Local Effects of Soda Taxes in Chicago

Abstract

The consumption of sugar-sweetened beverages has increased steadily since the 1970s. Consumption of these beverages is linked to obesity and higher health care costs. Furthermore, state and local governments are increasingly looking to alternative revenue sources. This paper seeks to determine what the consequences of a tax on sugar-sweetened beverages would be on consumption, revenues, and welfare. Specifically, it studies the consequences of a penny per ounce tax in the Chicago area.

Using historical food prices this paper uses econometric analysis to estimate elasticity and theoretical models to estimate tax effects. It finds that the price elasticity of food is approximately -1.3, and that a penny per ounce tax on sugar-sweetened beverages has the potential to bring about $50 million of revenue to Chicago.

Introduction

There are a variety of economic rationales for a soda tax. Foremost among them are the health consequences of excess caloric consumption and obesity. These costs can be divided into both externalities imposed on others and internalities imposed on the individual further down the road, but studies parsing out health costs into these categories are limited. As a comparison, the total external costs associated with smoking are about $.47 per pack, while, if factoring internalities, the health costs could range from $5 to $10 per pack (Gruber, 2011, 169-172)[1]. In the case of sugar-sweetened beverages, true externalities would be primarily limited to the adverse selection and moral hazard costs imposed on the health insurance risk pool. Overall health consequences relating to obesity are $147 billion, or 9.7% of all health care costs (Brownell, 2009)[2]. Berkley's Center for Weight and Health has found that the average person's caloric consumption has increased by over 300 calories per day since the 1970s. Of that increase, 43% is attributed to consumption of sweetened beverages (Lazarus, 2011)[3].

Soda taxes have traditionally been relatively small, ranging from 0-7% (Chaloupka, 2009)[5]. Many states have not had them, and those that have typically did so in conjunction with a grocery or vending tax. In 2010, New York State debated a penny per ounce tax, which was ultimately defeated in the legislature. Since this debate, several other states have begun to consider the possibility of pursuing such a tax. The California Assembly has proposed similar legislation (Lazarus, 2011), and Philadelphia's Mayor Nutter has proposed a $.02 per ounce tax (Shields, 2010)[6]. Other states have proposed eliminating soda's grocery tax exemption. Chicago has recently passed a tax on bottled water in the amount of $.05 per bottle.

As penny per ounce proposals become increasingly common, it is important to maintain perspective on the size of this tax. Based on the USDA data collected for this research, the average per ounce cost of sodas is roughly $.03, implying a 32% tax (see appendix). Current soda taxes in Chicago are 3% (Hamer, 2010)[15].

Literature Review

Previous research in this area has included a variety of studies estimating the price-elasticity of demand for food products. Andreyeva and Brownell (2009)[7] have performed a survey of previous studies relating to the price-elasticity of food. Their survey suggests that soda elasticity estimates typically range between -.8 and -1.2.

In addition, the USDA has studied the responsiveness of sugar-sweetened beverages to price as well as the relationship between soda consumption and obesity. Smith, Lin, and Lee[8] performed an analysis estimating the price-elasticity of sugar sweetened beverages and used this to consider the consequences of a 20% price increase. They also modeled the relationship between the associated reduction in caloric consumption and obesity rates. The authors found that a 20% increase in prices would reduce consumption of sweetened beverages by 26% (1.26 elasticity) and would reduce consumption by 37 calories per day per adult. Their obesity model suggested that this would reduce adult obesity from 33.4% to 30.1%. Brownell has focused on the health consequences of consumption of beverages, noting that the health care costs associated with obesity are 9.7% of total health care costs.

Chaloupka (2011), in conjunction with the Yale Rudd Center for food policy and obesity, has attempted to calculate the effects of soda taxes in various US cities as a share of the total US population[9]. Hacker and Greenstein (2011)[10] have performed a similar analysis of the effects of a $.05/12 oz tax on state revenue.

Researchers have attempted to estimate the consequences of cross border implications of raising state and local taxes, but studies specifically looking at sodas or other non-alcoholic beverages are limited. Furthermore, results have proven to be highly variable. Estimates have attributed anywhere from 25% to 80% of the reduction in consumption of cigarettes to cross border activity (Coats, 1995)[13].

This paper builds off existing research by examining the revenue and welfare consequences of a penny per ounce soda tax on the Chicago area.

Data

This analysis uses data from the USDA Food Atlas[11], which is a compilation of Nielsen Homescan survey results relating to a variety of food items. The data received was for the years 1999 to 2008, and broken down by quarter into 40 key market groups. Data included the price and total consumption of the following beverage categories: Non-alcoholic carbonated beverages, non-carbonated caloric beverages, water, juice, nonfat milk, and other milk.

Another data source was Beverage World, an industry publication, which tracks total sales by product type[12]. Control variables related to household income, population, and inflation were collected from the BLS and American Community Survey.

Methodology

<u>Econometric Model</u>

In order to determine the own-price elasticity of demand for sugar-sweetened beverages, this analysis employed an OLS regression to measure the relationship between price and sales. The regression uses the quantity of beverages consumed as the dependent variable and regressed against the price of various beverages as reported by the USDA, as well as some economy-wide controls, such as household income and inflation.

The specified relationship between consumption and prices is as follows:

$$Consumption = \sum_i \beta i \ln Pi + \sum_j \beta j\ Market\ j + \gamma 1\ Income + \gamma 2\ Population + \gamma 3\ Index$$

Where:

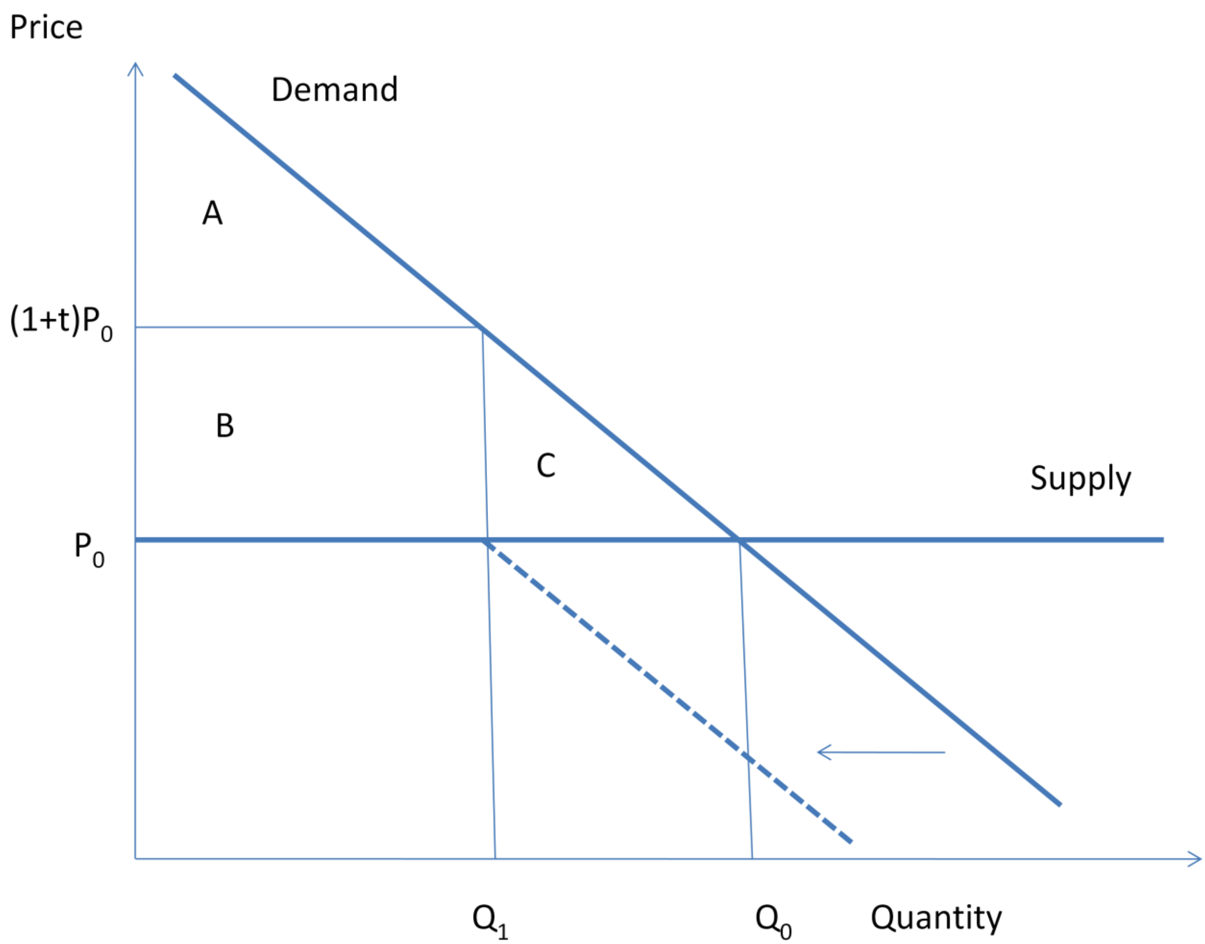
- *Consumption* is the total sales in sweetened beverages, determined by the total dollar amount spent as reported by the USDA food atlas, divided by the unit price.
- *Pi* is the price of sugar-sweetened beverages and its associated substitutes - non-carbonated caloric beverages, water, juice, nonfat milk, and other milk.
- *Market j* is a binary indicator for each of the 40 geographic markets designated by the USDA.
- *Income* is quarterly household income to distinguish substitution and income effects
- *Population* is quarterly population, to control for aggregate consumption growing over time.
- *Index* is the CPI by quarter, as prices were provided in nominal amounts.

Theoretical Model

The theoretical model made the following key assumptions:

- Prices would be passed along entirely to consumers (simplifying assumption due to limitations on producer cost data).
- Over the range in question, a linear demand model could approximate results.

Tax Incidence and impact on Equilibrium quantity



The above graph models the impact on prices, consumption and consumer surplus. Using the empirical results and actual price and quantity data, this model will be used to calculate the change in Consumer Surplus (areas B+C), deadweight loss (area C), and revenue (area B).

Results

<u>Elasticity</u>

The coefficients, errors, and p-values for key variables are as follows:

	β	SE	p
Log Price	-6,095,114	-1.02e+07	.003
Log Juice	1.15e+-7	1,363,478	.000
Log Water	5,517,481	1,012,097	.000
Log Nonfat	1,270,905	1,675,340	.448
Index	-114,140	36,568	.002
Income	-505	146	.001
Population	.004	.003	.188

(see appendix for raw output, including all market indicators)

The above coefficients represent changes in consumption in 100 gram units. The log price coefficient is associated with an own-price elasticity of -1.3. Also noteworthy is that income elasticity is negative, implying that sugar sweetened beverages are an inferior good. Market 16, Chicago, was not found to have any statistically significant endogenous differences from the general model.

Welfare Implications

(see appendix for detailed calculations on revenue and overall welfare)

The Beverage World sales publication gives total US sales of 16,844 million gallons of carbonated soft drinks and other sugar-sweetened drinks, such as sports and energy drinks. As Chicago's market was not statistically different from the general model, population weights suggest a total of 122M gallons consumed in Chicago. Excluding diet drinks, which typically make up 45.3% of sales and would not be eligible for such a tax (Chaloupka)[9], Chicagoans consume 66.7M gallons. An elasticity -1.3 and a 32% tax would reduce this to 41.6M, roughly a 37.6% reduction.

A penny per ounce imposed on 41.6 million gallons would generate government revenues of $49.9M. As a point of comparison, Chicago's 2009 tax revenue was $1,256M. A recent tax of $.05 cents per bottle of water implemented in January 2008 was designed to raise about $10.5M in new revenues (St. Clair, 2007)[16].

Consumer surplus prior to the enactment of taxes was approximately $102.7M, and was reduced to $37.4M. After considering tax revenue, the total deadweight loss of the tax is $12M.

Obesity and Health

The relationship between caloric consumption, obesity, and health is complex. Reductions in caloric consumption are not distributed evenly throughout the population, as sweetened beverages are consumed more heavily by lower income individuals. Because of this, is it difficult to determine exactly how the 37.6% reduction in consumption of sweetened beverages would impact obesity and health. It is safe to assume, however, that any change would be larger than that associated with the 20% reduction calculated in the USDA report, thus, the obesity reduction used by the USDA could be considered a floor for the potential health savings of reduction in consumption of this size. The USDA study estimated that a 20% increase in sweetened beverage prices would lead to a net reduction in caloric consumption of about 39.5 calories per day, or 4.1 pounds per year. Using the methodology from this report, the 37.6% reduction in sweetened beverage consumption would lead to roughly a 77.1 decline in calories consumed per day. The USDA study calculated that their 20% reduction in consumption would be connected with a reduction in obesity rates from 33.4% to 30.3%, a 9.28% reduction.

The benefit of this reduction in obesity is uncertain, again due to the complex relationship between these issues and the difficulty in controlling for other factors influencing health care costs. Brownell estimates that medical costs related to obesity total $147 billion, or 9.7% of medical costs. If we again consider the proportional impact on Chicago, a 9.28% obesity reduction would result in medical savings of $126.3M, over ten times the deadweight loss associated with the tax. It is possible for the cost savings to be even higher, as the change in consumption by this study suggests a much higher reduction in caloric consumption than assumed under the USDA study. Alternatively, the extent to which consumption is offset by cross border sales would reduce these savings. It is also important to note that these results are highly imprecise and have an uncertain time frame, as it can take several years for body weights to stabilize in response to these types of changes (Chow and Hall, 2008)[14].

Conclusions and Areas for Additional Research

This research shows that a tax of a penny per ounce on sugar-sweetened beverages could lead to $50 million dollars in tax revenue for Chicago. While the price-sensitivity of these beverages, along with the size of the tax, would cause a substantial reduction in economic activity, the benefits of this reduction could be several times larger than the associated cost. Research in other areas, such as cigarette taxes, suggests that the benefits would mostly be in the form of internalities, rather than externalities. Thus, the economic justification for these taxes largely hinges on whether this is an appropriate activity to regulate.

There are a variety of issues related to this topic that offer potential for further research. While it is traditional to assume that soda producers would pass the tax on to consumers, this may not be the case based on the level of concentration in the soda and beverage industry. Additional empirical research should be performed to ensure that consequences of the tax on producer surplus are in fact negligible.

Another issue is that given a price increase specific to a small geographic area, many consumers would seek opportunities to purchase their beverages outside of the tax jurisdiction. While smuggling and arbitrage have been studied with regards to cigarette taxes, studies relating to the effects of soda taxes on cross border purchases are limited. Furthermore, efforts to estimate this effect have historically varied widely. While current bottled water taxes are not as large as the soda taxes being proposed, this recent legislation, along with variation in state and local tax rates, does suggest a need to examine these consequences.

Lastly, additional exploration into modeling the relationship between consumption, obesity, and health care costs is needed. While the USDA study attempted to model this relationship, the exact details remain imprecise due to difficulty in controlling for other factors relating to health, as well as uncertainty in the time horizon involved in seeing these benefits.

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Appendix

The appendix provides detailed calculations based on data and empirical results.

Raw regression results:

Source	SS	df	MS
Model	2.9203e+16	47	6.2134e+14
Residual	1.9594e+16	1543	1.2698e+13
Total	4.8796e+16	1590	3.0690e+13

Number of obs	=	1591
F(47, 1543)	=	48.93
Prob > F	=	0.0000
R-squared	=	0.5985
Adj R-squared	=	0.5862
Root MSE	=	3.6e+06

salesvolume	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
logprice	-6095114	2068982	-2.95	0.003	-1.02e+07	-2036800
lognoncarbon	-1614794	1470725	-1.10	0.272	-4499626	1270037
logwater	5517481	1012097	5.45	0.000	3532250	7502713
logjuice	1.15e+07	1363478	8.43	0.000	8815141	1.42e+07
lognonfat	1270905	1675340	0.76	0.448	-2015278	4557089
logfat	-5987880	1302276	-4.60	0.000	-8542297	-3433462
priceindex	-114140.2	36568.03	-3.12	0.002	-185868.5	-42411.95
populationus	.0040566	.0030797	1.32	0.188	-.0019843	.0100975
householdi~e	-505.657	145.7662	-3.47	0.001	-791.5778	-219.7363
market1	2978639	1318192	2.26	0.024	393001.7	5564276
market2	605467.2	1316212	0.46	0.646	-1976287	3187221
market3	3096822	1260371	2.46	0.014	624601.2	5569043
market4	1895386	1289750	1.47	0.142	-634461.7	4425233
market5	3224894	1249169	2.58	0.010	774645.2	5675143
market6	2267996	1232337	1.84	0.066	-149236.8	4685228
market7	2754052	1314958	2.09	0.036	174758	5333345
market8	4601861	1317827	3.49	0.000	2016940	7186782
market9	-2023406	1220863	-1.66	0.098	-4418132	371319.7
market10	4205898	1337375	3.14	0.002	1582633	6829162
market11	569477.6	1331359	0.43	0.669	-2041986	3180941
market12	615542.8	1195005	0.52	0.607	-1728462	2959548
market13	475321.7	1334343	0.36	0.722	-2141996	3092639
market14	850378.5	1249823	0.68	0.496	-1601153	3301910
market15	842693.8	1209127	0.70	0.486	-1529012	3214399
market16	-783726.3	1255835	-0.62	0.533	-3247051	1679598
market17	7127020	1286728	5.54	0.000	4603099	9650940
market18	-387703.8	1264725	-0.31	0.759	-2868466	2093058
market19	2319240	1306910	1.77	0.076	-244268.4	4882747
market20	1632325	1309310	1.25	0.213	-935890.6	4200540
market21	3729615	1269425	2.94	0.003	1239635	6219595
market22	-1085170	1275703	-0.85	0.395	-3587464	1417124
market23	-1312208	1214683	-1.08	0.280	-3694812	1070396
market24	689892.4	1306036	0.53	0.597	-1871900	3251685
market25	6126780	1263068	4.85	0.000	3649268	8604291
market26	-361722.8	1220600	-0.30	0.767	-2755932	2032486
market81	101783.5	1558088	0.07	0.948	-2954411	3157978
market82	1036557	1489764	0.70	0.487	-1885619	3958733
market83	2.49e+07	1607187	15.52	0.000	2.18e+07	2.81e+07
market84	(omitted)					
market91	658980.2	1298865	0.51	0.612	-1888746	3206706
market92	1602303	1365465	1.17	0.241	-1076060	4280666
market93	1841048	1309221	1.41	0.160	-726991.5	4409089
market94	716784	1272440	0.56	0.573	-1779110	3212678
market95	5737553	1358697	4.22	0.000	3072466	8402640
market96	3173585	1390831	2.28	0.023	445466.9	5901702
market97	3268547	1326080	2.46	0.014	667437.5	5869656
market98	459657.7	1229955	0.37	0.709	-1952902	2872217
market99	1324780	1221286	1.08	0.278	-1070777	3720336
_cons	5.18e+07	8729258	5.94	0.000	3.47e+07	6.89e+07

Note: All data below comes from information gathered from the Food Atlas as of March 2010 (collected through 2008) and Beverage World "State of the Industry Report" for 2008.

Prices and Tax Rate

$.10443 = Average Chicago 2008 price of sweetened beverages per USDA data (per 100 grams).

($.10443/100g)(240g/8oz) = $.03133/oz

$.01 tax / $.03133 = 31.9%

Chicago already has a tax of 3%, so this would imply a tax increase of 28.9%.

Elasticity

$\varepsilon = (dQ/Dp)(P/Q) = \beta/Q = -6{,}095{,}114/4{,}676{,}440 = -1.303$

Consumption

Chicago Consumption = (soda+other sweetened)*Chicago Population / US population

=(13,919,000,000+2,925,000)*2,696,000/307,439,000 = 122,084,412 (gallons)

Eligible for tax = Chicago Consumption *non diet share

= (1-.453)* 122,084,412 = 66,780,174 (gallons)

Revised consumption = Eligible for tax*(1-price change * ε)

=66,780,174*(1-.28918*1.303) = 41,617,041 (gallons)

Revenue

=41,617,041 gallons*(128ounces / gallon) *($0.01 /ounce)

=$53,269,812

Surplus

In order to determine the surplus, need to consider the slope and intersect of demand curve.

Current spot is Q = 66,780,174 gal and p = $.03133/oz. With ε=-1.303, we can calculate a slope of

Slope = εQ/P = -1.303*66,780,174/$.03133 = -2,777,356,103gal/$ = dq/dp

So dp/dq = 1/2,777,356 = 3.60055E-10

As P=A-dp/dq*Q, we can set

A= .03133+3.60055E-10*66,780,174=.055375

Initial surplus=1/2*(.055375-.03133)*66,780,174*128=102,766,674

Revised surplus=1/2*(.055375-.04133)*41,617,041*128=37,408,726

Deadweight Loss

= Initial Surplus – revised surplus – revenue

= $102,766,674-$37,408,726-$53,269,812=$12,088,136

Health Implications

Relationship between beverage consumption and caloric consumption

	Elasticity	Percent Change	Calories Per Day	Change
Sweetened	-1.303	37.6%	216	-105.82
Juice	0.115	37.6%	122	5.28
Nonfat Milk	0.557	37.6%	112	23.46
				-77.09/day

Chicago obesity related medical costs:

=(147,000,000,000)*2,696/307,439 = 1,289,075,231

Potential reduction with a 9.8% obesity reduction:

=1,289,075,231*9.8%=126,329,372