0.0046 (0.0045) | 0.0014 (0.0014) |
| Medicaid expenditure | 0.0000* (0.0000) | 0.0000* (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Medicaid expenditure squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| **Total soft drink tax** | **-0.0042 (0.0031)** | **-0.0002 (0.0002)** | **-0.0034 (0.0027)** | **-0.0010 (0.0008)** |
| Number of Observations | 2530740 | | 2530740 | |
| R-squared | 0.0752 | | 0.0620 | |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 20. Probit Regression Results for the Effect of Incremental Soft Drink Tax on Percentage Obese: States with Positive Soft Drink Tax**

| Variables | Dependent Variable: Binary variable depending upon classification | | | |
|---|---|---|---|---|
| | Class 3 Obese | | Obese | |
| | Coefficient | Marginal effect | Coefficient | Marginal effect |
| Age | 0.0767*** (0.0017) | 0.0037*** (0.0001) | 0.0685*** (0.0008) | 0.0210*** (0.0003) |
| Age squared | -0.0008*** (0.0000) | 0.0000*** (0.0000) | -0.0007*** (0.0000) | -0.0002*** (0.0000) |
| Male | -0.1070*** (0.0256) | -0.0051*** (0.0012) | -0.0672*** (0.0092) | -0.0205*** (0.0028) |
| Non-Hispanic black | -0.0954*** (0.0121) | -0.0042*** (0.0005) | 0.5488*** (0.0117) | 0.1917*** (0.0045) |
| Hispanic | -0.2539*** (0.0193) | -0.0097*** (0.0006) | 0.1117*** (0.0146) | 0.0354*** (0.0048) |
| Other races | -0.0356 (0.0250) | -0.0017 (0.0011) | 0.0029 (0.0302) | 0.0009 (0.0093) |
| Some high school | -0.0290 (0.0218) | -0.0014 (0.0010) | -0.0170 (0.0108) | -0.0052 (0.0033) |
| High school graduate | -0.0404* (0.0222) | -0.0019* (0.0010) | -0.0560*** (0.0109) | -0.0170*** (0.0033) |
| Some college | 0.0245 (0.0214) | 0.0012 (0.0011) | -0.0330*** (0.0120) | -0.0100*** (0.0037) |
| College graduate | -0.1003*** (0.0222) | -0.0047*** (0.0010) | -0.2009*** (0.0125) | -0.0600*** (0.0037) |
| Married | -0.1564*** (0.0113) | -0.0077*** (0.0006) | -0.0298*** (0.0082) | -0.0091*** (0.0025) |
| Divorced | -0.1618*** (0.0096) | -0.0070*** (0.0004) | -0.0993*** (0.0070) | -0.0297*** (0.0021) |
| Widowed | -0.1264*** (0.0134) | -0.0055*** (0.0005) | -0.0183** (0.0075) | -0.0056** (0.0023) |
| Employed | -0.1465*** (0.0063) | -0.0073*** (0.0003) | -0.0503*** (0.0042) | -0.0155*** (0.0013) |
| Physical activity | -0.3672*** (0.0080) | -0.0216*** (0.0005) | -0.2819*** (0.0069) | -0.0905*** (0.0023) |
| Household Income >= $10k and <$15k | -0.0026 (0.0082) | -0.0001 (0.0004) | -0.0106* (0.0061) | -0.0032* (0.0019) |
| Household Income >= $15k and <$20k | -0.0738*** (0.0080) | -0.0033*** (0.0003) | -0.0502*** (0.0061) | -0.0151*** (0.0018) |
| Household Income >= $20k and <$25k | -0.1108*** (0.0097) | -0.0049*** (0.0004) | -0.0825*** (0.0069) | -0.0247*** (0.0020) |
| Household Income >= $25k and <$35k | -0.1546*** (0.0090) | -0.0067*** (0.0003) | -0.1127*** (0.0075) | -0.0335*** (0.0022) |
| Household Income >= $35k and <$50k | -0.2020*** (0.0107) | -0.0085*** (0.0004) | -0.1332*** (0.0093) | -0.0395*** (0.0027) |
| Household Income >= $50k and <$75k | -0.2614*** (0.0104) | -0.0106 ***(0.0003) | -0.1687*** (0.0112) | -0.0495*** (0.0032) |
| Household Income >= $75K | -0.4253*** (0.0147) | -0.0163*** (0.0004) | -0.3048*** (0.0124) | -0.0873*** (0.0033) |
| Public transit investment | 0.0000 (0.0005) | 0.0000 (0.0000) | -0.0001 (0.0004) | 0.0000 (0.0001) |
| Public transit investment squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.0020 (0.0084) | 0.0001 (0.0004) | 0.0046 (0.0047) | 0.0014 (0.0014) |
| Medicaid expenditure | 0.0001** (0.0000) | 0.0000** (0.0000) | 0.0000* (0.0000) | 0.0000* (0.0000) |
| Medicaid expenditure squared | 0.0000* (0.0000) | 0.0000* (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| **Incremental soft drink tax** | **-0.0029* (0.0017)** | **-0.0009* (0.0005)** | **-0.0017 (0.0047)** | **-0.0005 (0.0015)** |
| Number of Observations | 2530740 | | 2530740 | |
| R-squared | 0.0752 | | 0.0620 | |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 21. Ordered Probit Regression Results for the Effect of Total Soft Drink Tax on Percentage Obese**

| Variables | Dependent Variable: Individual obesity status (5-category in entire sample) | | | | |
|---|---|---|---|---|---|
| | Coefficients | Marginal Effects | | | |
| | | Class 3 obese | Class 2 obese | Class 1 obese | Normal weight |
| Age | 0.0668*** (0.0007) | 0.0034*** (0.0001) | 0.0060*** (0.0001) | 0.0111*** (0.0001) | -0.0187*** (0.0002) |
| Age squared | -0.0007*** (0.0000) | 0.0000*** (0.0000) | -0.0001*** (0.0000) | -0.0001*** (0.0000) | 0.0002*** (0.0000) |
| Male | -0.0369*** (0.0088) | -0.0018*** (0.0004) | -0.0033*** (0.0008) | -0.0061*** (0.0015) | 0.0103*** (0.0025) |
| Non-Hispanic black | 0.4253*** (0.0108) | 0.0311*** (0.0009) | 0.0455*** (0.0015) | 0.0688*** (0.0018) | -0.1378*** (0.0039) |
| Hispanic | 0.0670*** (0.0110) | 0.0036*** (0.0006) | 0.0062*** (0.0010) | 0.0111*** (0.0019) | -0.0193*** (0.0033) |
| Other races | -0.0435 (0.0265) | -0.0021* (0.0012) | -0.0038* (0.0023) | -0.0072* (0.0044) | 0.0119* (0.0071) |
| Some high school | -0.0112 (0.0094) | -0.0006 (0.0005) | -0.0010 (0.0007) | -0.0019 (0.0016) | 0.0031 (0.0026) |
| High school graduate | -0.0383*** (0.0100) | -0.0019*** (0.0005) | -0.0034*** (0.0009) | -0.0063*** (0.0017) | 0.0106*** (0.0027) |
| Some college | -0.0106 (0.0110) | -0.0005 (0.0006) | -0.0009 (0.0010) | -0.0018 (0.0018) | 0.0030 (0.0031) |
| College graduate | -0.1557*** (0.0121) | -0.0075*** (0.0006) | -0.0136*** (0.0010) | -0.0257*** (0.0020) | 0.0423*** (0.0032) |
| Married | -0.0428*** (0.0063) | -0.0022*** (0.0003) | -0.0038*** (0.0006) | -0.0071*** (0.0010) | 0.0120*** (0.0018) |
| Divorced | -0.0993*** (0.0061) | -0.0047*** (0.0003) | -0.0086*** (0.0005) | -0.0164*** (0.0010) | 0.0268*** (0.0016) |
| Widowed | -0.0365*** (0.0064) | -0.0018*** (0.0003) | -0.0032*** (0.0005) | -0.0060*** (0.0010) | 0.0100*** (0.0017) |
| Employed | -0.0550*** (0.0034) | -0.0028*** (0.0002) | -0.0050*** (0.0003) | -0.0091*** (0.0006) | 0.0155*** (0.0010) |
| Physical activity | -0.2603*** (0.0057) | -0.0151*** (0.0005) | -0.0250*** (0.0005) | -0.0431*** (0.0009) | 0.0773*** (0.0018) |
| Household Income >= $10k and <$15k | 0.0029 (0.0050) | 0.0001 (0.0003) | 0.0003 (0.0005) | 0.0005 (0.0008) | -0.0008 (0.0014) |
| Household Income >= $15k and <$20k | -0.0362*** (0.0048) | -0.0018*** (0.0002) | -0.0032*** (0.0004) | -0.0060*** (0.0008) | 0.0100*** (0.0013) |
| Household Income >= $20k and <$25k | -0.0610*** (0.0059) | -0.0029*** (0.0003) | -0.0053*** (0.0005) | -0.0101*** (0.0010) | 0.0166*** (0.0016) |
| Household Income >= $25k and <$35k | -0.0857*** (0.0061) | -0.0041*** (0.0003) | -0.0074*** (0.0005) | -0.0142*** (0.0010) | 0.0232*** (0.0016) |
| Household Income >= $35k and <$50k | -0.1051*** (0.0074) | -0.0049*** (0.0003) | -0.0091*** (0.0006) | -0.0173*** (0.0012) | 0.0283*** (0.0019) |
| Household Income >= $50k and <$75k | -0.1392*** (0.0088) | -0.0064*** (0.0004) | -0.0119*** (0.0007) | -0.0229*** (0.0014) | 0.0370*** (0.0022) |
| Household Income >= $75K | -0.2650*** (0.0106) | -0.0116*** (0.0005) | -0.0218*** (0.0009) | -0.0432*** (0.0016) | 0.0681*** (0.0025) |
| Public transit investment | -0.0004 (0.0003) | 0.0000 (0.0000) | 0.0000 (0.0000) | -0.0001 (0.0001) | 0.0001 (0.0001) |
| Public transit investment squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.0053 (0.0035) | 0.0003 (0.0002) | 0.0005 (0.0003) | 0.0009 (0.0006) | -0.0015 (0.0010) |
| Medicaid expenditure | 0.0000* (0.0000) | 0.0000** (0.0000) | 0.0000* (0.0000) | 0.0000* (0.0000) | 0.0000* (0.0000) |
| Medicaid expenditure squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| **Total soft drink tax** | **-0.0025 (0.0025)** | **-0.0001 (0.0001)** | **-0.0002 (0.0002)** | **-0.0004 (0.0004)** | **0.0007 (0.0007)** |
| Number of Observations | 3151285 | | | | |
| R-squared | 0.0395 | | | | |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 22. Ordered Probit Regression Results for the Effect of Incremental Soft Drink Tax on Percentage Obese**

| Variables | Dependent Variable: Individual obesity status (5-category in entire sample) | | | | |
|---|---|---|---|---|---|
| | Coefficients | Marginal Effects | | | |
| | | Class 3 obese | Class 2 obese | Class 1 obese | Normal weight |
| Age | 0.0668*** (0.0007) | 0.0034*** (0.0001) | 0.0060*** (0.0001) | 0.0111*** (0.0001) | -0.0187*** (0.0002) |
| Age squared | -0.0007*** (0.0000) | 0.0000*** (0.0000) | -0.0001*** (0.0000) | -0.0001*** (0.0000) | 0.0002*** (0.0000) |
| Male | -0.0369*** (0.0088) | -0.0018*** (0.0004) | -0.0033*** (0.0008) | -0.0061*** (0.0015) | 0.0103*** (0.0025) |
| Non-Hispanic black | 0.4253*** (0.0108) | 0.0311*** (0.0009) | 0.0455*** (0.0015) | 0.0688*** (0.0018) | -0.1378*** (0.0039) |
| Hispanic | 0.0670*** (0.0110) | 0.0036*** (0.0006) | 0.0062*** (0.0010) | 0.0111*** (0.0019) | -0.0193*** (0.0033) |
| Other races | -0.0435 (0.0265) | -0.0021* (0.0012) | -0.0038* (0.0023) | -0.0072* (0.0044) | 0.0119* (0.0071) |
| Some high school | -0.0111 (0.0094) | -0.0006 (0.0005) | -0.0010 (0.0007) | -0.0018 (0.0016) | 0.0031 (0.0026) |
| High school graduate | -0.0383*** (0.0100) | -0.0019*** (0.0005) | -0.0034*** (0.0009) | -0.0063*** (0.0017) | 0.0106*** (0.0028) |
| Some college | -0.0106 (0.0110) | -0.0005 (0.0006) | -0.0009 (0.0010) | -0.0018 (0.0018) | 0.0030 (0.0031) |
| College graduate | -0.1558*** (0.0121) | -0.0075*** (0.0006) | -0.0136*** (0.0010) | -0.0257*** (0.0020) | 0.0423*** (0.0032) |
| Married | -0.0428*** (0.0063) | -0.0022*** (0.0003) | -0.0038*** (0.0006) | -0.0071*** (0.0010) | 0.0120*** (0.0018) |
| Divorced | -0.0993*** (0.0061) | -0.0047*** (0.0003) | -0.0086*** (0.0005) | -0.0164*** (0.0010) | 0.0268*** (0.0016) |
| Widowed | -0.0365*** (0.0063) | -0.0018*** (0.0003) | -0.0032*** (0.0005) | -0.0060*** (0.0010) | 0.0100*** (0.0017) |
| Employed | -0.0550*** (0.0034) | -0.0028*** (0.0002) | -0.0050*** (0.0003) | -0.0091*** (0.0006) | 0.0155*** (0.0010) |
| Physical activity | -0.2604*** (0.0057) | -0.0151*** (0.0005) | -0.0250*** (0.0005) | -0.0431*** (0.0009) | 0.0773*** (0.0018) |
| Household Income >= $10k and <$15k | 0.0029 (0.0050) | 0.0001 (0.0003) | 0.0003 (0.0005) | 0.0005 (0.0008) | -0.0008 (0.0014) |
| Household Income >= $15k and <$20k | -0.0361*** (0.0048) | -0.0018*** (0.0002) | -0.0032*** (0.0004) | -0.0060*** (0.0008) | 0.0099*** (0.0013) |
| Household Income >= $20k and <$25k | -0.0610*** (0.0059) | -0.0029*** (0.0003) | -0.0053*** (0.0005) | -0.0101*** (0.0010) | 0.0166*** (0.0016) |
| Household Income >= $25k and <$35k | -0.0857*** (0.0061) | -0.0041*** (0.0003) | -0.0074*** (0.0005) | -0.0141*** (0.0010) | 0.0232*** (0.0016) |
| Household Income >= $35k and <$50k | -0.1051*** (0.0074) | -0.0049*** (0.0003) | -0.0091*** (0.0006) | -0.0173*** (0.0012) | 0.0283*** (0.0019) |
| Household Income >= $50k and <$75k | -0.1391*** (0.0088) | -0.0064*** (0.0004) | -0.0118*** (0.0007) | -0.0229*** (0.0014) | 0.0370*** (0.0022) |
| Household Income >= $75K | -0.2650*** (0.0106) | -0.0116*** (0.0005) | -0.0218*** (0.0009) | -0.0431*** (0.0017) | 0.0681*** (0.0025) |
| Public transit investment | -0.0003 (0.0003) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0001) | 0.0001 (0.0001) |
| Public transit investment squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.0052 (0.0036) | 0.0003 (0.0002) | 0.0005 (0.0003) | 0.0009 (0.0006) | -0.0015 (0.0010) |
| Medicaid expenditure | 0.0000** (0.0000) | 0.0000** (0.0000) | 0.0000** (0.0000) | 0.0000** (0.0000) | 0.0000** (0.0000) |
| Medicaid expenditure squared | 0.0000* (0.0000) | 0.0000* (0.0000) | 0.0000* (0.0000) | 0.0000* (0.0000) | 0.0000* (0.0000) |
| **Incremental soft drink tax** | **0.0010 (0.0036)** | **0.0001 (0.0002)** | **0.0001 (0.0003)** | **0.0002 (0.0006)** | **-0.0003 (0.0010)** |
| Number of Observations | 3151285 | | | | |
| R-squared | 0.0395 | | | | |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table 23. The Effect of Incremental Soft Drink Tax on Obesity Inequality Index: Gini Coefficient**

| Variables | Dependent variable: Gini Coefficient | | | |
|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (4)** |
| Share of male | | -0.0348*** (0.0062) | -0.0345*** (0.0060) | -0.0319*** (0.0084) |
| Average age | | -0.0012 (0.0008) | -0.0012 (0.0008) | -0.0009 (0.0010) |
| Average age squared | | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Share of Black and Hispanic | | 0.0015 (0.0051) | 0.0003 (0.0051) | -0.0060 (0.0047) |
| Share of college student or graduate | | -0.0005 (0.0094) | 0.0002 (0.0096) | -0.0069 (0.0095) |
| Share of married, divorced, or widowed | | -0.0070 (0.0101) | -0.0056 (0.0103) | -0.0154 (0.0111) |
| Share of employed or student | | -0.0116 (0.0071) | -0.0120* (0.0071) | -0.0067 (0.0055) |
| Share of people doing physical exercise | | 0.0090 (0.0077) | 0.0091 (0.0079) | 0.0051 (0.0082) |
| Share of income >= $50k | | -0.0007 (0.0040) | -0.0014 (0.0040) | -0.0033 (0.0048) |
| Violent crime rate | | | 0.0001 (0.0001) | -0.0001 (0.0001) |
| Vehicle miles traveled | | | 0.0010 (0.0015) | 0.0003 (0.0016) |
| Public transit investment | | | -0.0000** (0.0000) | 0.0000 (0.0000) |
| Medicaid expenditure | | | 0.0002 (0.0002) | 0.0004 (0.0002) |
| State park investment | | | -0.0001 (0.0001) | -0.0001 (0.0001) |
| Restaurants | | | -0.0007 (0.0010) | -0.0040** (0.0015) |
| Restaurants squared | | | 0.0000 (0.0000) | 0.0001** (0.0001) |
| Alcohol tax | | | -0.0001 (0.0007) | 0.0002 (0.0009) |
| Cigarette tax | | | 0.0004 (0.0014) | 0.0005 (0.0016) |
| Cigarette tax squared | | | 0.0001 (0.0005) | 0.0000 (0.0006) |
| Gas tax | | | 0.0011 (0.0014) | 0.0008 (0.0014) |
| **Incremental soft drink tax** | **-0.0001 (0.0002)** | **-0.0002 (0.0002)** | **-0.0002 (0.0002)** | **-0.0001 (0.0002)** |
| Constant | 0.0940*** (0.0006) | 0.1539*** (0.0246) | 0.1568*** (0.0261) | 0.1874*** (0.0277) |
| Number of Observations | 845 | 845 | 845 | 663 |
| R-squared | 0.6092 | 0.6785 | 0.6949 | 0.7399 |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, and year fixed effects.
Model (1), (2), and (3): Fixed effects model estimated in full sample.
Model (4): Fixed effects model estimated in the partial sample of states with a positive soda tax.

**Table 24. The Effect of Incremental Soft Drink Tax on Obesity Inequality Index: Generalized Entropy Index**

| **Variables** | **Dependent variable: Generalized Entropy Index** | | | |
|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (4)** |
| Share of male | | -0.0105*** (0.0030) | -0.0103*** (0.0028) | -0.0083** (0.0039) |
| Average age | | -0.0004 (0.0004) | -0.0005 (0.0004) | -0.0004 (0.0005) |
| Average age squared | | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Share of Black and Hispanic | | -0.0025 (0.0020) | -0.0028 (0.0021) | -0.0048** (0.0020) |
| Share of college student or graduate | | 0.0013 (0.0030) | 0.0019 (0.0031) | 0.0011 (0.0035) |
| Share of married, divorced, or widowed | | -0.0052 (0.0038) | -0.0052 (0.0038) | -0.0089** (0.0043) |
| Share of employed or student | | -0.0054 (0.0036) | -0.0055 (0.0036) | -0.0027 (0.0027) |
| Share of people doing physical exercise | | 0.0025 (0.0027) | 0.0023 (0.0027) | 0.0001 (0.0027) |
| Share of income >= $50k | | -0.0009 (0.0021) | -0.0009 (0.0021) | -0.0027 (0.0024) |
| Violent crime rate | | | 0.0000 (0.0001) | 0.0000 (0.0001) |
| Vehicle miles traveled | | | 0.0008 (0.0007) | 0.0004 (0.0007) |
| Public transit investment | | | 0.0000** (0.0000) | 0.0000** (0.0000) |
| Medicaid expenditure | | | 0.0001 (0.0001) | 0.0002* (0.0001) |
| State park investment | | | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Restaurants | | | -0.0004 (0.0004) | -0.0019*** (0.0005) |
| Restaurants squared | | | 0.0000 (0.0000) | 0.0001*** (0.0000) |
| Alcohol tax | | | -0.0001 (0.0003) | -0.0001 (0.0004) |
| Cigarette tax | | | -0.0005 (0.0007) | -0.0004 (0.0007) |
| Cigarette tax squared | | | 0.0002 (0.0003) | 0.0001 (0.0002) |
| Gas tax | | | 0.0007 (0.0009) | 0.0003 (0.0008) |
| **Incremental soft drink tax** | **-0.0001 (0.0001)** | **-0.0001* (0.0001)** | **-0.0001* (0.0001)** | **-0.0001 (0.0001)** |
| Constant | 0.0158*** (0.0003) | 0.0398*** (0.0125) | 0.0493*** (0.0130) | 0.0541*** (0.0142) |
| Number of Observations | 845 | 845 | 845 | 663 |
| R-squared | 0.5846 | 0.6152 | 0.6234 | 0.6644 |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, and year fixed effects.
Model (1), (2), and (3): Fixed effects model estimated in full sample.
Model (4): Fixed effects model estimated in the partial sample of states with a positive soda tax.

**Table 25. First-order Autoregressive Regression Results for the Effect of Incremental Soft Drink Tax on Obesity Inequality Index**

| Variables | Dependent variable: Gini Coefficient | | Dependent variable: Generalized Entropy Index | |
|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (4)** |
| Share of male | -0.0296*** (0.0056) | -0.0435*** (0.0056) | -0.0085*** (0.0027) | -0.0147*** (0.0026) |
| Average age | 0.0041*** (0.0004) | 0.0012 (0.0009) | 0.0011*** (0.0002) | 0.0006 (0.0004) |
| Average age squared | 0.0000*** (0.0000) | 0.0000 (0.0000) | 0.0000*** (0.0000) | 0.0000 (0.0000) |
| Share of Black and Hispanic | 0.0158*** (0.0048) | 0.0069* (0.0035) | 0.0029 (0.0022) | -0.0002 (0.0015) |
| Share of college student or graduate | 0.0122** (0.0051) | -0.0001 (0.0046) | 0.0044* (0.0024) | -0.0011 (0.0021) |
| Share of married, divorced, or widowed | -0.0185** (0.0080) | -0.0207*** (0.0069) | -0.0103*** (0.0038) | -0.0105*** (0.0031) |
| Share of employed or student | -0.0078 (0.0050) | -0.0096** (0.0047) | -0.0038 (0.0024) | -0.0044 (0.0022) |
| Share of people doing physical exercise | 0.0076** (0.0034) | 0.0054* (0.0032) | 0.0019 (0.0016) | 0.0018 (0.0015) |
| Share of income >= $50k | 0.0145*** (0.0033) | 0.0227*** (0.0029) | 0.0069*** (0.0015) | 0.0095*** (0.0013) |
| Violent crime rate | -0.0003* (0.0002) | -0.0004*** (0.0001) | -0.0001 (0.0001) | -0.0001** (0.0001) |
| Vehicle miles traveled | 0.0003 (0.0019) | 0.0034** (0.0016) | 0.0002 (0.0008) | 0.0013* (0.0007) |
| Public transit investment | 0.0000 (0.0000) | 0.0000*** (0.0000) | 0.0000 (0.0000) | 0.0000*** (0.0000) |
| Medicaid expenditure | 0.0010 (0.0011) | 0.0000 (0.0010) | -0.0003 (0.0005) | -0.0004 (0.0004) |
| State park investment | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Restaurants | 0.0002 (0.0003) | 0.0001 (0.0002) | 0.0001 (0.0001) | 0.0000 (0.0001) |
| Restaurants squared | 0.0000 (0.0001) | 0.0001 (0.0001) | 0.0000 (0.0001) | 0.0000 (0.0000) |
| Alcohol tax | -0.0027*** (0.0007) | -0.0008** (0.0003) | -0.0010*** (0.0003) | -0.0002 (0.0001) |
| Cigarette tax | 0.0010 (0.0015) | -0.0005 (0.0015) | 0.0000 (0.0007) | -0.0006 (0.0007) |
| Cigarette tax squared | -0.0003 (0.0006) | 0.0002 (0.0006) | 0.0000 (0.0003) | 0.0002 (0.0003) |
| Gas tax | 0.0033** (0.0015) | 0.0028* (0.0015) | 0.0006 (0.0007) | 0.0006 (0.0008) |
| **Incremental Soft drink tax** | **-0.0001 (0.0002)** | **-0.0003*** (0.0001)** | **-0.0001 (0.0001)** | **-0.0001*** (0.0000)** |
| Constant | 0.0024*** (0.0008) | 0.0985** (0.0243) | 0.0011** (0.0005) | 0.0186* (0.0105) |
| Number of Observations | 795 | 845 | 795 | 845 |
| R-squared | 0.3070 | 0.6212 | 0.2875 | 0.5793 |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, and year fixed effects.
Model (1) and (3): Fixed effects first-order autoregressive model.
Model (2) and (4): Random effects first-order autoregressive model.

# APPENDICES

# APPENDIX A

TRUNCATED REGRESSION MODELS

**Table A1. Comparison between Truncated and OLS Regression Results with Total Soft Drink Tax**

| Variables | Truncated regression models | | | OLS models with censored sample | | |
|---|---|---|---|---|---|---|
| | **BMI < 30** | **BMI < 35** | **BMI < 40** | **BMI < 30** | **BMI < 35** | **BMI < 40** |
| Age | 0.1832*** (0.0021) | 0.2301*** (0.0023) | 0.2716*** (0.0027) | 0.1403*** (0.0013) | 0.2143*** (0.0019) | 0.2676*** (0.0026) |
| Age squared | -0.0015*** (0.0000) | -0.0021*** (0.0000) | -0.0025*** (0.0000) | -0.0012*** (0.0000) | -0.0019*** (0.0000) | -0.0025*** (0.0000) |
| Male | 1.3047*** (0.0176) | 0.8264*** (0.0229) | 0.5400*** (0.0304) | 0.9520*** (0.0158) | 0.7577*** (0.0226) | 0.5300*** (0.0302) |
| Non-Hispanic black | 1.6191*** (0.0324) | 2.3344*** (0.0424) | 2.6430*** (0.0529) | 1.1323*** (0.0199) | 2.0577*** (0.0333) | 2.5554*** (0.0490) |
| Hispanic | 1.6550*** (0.0506) | 1.4386*** (0.0524) | 1.1331*** (0.0495) | 1.1602*** (0.0340) | 1.3040*** (0.0468) | 1.1117*** (0.0486) |
| Other races | -0.2846*** (0.0951) | -0.1036 (0.1163) | -0.2032* (0.1217) | -0.2242*** (0.0748) | -0.0976 (0.1090) | -0.2004 (0.1203) |
| Some high school | 0.0090 (0.0361) | -0.0069 (0.0272) | -0.0024 (0.0244) | 0.0129 (0.0247) | -0.0028 (0.0242) | -0.0028 (0.0238) |
| High school graduate | 0.0633* (0.370) | -0.0664** (0.0325) | -0.0955*** (0.0290) | 0.0531** (0.0247) | -0.0546* (0.0286) | -0.0927*** (0.0282) |
| Some college | 0.0092 (0.0391) | -0.0862** (0.0354) | -0.0778** (0.0335) | 0.0135 (0.0264) | -0.0723** (0.0312) | -0.0752** (0.0327) |
| College graduate | -0.4531*** (0.0451) | -0.6714*** (0.0444) | -0.7390*** (0.0423) | -0.3258*** (0.0319) | -0.6124*** (0.0405) | -0.7262*** (0.0417) |
| Married | 0.4024*** (0.0163) | 0.2714*** (0.0200) | 0.1408*** (0.0220) | 0.3061*** (0.0119) | 0.2536*** (0.0182) | 0.1397*** (0.0216) |
| Divorced | 0.0038 (0.0159) | -0.1227*** (0.0181) | -0.2435*** (0.0226) | 0.0161 (0.0118) | -0.1079*** (0.0166) | -0.2377*** (0.0221) |
| Widowed | 0.3575*** (0.0149) | 0.2787*** (0.0168) | 0.1443*** (0.0191) | 0.2862*** (0.0115) | 0.2617*** (0.0154) | 0.1430*** (0.0188) |
| Employed | 0.1880*** (0.0106) | 0.0704*** (0.0121) | -0.0285** (0.0133) | 0.1346*** (0.0076) | 0.0643*** (0.0112) | -0.0273** (0.0131) |
| Physical activity | -0.0537*** (0.0106) | -0.4600*** (0.0152) | -0.7865*** (0.0195) | -0.0398*** (0.0078) | -0.4188*** (0.0142) | -0.7695*** (0.0192) |
| Household Income >= $10k and <$15k | 0.1364*** (0.0189) | 0.0932*** (0.0182) | 0.0409** (0.0205) | 0.1094*** (0.0143) | 0.0856*** (0.0166) | 0.0403** (0.0200) |
| Household Income >= $15k and <$20k | 0.1603*** (0.0186) | 0.0610*** (0.0190) | -0.0516** (0.0219) | 0.1293*** (0.0139) | 0.0563*** (0.0173) | -0.0500** (0.0214) |
| Household Income >= $20k and <$25k | 0.1890*** (0.0220) | 0.0297 (0.0212) | -0.1276*** (0.0254) | 0.1516*** (0.0167) | 0.0284 (0.0194) | -0.1240*** (0.0247) |
| Household Income >= $25k and <$35k | 0.2657*** (0.0195) | 0.0444** (0.0207) | -0.1607*** (0.0250) | 0.2078*** (0.0145) | 0.0417** (0.0188) | -0.1565*** (0.0243) |
| Household Income >= $35k and <$50k | 0.3250*** (0.0201) | 0.0603*** (0.0230) | -0.1784*** (0.0290) | 0.2512*** (0.0149) | 0.0565*** (0.0210) | -0.1737*** (0.0282) |
| Household Income >= $50k and <$75k | 0.3129*** (0.0237) | 0.0080 (0.0286) | -0.2710*** (0.0368) | 0.2432*** (0.0177) | 0.0092 (0.0260) | -0.2644*** (0.0358) |
| Household Income >= $75K | 0.0763*** (0.0257) | -0.3562*** (0.0330) | -0.7341*** (0.0434) | 0.0728*** (0.0192) | -0.3245*** (0.0299) | -0.7197*** (0.0421) |
| Public transit investment | -0.0002 (0.0012) | -0.0002 (0.0011) | -0.0017 (0.0012) | -0.0001 (0.0009) | 0.0000 (0.0010) | -0.0016 (0.0012) |
| Public transit investment squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.0219* (0.0117) | 0.0272** (0.0132) | 0.0356** (0.0160) | 0.0139 (0.0089) | 0.0223* (0.0119) | 0.0336** (0.0155) |
| Medicaid expenditure | 0.0000 (0.0000) | 0.0001 (0.0001) | 0.0001 (0.0001) | 0.0000 (0.0000) | 0.0000 (0.0001) | 0.0001 (0.0001) |
| Medicaid expenditure squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| **Total soft drink tax** | -0.0005 (0.0039) | -0.0062 (0.0053) | -0.0086 (0.0084) | -0.0004 (0.0030) | -0.0056 (0.0047) | -0.0084 (0.0081) |
| Number of Observations | 2380342 | 2881476 | 3065806 | 2380342 | 2881476 | 3065806 |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.

**Table A2. Comparison between Truncated and OLS Regression Results with Incremental Soft Drink Tax**

| Variables | Truncated regression models | | | OLS models with censored sample | | |
|---|---|---|---|---|---|---|
| | BMI < 30 | BMI < 35 | BMI < 40 | BMI < 30 | BMI < 35 | BMI < 40 |
| Age | 0.1832*** (0.0021) | 0.2302*** (0.0023) | 0.2716*** (0.0027) | 0.1403*** (0.0013) | 0.2143*** (0.0019) | 0.2676*** (0.0026) |
| Age squared | -0.0015*** (0.0000) | -0.0021*** (0.0000) | -0.0025*** (0.0000) | -0.0012*** (0.0000) | -0.0019*** (0.0000) | -0.0025*** (0.0000) |
| Male | 1.3047*** (0.0176) | 0.8264*** (0.0229) | 0.5400*** (0.0304) | 0.9520*** (0.0158) | 0.7577*** (0.0226) | 0.5300*** (0.0302) |
| Non-Hispanic black | 1.6191*** (0.0324) | 2.3345*** (0.0424) | 2.6431*** (0.0530) | 1.1324*** (0.0199) | 2.0579*** (0.0333) | 2.5555*** (0.0491) |
| Hispanic | 1.6550*** (0.0505) | 1.4385*** (0.0524) | 1.1330*** (0.0494) | 1.1602*** (0.0340) | 1.3040*** (0.0468) | 1.1116*** (0.0486) |
| Other races | -0.2846*** (0.0951) | -0.1035 (0.1163) | -0.2031* (0.1217) | -0.2242*** (0.0748) | -0.0976 (0.1090) | -0.2003 (0.1203) |
| Some high school | 0.0090 (0.0361) | -0.0069 (0.0272) | -0.0024 (0.0244) | 0.0129 (0.0247) | -0.0028 (0.0242) | -0.0028 (0.0238) |
| High school graduate | 0.0633* (0.0370) | -0.0664** (0.0325) | -0.0955*** (0.0290) | 0.0531** (0.0248) | -0.0546* (0.0286) | -0.0928*** (0.0282) |
| Some college | 0.0092 (0.0391) | -0.0862** (0.0354) | -0.0778** (0.0335) | 0.0135 (0.0264) | -0.0723** (0.0312) | -0.0752** (0.0327) |
| College graduate | -0.4531*** (0.0451) | -0.6715*** (0.0445) | -0.7391*** (0.0423) | -0.3257*** (0.0319) | -0.6124*** (0.0405) | -0.7263*** (0.0417) |
| Married | 0.4024*** (0.0163) | 0.2713*** (0.0200) | 0.1408*** (0.0220) | 0.3061*** (0.0119) | 0.2535*** (0.0182) | 0.1396*** (0.0216) |
| Divorced | 0.0038 (0.0159) | -0.1227*** (0.0181) | -0.2435*** (0.0226) | 0.0161 (0.0118) | -0.1079*** (0.0166) | -0.2377*** (0.0221) |
| Widowed | 0.3575*** (0.0149) | 0.2787*** (0.0168) | 0.1444*** (0.0191) | 0.2862*** (0.0115) | 0.2617*** (0.0154) | 0.1430*** (0.0188) |
| Employed | 0.1880*** (0.0106) | 0.0703*** (0.0121) | -0.0285** (0.0133) | 0.1346*** (0.0076) | 0.0643*** (0.0112) | -0.0273** (0.0131) |
| Physical activity | -0.0537*** (0.0106) | -0.4600*** (0.0152) | -0.7865*** (0.0195) | -0.0398*** (0.0078) | -0.4188*** (0.0142) | -0.7696*** (0.0192) |
| Household Income >= $10k and <$15k | 0.1365*** (0.0190) | 0.0933*** (0.0182) | 0.0409** (0.0205) | 0.1095*** (0.0143) | 0.0856*** (0.0166) | 0.0403** (0.0201) |
| Household Income >= $15k and <$20k | 0.1604*** (0.0186) | 0.0611*** (0.0190) | -0.0515** (0.0220) | 0.1293*** (0.0139) | 0.0564*** (0.0173) | -0.0500** (0.0214) |
| Household Income >= $20k and <$25k | 0.1890*** (0.0220) | 0.0298 (0.0212) | -0.1274*** (0.0254) | 0.1516*** (0.0167) | 0.0285 (0.0194) | -0.1239*** (0.0247) |
| Household Income >= $25k and <$35k | 0.2657*** (0.0195) | 0.0445** (0.0207) | -0.1606*** (0.0251) | 0.2078*** (0.0145) | 0.0418** (0.0188) | -0.1563*** (0.0244) |
| Household Income >= $35k and <$50k | 0.3250*** (0.0201) | 0.0604*** (0.0231) | -0.1782*** (0.0291) | 0.2512*** (0.0149) | 0.0565*** (0.0210) | -0.1735*** (0.0283) |
| Household Income >= $50k and <$75k | 0.3129*** (0.0236) | 0.0081 (0.0286) | -0.2707*** (0.0369) | 0.2432*** (0.0177) | 0.0093 (0.0260) | -0.2642*** (0.0359) |
| Household Income >= $75K | 0.0764*** (0.0256) | -0.3561*** (0.0331) | -0.7338*** (0.0434) | 0.0728*** (0.0191) | -0.3243*** (0.0299) | -0.7195*** (0.0422) |
| Public transit investment | -0.0002 (0.0011) | 0.0000 (0.0011) | -0.0015 (0.0013) | -0.0001 (0.0009) | 0.0001 (0.0011) | -0.0014 (0.0013) |
| Public transit investment squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| Vehicle miles traveled | 0.0220* (0.0117) | 0.0274** (0.0133) | 0.0355** (0.0164) | 0.0140 (0.0090) | 0.0226* (0.0120) | 0.0335** (0.0158) |
| Medicaid expenditure | 0.0000 (0.0000) | 0.0001 (0.0001) | 0.0001 (0.0001) | 0.0000 (0.0000) | 0.0001 (0.0000) | 0.0001 (0.0001) |
| Medicaid expenditure squared | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) | 0.0000 (0.0000) |
| **Incremental soft drink tax** | -0.0020 (0.0076) | -0.0057 (0.0105) | 0.0018 (0.0129) | -0.0025 (0.0057) | -0.0065 (0.0098) | 0.0011 (0.0127) |
| Number of Observations | 2380342 | 2881476 | 3065806 | 2380342 | 2881476 | 3065806 |

Notes: *, **, and *** indicate significance level at 10, 5, and 1 percent, respectively.
Figures in Parentheses presents Heteroscedasticity-robust standard errors clustered at the state level.
Each specification includes state, year, and month fixed effects.