The Effects of a Sugar-Sweetened Beverage Tax: Consumption, Calorie Intake, Obesity, and Tax Burden by Income

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Abstract

Taxing sugar-sweetened beverages has been proposed as a means to reduce calorie intake, improve diet and health, and generate revenue that governments can use to address the obesity-caused health and economic burden. Two beverage demand systems were estimated using retail purchase data for high-income and low-income households. Using the estimated demand elasticities we examined the impacts of a hypothetical 20-percent effective tax rate (or about 0.5 cent per ounce) on beverage consumption, calorie intake, body weight, and tax revenue and burden. Our results suggest that such a tax would induce an average reduction of 34 and 40 calories per day among adults and children, respectively. These calorie reductions could translate to 3.6 and 4.2 pounds of weight reductions for adults and children and hence reduce the obesity rate from 33.5 percent to 30.8 percent for adults and from 16.1 percent to 13.4 percent for children. Tax revenue is estimated to total $5.8 billion in 2007. The tax burden represents about one percent of per-capita food and beverage spending and is regressive.

Keywords: beverage demand, sugar-sweetened beverage tax, soda tax, obesity, tax revenue

JEL Classification System: C32; D12; Q18

Introduction

Over the past three decades, U.S. obesity rates have more than double among adults and tripled among children (Flegal et al., 2010; Ogden et al., 2010). Although the obesity prevalence has plateaued in recent years, it remains a major health and economic concern in the United States. Concurrently, children and adults have substantially increased their consumption of sugar-sweetened beverages (SSB) (figure 1). As researchers examine intervention strategies to tackle American weight gain, the association between obesity and SSB consumption has received increasing attention.

[Insert figure 1 about here]

Responding to high childhood obesity rates, the Institute of Medicine (IOM, 2009) recently advocated local Governments tax calorie-dense, nutrient-poor foods and beverages. Similar recommendations have been proposed as a means of reducing SSB consumption, improving diet and health, and generating revenue for obesity-prevention programs (Brownell and Frieden, 2009; Jacobson and Brownell, 2000; Powell and Chaloupka, 2009).

In this study, we estimate the effect of taxing SSBs on beverage consumption, calorie intake, body weight, and tax revenue. Our approach involves the estimation of beverage demand using national household purchase data. We apply the demand elasticities and a hypothetical tax rate to nationally representative surveys of individual consumption to estimate adjustments in calorie intake from beverages and resulting body-weight changes. Nationally representative data allow us to calculate the tax-induced reduction in obesity. Two beverage demand systems are stratified by income to improve elasticity estimates, compare tax effects by income, and determine the regressivity.

Review of Literature

Two recent systematic literature reviews find a positive link between SSB consumption and obesity (Malik et al., 2006; Vartanian et al., 2007). Vartanian et al. (2007) found that studies with stronger methods (longitudinal and experimental vs. cross-sectional) reported larger effects of increased SSB consumption on increased energy intake and weight gain. Duffey et al. (2010) examined the consumption of four foods (soda, whole milk, pizza, and hamburger) using 20-year longitudinal data and found a soda tax, without considering other beverages except whole milk, would significantly decrease energy intake.

Some studies point to evidence of large price responses in school cafeteria experiments that cut the price of healthy snacks and raise the price of unhealthy snacks (French et al., 2001; Jeffrey et al., 1994). Results from in-school experiments may not be comparable in retail food markets because children have unique utility functions partly due to limited resources and the variety of snacks in schools is restricted.

Cross-sectional studies investigating State-level soda taxes and body weight have found minimal to no association (Fletcher et al., 2009 and 2010; Powell et al., 2009; Sturm et al., 2010). A plausible explanation is that sales taxes are generally small and not displayed on the supermarket shelf, and therefore, consumers may be unaware and less responsive when making retail purchases (McLaughlin, 2009). Furthermore, obesity is affected by numerous factors in addition to beverage prices.

A recent review of food demand research revealed an own-price elasticity for sodas and other beverages of -0.8 to -1.0 (Andreyeva et al., 2010). The reported demand elasticities have been used to extrapolate potential effects of a SSB tax (Andreyeva et al., 2010; Brownell et al., 2009; Chaloupka et al., 2009). Schoreter et al. (2009) utilized elasticities for regular and diet sodas reported by Dhar et al. (2003) and found that a 10-percent tax on regular soda would reduce body weight by 0.2 pounds; no other alternative beverages, however, were considered.

There are deficiencies in the reported elasticities for our evaluation. When a particular beverage is taxed, consumers will respond by reallocating their beverage purchases among alternative beverage choices. Lacking cross-price estimates has led researchers to rely solely on the own-price elasticity (Brownell et al., 2009; Chaloupka et al., 2009). This is a major limitation for evaluating the impact of a SSB tax on obesity because some juices and milk have more calories than regular sodas (USDA-ARS, 2010).

Secondly, in order to fully examine beverage-energy intake, SSBs and their low-calorie counterparts need to be distinguished. There are studies that differentiate regular and diet sodas (Dhar et al., 2003; Pittman, 2004; Bergtold et al., 2004), but to our knowledge, there has been no attempt to separate sugar-sweetened sports, energy, or fruit drinks from their low-calorie counterparts. We specify a demand system to address the above limitations.

Data and Methods

Two nationwide datasets are used to evaluate dietary and economic impacts of levying a tax on SSBs. Data from 1998-2007 Nielsen Homescan panels (Nielsen, 2007) are used to estimate two beverage demand systems stratified by income. The demand price elasticities and a hypothetical tax are applied to individual food intake data from the 2003-06 National Health and Nutrition Examination Survey (NHANES, CDC-NCHS, 2009) to estimate changes in beverage consumption, calorie intake, and body weight for each NHANES respondent.

Nielsen Homescan Panel

Nielsen maintains a Homescan panel utilizing a sample design and sample weight for national projection based on nine demographic characteristics, including age, income, household size, education, occupation, race, and ethnicity (Muth et al., 2007). Nielsen also recruits a reserve pool of households who participate when a panelist of similar demographic characteristics drops out. Homescan data available to us ranged in sample size from roughly 7,500 to 63,000 (depending on the year) averaging 22,750 household during 1998-2007. Sample weights allow us to project to national figures for each year.

In the case of beverages, each household scans the Uniform Product Code (UPC) for all purchases made at grocery stores or other retail outlets, generally on a weekly basis. In addition to demographics, the data also include quantities, expenditures, and product characteristics. Beverages are grouped into eight categories—sugar-sweetened beverages, diet (low-calorie) beverages, three types of milk, 100 percent juices, coffee/tea, and bottled water (see table 1 for definitions).

[Insert table 1 here]

Beverages in powdered or concentrate form are converted into ready-to-drink quantities. We aggregate purchase quantities and expenditures (net of coupon and promotional discounts) into 120 monthly observations for each income group. Monthly price is imputed as a unit value by taking the ratio of expenditure to quantity. The midpoint of the reported income range and the household size are used to express household income as a percent of the Federal poverty threshold. To classify households into high and low income, we use the 185-percent poverty threshold, which is the income eligibility cutoff for the Special Supplemental Nutrition Program for Women, Infants, and Children (USDA-FNS, 2010).

Sample means and standard errors of the variables in the demand system are reported in table 2. Low-income households allocated a larger proportion of their beverage budget to SSB and whole milk, while high-income households allocated a higher share to diet drinks. Consistent with the literature, low-income households pay lower prices than high-income households for all beverages due to quality differences, brand-level purchases, economies of scale, and neighborhood effects (see Ver Ploeg et al., 2009).

[Insert table 2 about here]

National Health and Nutrition Examination Survey (NHANES)

NHANES respondents undertake a comprehensive medical examination, as well as report 24-hour dietary intakes, income, and demographic information. Nutrient information embedded in NHANES allows us to aggregate beverage consumption into eight categories, as in the Homescan data. Using the 2003-06 NHANES data and after excluding children younger than 2, pregnant and/or lactating women, and those with missing beverage intake or income data, our sample consists of 15,613 respondents (7,291 children aged 2 to 19 and 8,322 adults 20 and older). Infants and pregnant/lactating women are excluded because of lacking body weight thresholds for weight classification.

During 2003-06, daily per capita consumption of the eight beverages varied by age and income (table 3). On average, low-income adults consumed more SSBs per day than high income adults by 61 calories, or about half of a 12 ounce can of cola. SSBs accounted for 58 percent of beverage calories consumed by low-income adults, compared to 51 percent by high-income adults. Conversely, low-income children consumed fewer calories from SSBs (46 percent of beverages calories) than high-income children (49 percent). Low-income individuals (both adults and children) consumed more juices and whole milk, but less skim milk, coffee/tea, and bottled water than high-income individuals.

[Insert table 3 about here]

Almost Ideal Demand System

This study focuses on beverage consumption, and therefore, beverages are assumed to be weakly separable from all other goods. The Almost Ideal Demand System (AIDS, Deaton and Muellbauer, 1980) is used for our empirical estimation of a beverage demand system, as shown in equation (1)

(1) $w_i = \alpha_i^* + \sum_i \gamma_{ij} \ln p_j + \beta_i \ln(m/\boldsymbol{P^*}) + e_i \qquad i = 1, \ldots, n,$

where w_i is the beverage expenditure share for beverage i; p_j is the price for beverage j; m is the total expenditure for all beverages; and e_i is the disturbance term. $\boldsymbol{P^*}$ is a price index defined by

$$\ln\boldsymbol{P^*} = \alpha_0^* + \sum \alpha_i^* \ln p_i + 1/2 \sum_i\sum_j \gamma_{ij}^* \ln p_i \ln p_j$$

We hypothesized that monthly beverage consumption is influenced by temperature and it exhibits a time trend over the sample period. The method developed by Alston et al (2001) was used to incorporate temperature and time trend variables are incorporated into the constant terms in the AIDS model:

$$\alpha_i^* = \alpha_i + \varphi_{1i} \text{ (temperature)} + \varphi_{2i} \text{ (time trend) and}$$

$$\alpha_0^* = \alpha_0 + \upsilon_{1i} \text{ (temperature)} + \upsilon_{2i} \text{ (time trend).}$$

Parameters to be estimated are α_i, φ_{1i}, φ_{2i}, υ_{1i}, υ_{2i}, γ_{ij}, and β_i. Conditional expenditure (ε_i) and uncompensated price (ε_{ij}) elasticity estimates at sample means can be calculated as:

(2) $\varepsilon_i = 1 + \beta_i/w_i$ and

(3) $\varepsilon_{ij} = (\gamma_{ij} - \beta_i (w_j - \beta_j \ln (m/ \boldsymbol{P^*}))/w_i - \delta_{ij};$

where δ_{ij} is the Kronnecker delta that is unity if $i = j$ and zero otherwise.

The iterative seemingly-unrelated-regression technique was used to estimate the AIDS model with homogeneity and symmetry conditions imposed. The data for the AIDS model (1) add up by construction. The estimates were corrected for the first-order autocorrelation (Berndt and Savin, 1975). For brevity, the parameter estimates are not reported (but available upon request) and the demand elasticities are reported in tables 4 and 5.

Results of Beverage Demands

All own-price elasticities for both low- and high-income populations are found to be negative and statistically significant at the 1% probability level, with the exception of skim milk for low-income (tables 4 and 5). Among the low-income population, the demands for diet drinks, skim milk, whole milk, and bottled water are found to be own-price inelastic, whereas the demands for SSBs, low-fat milk, juices, and coffee/tea are own-price unitary at the 95% confidence level. Of the 56 cross-price elasticities for low income, 17 of them are statistically different from zero at least at the 5% probability level, and 6 (11) of them are positive (negative) indicating substitution (complement) relationships. Little research has been done on low-income beverage demand with the exception of Yen et al. (2004), in which case, our elasticities are comparable.

[Insert tables 4 & 5 about here]

Among high-income households, SSB is the only category that is own-price elastic (-1.29 at the mean), indicating a 10 percent increase in price will decrease purchases by 12.9 percent. Among the remaining seven beverages, high-income households are found to be less price responsive for diet drinks, low-fat milk, and coffee/tea (with mean elasticities ranging from -0.33 to -0.46) than for skim milk, whole milk, juices, and bottled water. Of the 56 cross-price elasticities for high income, 23 were statistically different from zero at the 5% probability level.

The magnitude of own-price responsiveness among beverage categories varies across income populations. For example, the low-income demand for diet drinks is more price elastic than the high-income demand (-0.70 vs. -0.46), but the finding is reversed for SSBs (-0.95 vs. -

1.29). Likewise, the demands for skim milk, whole milk, and bottled water are found to be more price elastic for high-income households than those for low-income households.

Effects of Taxing Sugar-Sweetened Beverages

Several key assumptions are made in order to evaluate the effects of a SSB tax using the estimated demand elasticities. First, there are potential differences within the at-home and away-from-home markets. Due to data limitations, estimating the away-from-home demand for beverages is challenging. Consumers often pay a single price for a meal, such as a combo meal at a fast food restaurant, which often includes a beverage. Additionally, some restaurants offer free refills. Thus, quantity is ill-measured for the price. Consequently, we assume the same demand elasticities for at-home and away-from-home consumption. This assumption has been made implicitly in the past studies estimating changes in beverage consumption from taxation (Andreyeva et al., 2010; Brownell et al., 2009; Chaloupka et al., 2009; Schroeter et al., 2008). Further, using household purchase data allows us to examine the impacts of a SSB tax by income.

Secondly, a tax can be levied as an ad valorem excise tax based on price (e.g., sales tax) or as a specific excise tax based on volume. A sales tax is usually paid by consumers making retail purchases, whereas a specific excise tax is usually paid by those who are further up in the distribution chain (i.e., manufacturers or distributors). A sales tax is generally not displayed on the shelf in grocery stores, and thus consumers may not be aware of the tax burden. Moreover, beverage prices vary by brand, container size, and other factors creating an incentive for consumers to substitute lower priced beverages for the higher price ones, resulting in limited response to a sales tax (Brownell et al). Finally, individuals receiving food stamp benefits from the Federal Government are exempt from paying sales taxes on beverages and are therefore, not affected by such a policy.

When a specific excise tax is levied, it will be shared by producers and consumers depending on the demand and supply conditions. In this study, we assumed that an excise tax is levied such that consumers face a 20-percent price increase on all SSBs. A 20-percent tax rate is chosen for illustration purposes and due to its closeness to proposals in various States, such as New York.

A final assumption addresses the inevitable waste between the amount purchased and consumed. Our demand estimates are based on purchase data and impacts are measured using intake data. We assumed a constant proportional waste measure—percentage change in purchases is equivalent to the change in consumption.

Tax-induced changes in calorie intake

Applying the estimated demand elasticities and a 20-percent effective tax to individual consumption data from NHANES, we estimate changes in beverage consumption and associated calorie intake (table 6). There are mixed complements and substitutes among the eight beverage categories. Our results suggest a net decrease in calorie intake from all beverages of 36.8 calories a day for low-income adults, 33.3 for high-income adults, 34.2 for all adults, 33.1 for low-income children, 44.7 for high-income children, and 40 for all children.

Net changes in calorie intake from non-SSBs are small relative to those of SSBs. The small changes in non-SSB consumption essentially cancel each other out. This finding does not imply ignoring cross-price effects will not bias the estimated impacts. Exclusion of all relevant beverages would result in an incomplete beverage demand system and hence bias the demand elasticity estimates.

Potential reductions in body weight and obesity prevalence

The dynamic relationship between calorie intake and body weight is quite complex—given a fixed reduction in daily energy intake, an individual's weight will decrease sharply but then saturate to a new steady state, which can take several years to achieve (Chow and Hall, 2008). One frequently used relationship in textbooks (e.g., Whitney et al., 2002) and scientific articles (e.g., Duffey et al., 2010) is that a pound of fat tissue has about 3,500 calories, which we use to predict the tax-induced weight loss and the resulting changes in the overweight and obesity prevalence.

The NHANES collects information on food and nutrient intake, as well as measured body weight and height for each respondent, making the data applicable for translating a reduction in calorie intake into body weight changes. By calculating body weight reductions for each respondent, we use the sample weights to estimate the after-tax prevalence of overweight and obesity.

Among adults, the tax was predicted to result in a weight loss of 3.8, 3.5, and 3.6 pounds, respectively, for low-income, high-income, and all adults, respectively. These weight losses decrease the proportion of overweight adults from 66.9 percent to 62.8 percent and from 33.5 percent to 30.8 percent for the obesity prevalence. According to 2003-06 NHANES data, almost 5 percent of adults in the U.S. were overweight by no more than 3 pounds. Therefore, a small reduction in body weight can have a measurable effect on the obesity prevalence. Further, some overweight and obese adults consumed large quantities of SSBs, and are expected to experience sufficient weight loss to improve their body weight status.

The tax-induced weight losses are predicted to be 3.5, 4.7, and 4.2 pounds for low-income, high-income, and all children, respectively. The prevalence of overweight children (at the 85th percentile or higher) is predicted to decline from 32 percent to 26.7 percent and the obesity prevalence (95th percentile or higher) would decline from 16.1 percent to 13.4 percent. Overall, the reduction in overweight and obesity prevalence is predicted to be similar between high- and low-income adults but larger for high-income children than for their low-income counterparts.

Tax revenue and burden

Under the assumed 20-percent effective tax rate, we calculate tax revenues by multiplying the tax (in dollars) by the after-tax consumption. We use the average SSB price reported by Homescan panelists in 2007 (2.37 cents per ounce for high income and 2.19 for low income) to calculate the tax revenue for each income group. We predict, on average, per capita tax revenues from SSB consumption to total $19.19 in a year. In 2007, there were approximately 301.6 million people in the U.S. (US Census Bureau, 2010). Therefore, we estimate tax revenues of $5.8 billion over a year. This estimate is comparable, after adjusting for tax rate, to the $14.9 billion from a 1-cent-per-ounce tax predicted for the 2010 population by the Rudd Center for Food Policy and Obesity.

Our estimates indicate that low-income individuals would pay slightly more SSB tax than high-income individuals ($19.97 versus $18.84). According to the Consumer Expenditure Survey (US Bureau of Labor Statistics, 2007), per capita spending on foods and beverages in 2007 was $1,920 and $3,125 for low- and high-income populations. By expressing the SSB tax as a percent of total food and beverage spending, we conclude that a tax on SSB is more burdensome to the low-income population, although it represents about 1 percent of their total food and beverage spending.

Conclusions

The use of economic incentives or disincentives to encourage healthful food choices, and hence reduce the incidence of obesity, has received heightened support and attracted research efforts. The rich food demand literature suggests many foods are generally own-price inelastic (Andreyeva et al., 2010). Under inelastic demand, price manipulations alone will not induce large consumer responses. Researchers have examined the effects of taxing salty snacks and fat in dairy products, as well as the effects of subsidizing the consumption of fruits, vegetables, and milk (Kuchler et al., 2004; Chouinard et al., 2007; Lin et al., 2010). These three empirical studies support the economic theory that "[the] first fundamental theorem of taxation: a tax has little effect on inelastic goods" (McCloskey, 1982, p. 309).

A void exists in the beverage demand literature for elasticities needed to address the budget allocation among competing beverages distinguished by calorie contents. In this study, we estimated two beverage demand systems to obtain the demand elasticities for eight beverages among low- and high-income populations. The demand elasticities were applied to individual intake data from NHANES to estimate the tax-induced reduction in calories.

On average, reductions in daily intake of 34.2 and 40 calories were predicted for adults and children, respectively. Applying the frequently used relationship of 3500 calories for one pound of body weight, we estimated a weight loss of 3.6 and 4.2 pounds for adults and children, respectively. Because a large number of adults and children are a few pounds over the overweight and obesity thresholds, and many overweight and obese individuals consume large quantities of SSBs, the corresponding reductions in obesity prevalence are noticeable—from 33.5 to 30.8 percent for adults and 16.1 to 13.4 percent for children. NHANES data also indicate many individuals are just a few pounds below the BMI cutoffs for overweight and obesity. Reduced consumption of SSBs triggered by the tax could prevent them from joining the ranks of the obese or overweight. However, it will take substantial reductions in energy intake, and/or increases in energy expenditure, to reverse three decades of U.S. weight gain. In order to reach similar mean weights of the 1970's, Swinburn et al. (2009) found that a reversal of increased energy intake on the order of 500 calories per day for adults and 350 calories per day for children would be necessary. The authors conclude that policies should focus on drivers of energy overconsumption (Swinburn et al., 2009).

Revenue from taxing SSBs is estimated to be sizable—a 20-percent increase in the price of SSBs paid by consumers (i.e., 0.44 to 0.47 cent per ounce) would generate $ 5.8 billion over a year. The tax burden is found to be about 1 percent of food and beverage spending, but it is regressive. This regressive nature of SSB tax is a concern and motivates other intervention proposals, such as financial incentives to increase supply of nutrient-rich, low-calorie beverages, or financial disincentives to curtail supply of nutrient-poor, calorie-dense beverages.

To address childhood obesity, laws and regulations at State and local levels have been enacted to restrict the supply of sugar-sweetened beverages in schools. In 2009, there are 31 States which had policies limiting access to and/or setting nutrition standards for competitive foods, including sugar-sweetened beverages, at school (Trust for America's Health, 2009). Children have responded positively to price interventions aiming at promoting healthy eating at school. Because children consume more beverages and calories at home than at school, effective nutrition education, such as Team Nutrition (USDA-FNS, 2010), is needed to achieve a healthy overall diet.

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Table 1. Beverage categories and definitions.

Beverage Category	Types of beverages included
Sugar-sweetened (SSB)	Soda, fruit drinks, sports and energy drinks, and powdered mixes with added sugars
Diet (low-calorie)	Low- or no-calorie versions of the above SSB category
Skim milk	Milk labeled as skim or nonfat
Low-fat milk	Milk labeled as low-fat or reduced, includes 0.5 – 2%
Whole milk	Milk labeled as whole
Juices	All fruit and vegetable juices containing 100% juice
Coffee/tea	Liquid coffee and teas, excludes dry beans and leaves
Bottled water	Bottled water, excludes tap water

Note: Nielsen does not provide information to distinguish caloric and noncaloric coffee/teas.
Source: Categories based on authors' definitions.

Table 2. Variable definitions and summary statistics, 1998-2007.

		Low-income		High-income	
Variable	Definition	Mean	St. Dev.	Mean	St. Dev.
p_1	Nominal price for SSB, $/gal	2.53	0.15	2.66	0.19
p_2	Nominal price for diet, $/gal	1.68	0.21	2.12	0.16
p_3	Nominal price for skim milk, $/gal	2.79	0.27	2.80	0.26
p_4	Nominal price for low-fat milk, $/gal	2.72	0.29	2.80	0.29
p_5	Nominal price for whole milk, $/gal	2.94	0.31	3.02	0.31
p_6	Nominal price for juice, $/gal	4.23	0.42	4.40	0.44
p_7	Nominal price for coffee/tea, $/gal	3.72	0.54	4.12	0.35
p_8	Nominal price for bottled water, $/gal	1.28	0.19	1.43	0.15
w_1	Beverage budget share for SSB	0.39	0.04	0.32	0.03
w_2	Beverage budget share for diet drinks	0.13	0.02	0.17	0.01
w_3	Beverage budget share for skim milk	0.04	0.01	0.06	0.01
w_4	Beverage budget share for low-fat milk	0.14	0.01	0.14	0.01
w_5	Beverage budget share for whole milk	0.09	0.01	0.05	0.00
w_6	Beverage budget share for juice	0.14	0.01	0.17	0.01
w_7	Beverage budget share for coffee/tea	0.02	0.01	0.03	0.01
w_8	Beverage budget share for bottled water	0.05	0.02	0.06	0.03
φ_1	Average U.S. monthly temperature	54.37	14.93	54.37	14.93

Notes: Temperature is measured in Fahrenheit (NOAA, 2009). Means for all budget shares are significantly different at least at the 5 percent level using *t* tests for independent samples.

Table 3. Beverage consumption and calories by income and age.

	Adults		Children	
	Low Income	High Income	Low Income	High Income
Average consumption	Ounces per day			
Sugary drinks	17.0	12.2	16.0	16.9
Diet drinks	3.6	6.7	0.9	1.3
Skim milk	0.6	1.2	0.5	1.4
Low-fat milk	2.5	2.5	4.1	5.7
Whole milk	2.0	0.9	4.2	2.0
Juices	2.8	2.6	4.5	3.6
Tea/Coffee	15.3	19.8	2.3	2.5
Bottled water	6.1	7.9	3.1	4.0
Total	49.8	53.9	35.7	37.4
Average calories	Calories per day			
Sugary drinks	197	136	189	195
Diet drinks	2	3	1	1
Skim milk	6	13	6	14
Low-fat milk	37	37	64	85
Whole milk	37	16	79	38
Juices	38	35	63	50
Tea/Coffee	20	28	11	10
Bottled water	0	0	0	0
Total	337	269	411	394
Sample size	3292	5030	4080	3211

Source: Authors' calculation of 2003-06 National Health and Nutrition Examination Survey (NHANES), first-day intake data.

Table 4. Low-income population beverage demand elasticities in the U.S., 1998-2007.

Beverage	Uncompensated Price Elasticities ε_{i1}	ε_{i2}	ε_{i3}	ε_{i4}	ε_{i5}	ε_{i6}	ε_{i7}	ε_{i8}	Expenditure Elasticities ε_i
Sugary drinks	-0.949***	-0.079**	-0.055**	-0.099**	0.053*	0.163***	-0.022	-0.034	1.023***
	(0.082)	(0.036)	(0.023)	(0.041)	(0.030)	(0.045)	(0.015)	(0.023)	(0.0190
Diet drinks	-0.230**	-0.695***	0.025	0.183***	-0.312***	-0.014	0.032	-0.013	1.024***
	(0.104)	(0.093)	(0.036)	(0.063)	(0.052)	(0.069)	(0.025)	(0.039)	(0.021)
Skim milk	-0.583***	0.085	-0.367	0.417	-0.023	-0.395	-0.031	-0.146	1.042***
	(0.236)	(0.128)	(0.320)	(0.354)	(0.308)	(0.246)	(0.081)	(0.109)	(0.048)
Low fat milk	-0.250**	0.185***	0.115	-0.820***	0.097	-0.214**	-0.035	-0.032	0.955***
	(0.115)	(0.059)	(0.095)	(0.188)	(0.142)	(0.101)	(0.034)	(0.047)	(0.037)
Whole milk	0.242*	-0.459***	-0.007	0.146	-0.631***	-0.328**	0.061	-0.014	0.990***
	(0.129)	(0.077)	(0.128)	(0.221)	(0.244)	(0.136)	(0.043)	(0.062)	(0.021)
Juices	0.473***	-0.010	-0.106	-0.223**	-0.215**	-1.017***	0.010	0.093*	0.995***
	(0.127)	(0.067)	(0.067)	(0.103)	(0.089)	(0.130)	(0.033)	(0.049)	(0.016)
Coffee/tea	-0.408	0.268	-0.057	-0.256	0.323	0.099	-0.802***	0.020	0.813***
	(0.326)	(0.188)	(0.169)	(0.269)	(0.215)	(0.253)	(0.148)	(0.138)	(0.150)
Bottled water	-0.255	-0.027	-0.114	-0.095	-0.023	0.282**	0.005	-0.718***	0.945***
	(0.199)	(0.113)	(0.088)	(0.141)	(0.121)	(0.144)	(0.053)	(0.114)	(0.047)

Notes: ***, **, and * indicate a level of significance of 1, 5, and 10 percent, respectively. Standard errors are in parentheses. Highlighted numbers indicate uncompensated own-price elasticities; all other uncompensated elasticities are cross-price estimates.

Source: Authors' calculations based on Nielsen Homescan data, 1998-2007.

Table 5. High-income population beverage demand elasticities in the U.S., 1998-2007.

Beverage	Uncompensated Price Elasticities								Expenditure Elasticities
	ε_{i1}	ε_{i2}	ε_{i3}	ε_{i4}	ε_{i5}	ε_{i6}	ε_{i7}	ε_{i8}	ε_{i}
Sugary drinks	-1.292***	-0.283***	0.056***	0.061*	-0.020	0.253***	-0.013	0.201***	1.036***
	(0.096)	(0.059)	(0.021)	(0.035)	(0.021)	(0.049)	(0.023)	(0.039)	(0.045)
Diet drinks	-0.591***	-0.464***	-0.024	-0.045	-0.058	0.024	-0.015	-0.101	1.274***
	(0.112)	(0.125)	(0.033)	(0.052)	(0.036)	(0.076)	(0.035)	(0.063)	(0.052)
Skim milk	0.344***	0.004	-0.883***	-0.114	0.476***	-0.402***	-0.022	-0.265***	0.863***
	(0.107)	(0.092)	(0.170)	(0.160)	(0.127)	(0.086)	(0.033)	(0.057)	(0.050)
Low fat milk	0.227***	0.029	-0.046	-0.383***	-0.145**	-0.279***	0.018	-0.197***	0.777***
	(0.081)	(0.064)	(0.072)	(0.107)	(0.073)	(0.058)	(0.024)	(0.041)	(0.043)
Whole milk	-0.054	-0.114	0.564***	-0.383**	-0.804***	-0.135	-0.020	0.129*	0.817***
	(0.130)	(0.118)	(0.149)	(0.190)	(0.202)	(0.106)	(0.042)	(0.071)	(0.061)
Juices	0.529***	0.089	-0.153***	-0.248***	-0.048	-0.928***	-0.046*	-0.106**	0.911***
	(0.093)	(0.077)	(0.031)	(0.047)	(0.033)	(0.084)	(0.028)	(0.048)	(0.048)
Coffee/tea	-0.185	-0.069	-0.067	0.047	-0.055	-0.322*	-0.331***	-0.124	1.106***
	(0.278)	(0.227)	(0.079)	(0.125)	(0.083)	(0.181)	(0.128)	(0.159)	(0.143)
Bottled water	1.005***	-0.229	-0.264***	-0.452***	0.095*	-0.290**	-0.049	-0.832***	1.015***
	(0.192)	(0.164)	(0.054)	(0.087)	(0.058)	(0.126)	(0.065)	(0.155)	(0.104)

Notes: ***, **, and * indicate a level of significance of 1, 5, and 10 percent, respectively. Standard errors are in parentheses. Highlighted numbers indicate uncompensated own-price elasticities; all other uncompensated elasticities are cross-price estimates.

Source: Authors' calculations based on Nielsen Homescan data, 1998-2007.

Table 6. Effects of a 20% tax on beverage calories and body weight status: age and income

	Adults			Children		
	Low income	High income	All	Low income	High income	All
Change in calories (kcal/day):						
All beverages	-36.8	-33.3	-34.2	-33.1	-44.7	-40.0
Sugary drinks	-37.5	-35.2	-35.9	-35.8	-50.3	-44.4
Diet drinks	-0.0	-0.1	-0.1	0.0	0.0	0.0
Skim milk	-0.3	0.3	0.1	-0.4	0.5	0.2
Low-fat milk	-1.0	0.7	0.2	-2.2	2.5	0.6
Whole milk	1.2	-0.1	0.3	2.6	-0.3	0.9
Juices	1.7	1.5	1.6	3.6	3.1	3.2
Tea/Coffee	-0.9	-0.4	-0.5	-0.6	-0.3	-0.4
Bottled water	0.0	0.0	0.0	0.0	0.0	0.0

Source: Authors' calculation of 2003-06 National Health and Nutrition Examination Survey (NHANES).

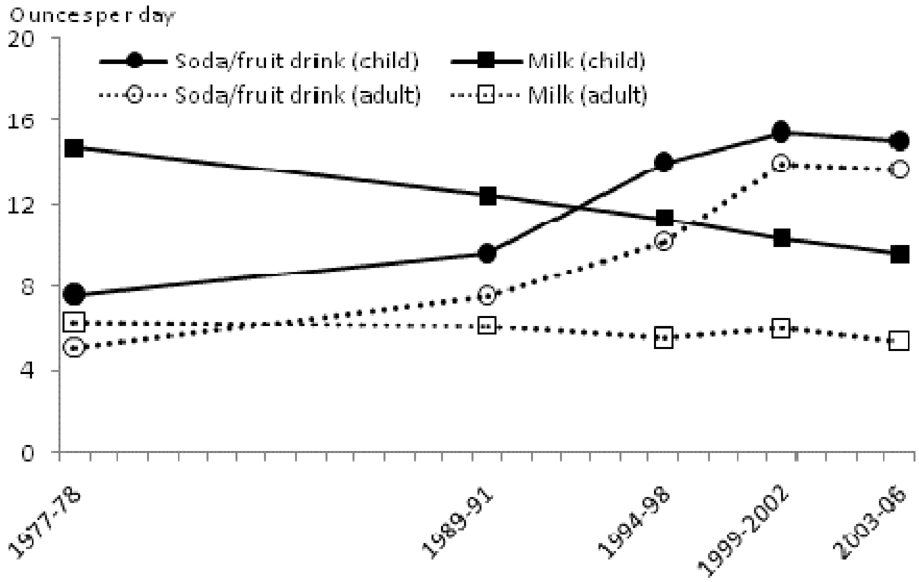

Figure 1. Adult and child beverage consumption, 1977-2006.
Source: Authors' calculation of 1977-78 Nationwide Food Consumption Survey (NFCS), 1989-91 and 1994-98 Continuing Survey of Food Intakes by Individuals (CSFII), 1999-2002 and 2003-06 National Health and Nutrition Examination Survey (NHANES).