The United States Sweetener Excise Tax Policy Analysis

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Abstract

The United States accounts for one of the highest per-capita caloric sweetener consumption in the world. The American Heart Association recommends a maximum of around 6 to 9 teaspoons of per-capita sweetener consumption per day (equivalent to 23.8 pounds to 35.71 pounds per-capita, per year). The current US per-capita sweetener consumption is approximately 19 teaspoons/day. This high sweetener consumption is often linked to major health ailments such as obesity, Type 2 diabetes, and cardiovascular diseases. This study uses a supply and demand framework to evaluate the amount of excise tax on major sweeteners (sugar and high fructose corn syrup) sufficient to reduce excess sweetener consumption to the recommended level. Results suggest a maximum consumer tax of 12 cents per pound on both sugar and HFCS sufficient to reduce consumption to the recommended level. Also, a maximum producer tax of 25 cents per pound on sugar and 95 cents per pound on HFCS is suggested to reduce consumption to the recommended level.

Smith (1776) in his famous piece, The Wealth of Nations, stated that

> *"Sugar, rum, and tobacco, are commodities which are no where necessaries of life, which are become objects of almost universal consumption, and which are therefore extremely proper subjects of taxation"*.

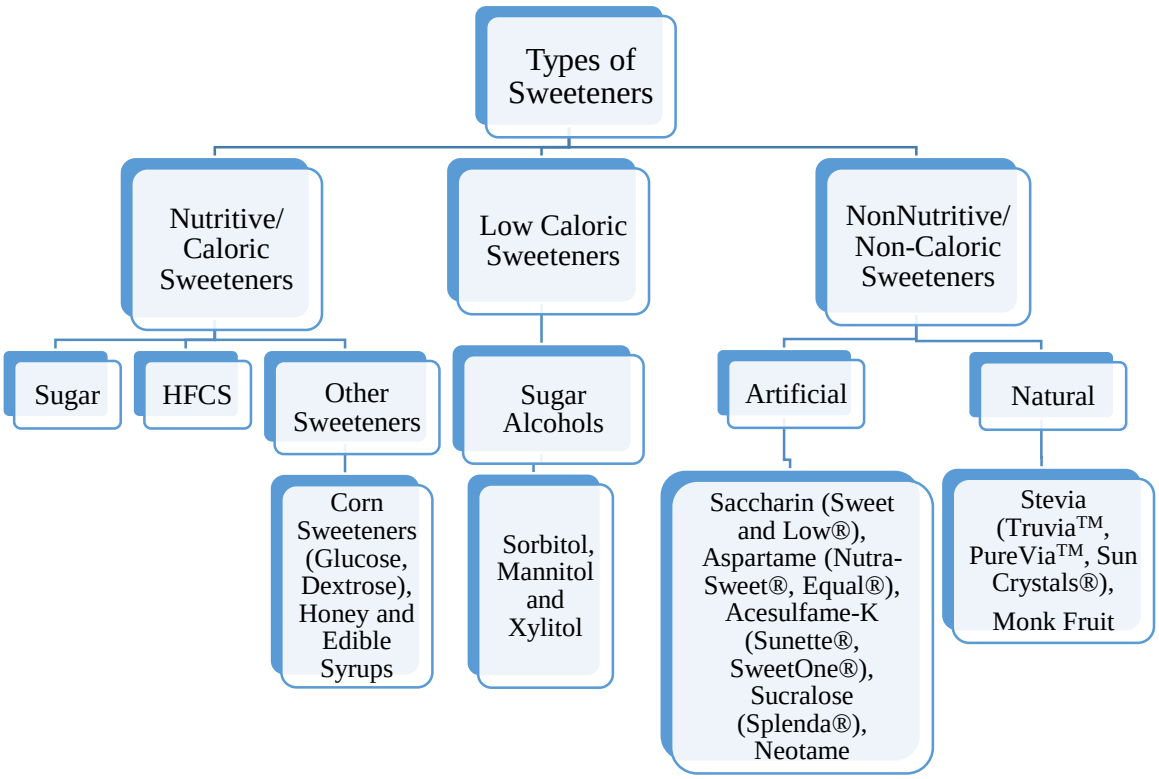
Introduction

Obesity has become one of the major epidemics in the United States and other developed countries (James et al., 2001). Although obesity is a result of many factors, the modern food environment was found to be the major factor (Cutler et al., 2003). In the United States, recent data reveal that over 35% of adults and 16.9% of children and adolescents are obese (Pomeranz, 2013). Type 2 diabetes and cardiovascular diseases are also prevalent in the United States. Annually, about $79 billion of Medicare funds are directed toward obesity and overweight problems at US taxpayers' expense (Brownell and Frieden, 2009). Obesity and overweight-related health costs together accounted for about 9.1% of the US health care expenditure (Brownell et al., 2009). A large body of literature has linked excess sweetener consumption to major health ailments like obesity, Type 2 diabetes, and other cardiovascular diseases (Johnson et al., 2009; Malik, Schulze, and Hu, 2006; Vartanian, Schwartz, and Brownell, 2007).

Sweeteners used in food additives are broadly classified into caloric (nutritive), low caloric and non-caloric (non-nutritive) (Figure 1). Caloric

sweeteners constitute sugar, high fructose corn syrup (HFCS), honey, corn sweeteners (i.e., glucose and dextrose), and other edible syrups. Low caloric sweeteners such as sugar alcohols including sorbitol, mannitol, and xylitol etc., are present naturally in fruits and vegetables. Human body does not absorb sugar alcohols and their excess consumption may cause laxative effect.

Figure 1. Types of Sweeteners



Finally, non-caloric sweeteners comprise of two sub-categories—artificial and natural. Artificial sweeteners constitute saccharine, aspartame, acesulfame–K, and sucralose with their respective trade names in parentheses as shown in Figure 1. Stevia (Truvia®, PureVia®, and Sun Crystals®), and monk fruit are

classified as non-caloric natural sweeteners. As a whole, caloric sweeteners constitute a majority share of total sweetener consumption in the United States. Hence, in our study, the excise tax analysis is primarily focused on caloric sweeteners— sugar and HFCS.

Sugar and high fructose corn syrup (HFCS) together account for most[1] (82–87%) of the caloric sweetener consumption in the United States. Due to high sugar prices, HFCS has displaced sugar in the US soft-drink industry. The US sweetener intake increased by 19% between 1970 and 2005 (Johnson et al., 2009). The United States Department of Agriculture (USDA) reported that US per-capita soft-drink consumption has increased by 500% in the last 50 years (Putnam and Allshouse, 1999).

Most of the previous studies have concentrated more on sugar-sweetened beverage (SSB) taxation, even though sugar sweetened beverages constitute less than 50% of the added sugar consumed in the United States (Health.gov, 2010). Moreover, a SSB tax may not be fair because SSB producers use HFCS as the main sweetener in the soft-drink/beverage industry. A recent study by Miao, Beghin and Jensen (MBJ)[2] (2012) also found that final consumption tax on sweetener containing products was more effective in reducing the quantity intake than the SSB taxation. On the other hand, the chocolate industry uses sugar as the main ingredient. Hence, it may not be fair if we continue with the

[1] The percentage was computed using per-capita consumption data collected from USDA's Sugar and Sweetener Yearbook tables for sugar, HFCS, and other sweeteners from 1970 to 2013. Other sweeteners include corn sweeteners (glucose, dextrose), honey and other edible syrups.
[2] Hereafter, Miao, Beghin and Jensen (2012) is referred as MBJ (2012) throughout our paper

SSB taxation. Instead, the goal of a sweetener tax policy should be based on the amount of sweetener used as an input in food additives.

Our paper evaluates the amount of excise tax imposed on producers and consumers of major caloric sweeteners sufficient to reduce their consumption to the American Heart Association's (AHA) recommended level. Pomaranz (2013) proposes several taxing strategies—taxing the person; taxing the product; taxing the nutrient, calorie, or ingredient; and taxing the manufacturer. In a recent study by MBJ (2012), taxing sweeteners at input level rather than at consumer level, would effectively reduce the demand for added sugar, impose less consumer tax and overall have the lowest welfare cost. According to their study, a soda tax of one-cent-per ounce on added sugar reduced the demand by 7.73%. Evidence from tobacco and alcohol taxes has shown that there is a significant reduction in consumption and thereby a decrease in health care costs.

In the United States, 33 states have implemented the soft-drink mean sales tax (around 5.2%). This tax was not enough to reduce sweetener consumption to the desired level and to generate sizable revenues (Brownell et al., 2009). The results of a study by Fletcher, Frisvold, and Tefft (2009) suggest that current soft-drink taxes impact a small population, implying that the taxes are not high enough. Moreover, a sales tax[3] may force consumers to prefer and to buy cheaper

[3] A sales tax is a tax levied as a percentage of the price.

sweetener products. A study by Zheng et al. (2013) states that shelf prices do not include the sales tax, and it is only included at the cash register.

Hence, the proposed excise tax[4] has two advantages over the sales tax. First, the excise tax reflects on the price marked on the product. Second, the excise tax is proposed on a per-unit basis compared to the sales tax, which is imposed as a percentage of the price. A penny-per-ounce excise tax on soda totaled $1.2 billion in New York State alone (Brownell and Frieden, 2009). In the New York survey, the support for a sweetener excise tax rose from 52% to 72% when it was specified that the generated revenue would be spent on obesity prevention (Brownell and Frieden, 2009).

This study contributes to the literature by focusing on the amount of the excise tax on sugar and HFCS sufficient to reduce the total sweetener consumption to the AHA-recommended level. This study analyzes the following research questions:

- How much excise tax must be imposed to reduce per-capita sweetener consumption to the AHA-recommended level?
- How much government revenue is generated through the taxation?

The AHA-recommended level of per-capita sweetener consumption is about 6 teaspoons/day (based on 1800 calories/day) for women and 9

[4] An excise tax is a tax levied on a per-unit basis, such as volume or quantity.

teaspoons/day (based on 2200 calories/day) for men[5]. Currently, the US per-capita sweetener consumption levels are about 19 teaspoons per annum (40 teaspoons of sweetener deliveries/day). This excess sweetener consumption has often been linked to health ailments such as obesity, Type 2 diabetes, and cardiovascular diseases (Johnson et al., 2009). In this analysis, the total teaspoons of sweeteners are computed on a yearly basis and converted into pounds per capita, per year. Therefore, 6 teaspoons per day equal 2190 teaspoons per annum, or 23.8 pounds per annum (Calcul.com). Similarly, 9 teaspoons per day equal 3285 teaspoons per annum, or 35.71 pounds per annum (Calcul.com). Because the sweetener prices are available in cents per pound, per annum, the quantities of consumption are analyzed in pounds per annum.

The excise tax policy evaluation is carried out with a supply and demand framework covering two major caloric sweeteners, such as sugar and HFCS. To carry out the analysis, we need supply elasticities, own-price elasticities, and cross-price elasticities for sugar and HFCS. Own-price elasticities and cross-price elasticities are computed through the time-series version of the Almost Ideal Demand System (AIDS). Supply elasticities are obtained from the OECD–FAO Aglink-Cosimo model due to insufficient data.

[5] In our study, teaspoons/capita/day are converted into pounds/capita/year as sweetener prices are available in cents per pounds. Therefore, 6 teaspoons/capita/day are equivalent to 23.8 pounds/capita/year and 9 teaspoons/capita/day are same as 35.71 pounds/capita/year

Table 1. Elasticities of sugar and HFCS used in our study

	Elasticities		
Commodity	Supply	Own-Price	Cross-Price
Sugar	0.72[a]	–1.475[b]	0.03[b]
HFCS	0.07[a]	–0.55[b]	0.09[b]

[a] Obtained from the OECD–FAO Aglink-Cosimo model,
[b] Computed from time-series version of the Almost Ideal Demand System (AIDS) model. (Find the results in the later section of the paper)

Recent Sweetener Tax Policies

There are three sweetener related tax policies introduced recently. They are—the SWEET Act, Mexican soda tax, and Berkeley's soda tax. US House Representative Rosa DeLauro introduced the "Sugar-Sweetened Beverages (SSB) Tax Act of 2014", or the "SWEET Act", in an effort to reduce the excess consumption of SSBs (Reuters, 2014). She proposed a penny tax per 4.2 grams of caloric sweetener such as sugar and HFCS (Nytimes.com, 2014). On the other hand, the American Beverage Association (ABA) claims that "people don't support taxes and bans on common grocery items, like soft-drinks" (American Beverage Association, 2014).

Effective January 1, 2014, Mexico introduced an excise tax of one peso ($ 0.08) per liter of drinks with added sugars. A study by a team of University of North Carolina researchers compared the taxed beverages of the first quarter of 2014 with the first quarter purchases of 2013. The preliminary results of the study reveal that there is a 10% decline in taxed beverage purchases (National Institute of Public Health, Mexico).

On November 4, 2014, Berkeley, California, passed a one-cent-per-fluid-ounce soda tax on sugar-sweetened drinks. In light of these success stories, it is important to quantify the excise tax sufficient to reduce the excess sweetener consumption to the AHA-recommended level. Hence, it is important to understand the amount of excise tax sufficient to reduce the excess sweetener consumption to the AHA-recommended level.

Proportional Tax vs Differential Tax

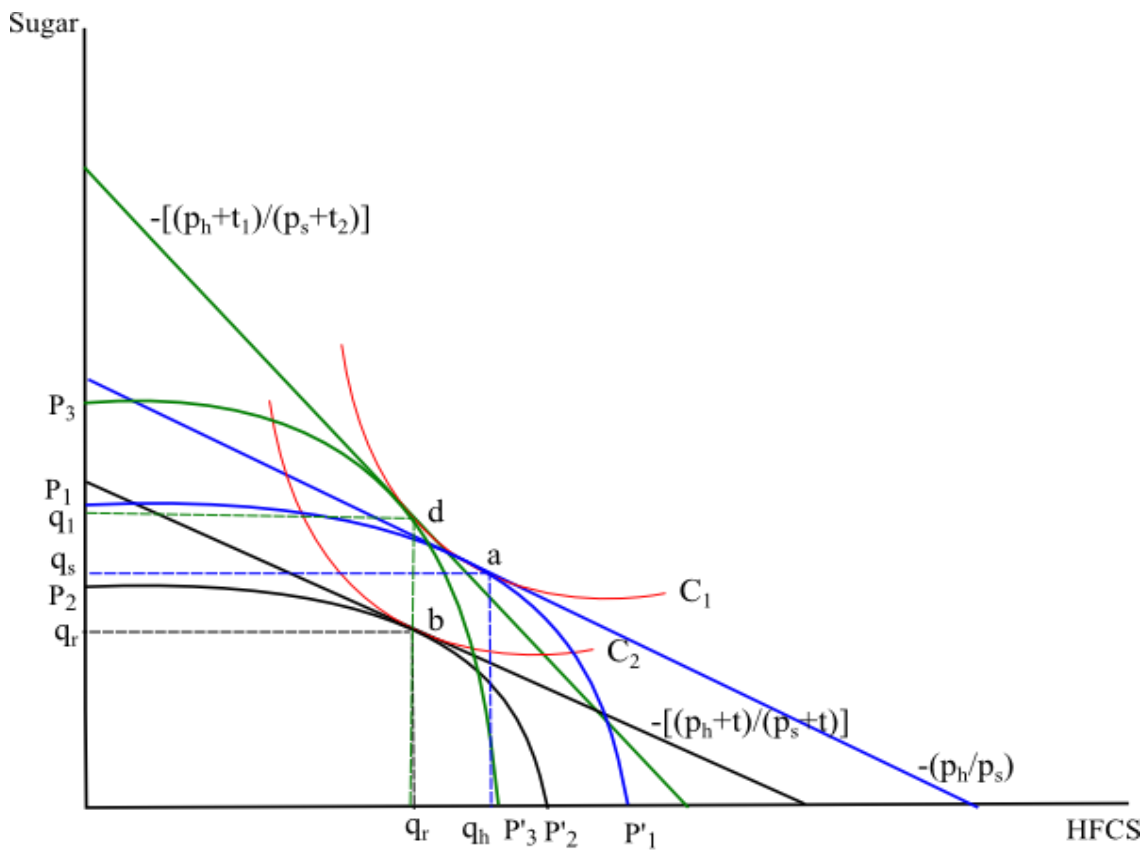
A theoretical model of proportional tax versus differential tax is presented in Figure 2. A proportional tax is the equal tax imposed on different commodities or markets irrespective of the income, whereas differential tax is a tax imposed differently on different commodities or markets for achieving a given government revenue.

Consider C_1 and C_2 are a set of indifference curves representing the consumer preferences for sugar and HFCS. $P_1P'_1$, $P_2P'_2$, and $P_3P'_3$ are the production possibility frontiers with their relative prices $-(p_h/p_s)$, $-[(p_h+t)/(p_s+t)]$, and $-[(p_h+t_1)/(p_s+t_2)]$, respectively. Assume point a, initial consumption with q_s and q_h representing the initial sugar and HFCS consumption, respectively. If we impose a proportional tax t on both sugar and HFCS to reduce their consumption level to point b, the recommended level (q_r). Hence, the movement from consumption point a to consumption point b is due to a proportional tax t.

Suppose a differential tax of t_1 on HFCS and t_2 on sugar is imposed, then consumption shifts from point a to point d. A differential tax allows substitution

between sugar and HFCS. Assume that t_2 is less than t_1, then substitution takes place between sugar and HFCS, and hence sugar consumption increases from q_s to q_1. A differential tax on sugar and HFCS do not allow us to reach our overall objective—to reduce both sugar and HFCS consumption to the AHA recommended level (q_r). Hence, a proportional tax is appropriate to our study. Excise tax and general sales tax are few examples of a proportional tax. In our study, an excise tax is used as a policy instrument to reduce both the sugar and HFCS consumption to the AHA recommended level.

Figure 2. Proportional Tax Vs Differential Tax



Data and Model

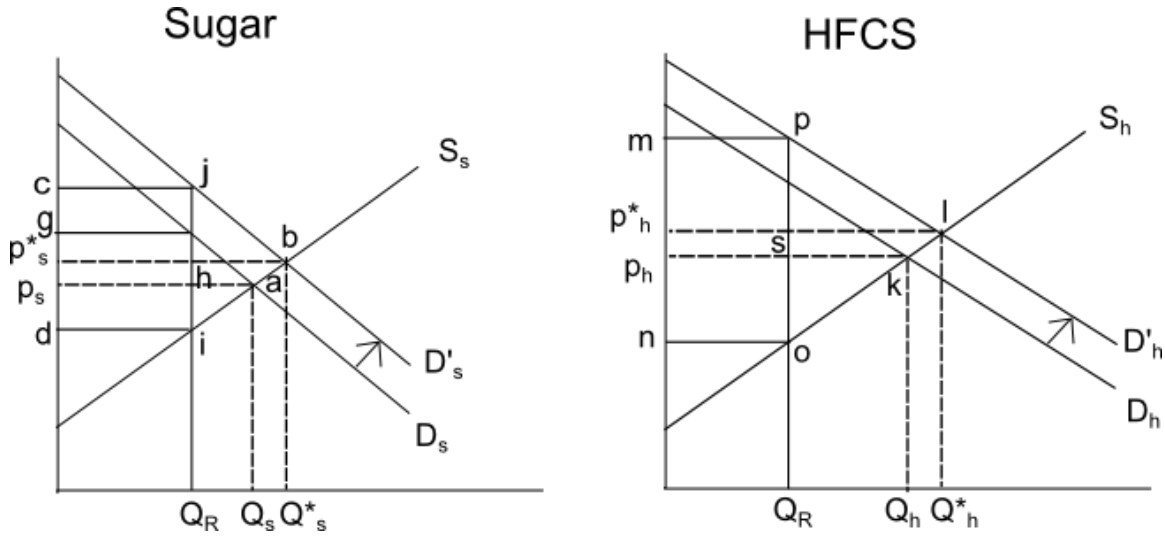
The annual US price and quantity data are used for the per-capita consumption of sugar and HFCS from 1987 to 2013 collected from USDA (2014). Own-price elasticities and cross price elasticities are computed through a time-series version of the Almost Ideal Demand System (AIDS). For estimation of a differential demand model, we need at least three commodities for imposing homogeneity and symmetry restrictions. Therefore, honey is used as the third commodity and own-price elasticities and cross-price elasticities of sugar and HFCS are computed and used in the study.

Supply and Demand Framework

Figure 3 shows the excise tax model of sugar (Panel a) and HFCS (Panel b) in a supply and demand framework. In Panel (a), Ds and Ss are initial demand and supply of sugar. On the other hand, Panel (b) shows initial demand (D_h) and supply (S_h) of HFCS. Consider Panel (a), suppose an initial tax of ($g - d$) is imposed on sugar, then the demand for HFCS increases because of substitution.

Hence, the HFCS demand curve in Panel (b) shifts from D_h to D'_h. Now, a tax of ($m - n$) is imposed on the HFCS to reduce its consumption to the recommended (Q_R) level. A tax on HFCS shifts the demand curve of sugar in Panel (a) from D_s to D'_s. Finally, a tax ($c - d$) is imposed on sugar to reduce its consumption to the recommended (Q_R) level.

Figure 3. Analysis of the excise tax on sweeteners



(a) (b)

The excise tax on a sweetener results in a government revenue equivalent to the areas *cjdi* and *mnop* from sugar and HFCS, respectively. Sugar consumers and producers contribute $cjhp_s^*$ and p_s^*hid, respectively, to a total revenue of *cjdi*. In addition, HFCS consumers and producers contribute $mpsp_h^*$ and $sonp_h^*$ to a total revenue of *mnop*. Government intervention of taxing sweeteners caused a dead weight loss of *ijb* (sugar) and *opl* (HFCS). As a whole, a tax of (c – d) on sugar and (m – n) on HFCS is imposed to reduce their consumption levels to the recommended level. A total government revenue (TR) is given by

$$TR = (c - d)*Q_R + (m - n)*Q_R$$

Empirical Model to Obtain Own-Price Elasticities and Cross-Price Elasticities

The own-price elasticities and cross-price elasticities are computed through a differential demand model (i.e., a time series version of the Deaton and Muellbauer's AIDS Model). The supply elasticities were taken from OECD–FAO Aglink-Cosimo Model. For an estimation of this model, we require at least three commodities. In addition to sugar and HFCS, honey was chosen as the third commodity for the estimation of the model. Later, the own-price elasticties and cross-price elasticities of sugar and HFCS were used in the supply and demand framework to evaluate the amount of the excise tax to decrease sweetener consumption to the AHA-recommended level. The time-series version of the AIDS model as given by Deaton and Muellbauer (1980) is shown below

$$dw_i = \beta_i \, d\ln\left(\frac{m}{P}\right) + \sum_j \gamma_{ij} \, d\ln p_j$$

where

w_i is the budget share of good i

m is the income/expenditure

p_j is the price of good j

β and γ are the quantity coefficient and the slutsky cross-price coefficient estimates, respectively,

$d\ln\left(\frac{m}{P}\right) = d(\ln Q)$

$d\,(\ln Q) = \sum_j w_j \;\, d\ln q_j$ is the divisia volume index

$d\,(\ln P) = \sum_j w_j \;\, d\ln p_j$ is the divisia price index

The above model has to satisfy the following

- adding up constraint: $\sum_i \beta_i = 0$,
- homogeneity: $\sum_i \gamma_{ij} = 0$ and
- slutsky symmetry: $\gamma_{ij} = \gamma_{ji}$.

The parameter estimates were obtained from the above analysis and are used for computing price elasticities for sugar and HFCS. The formulae for the own-price elasticity and cross-price elasticity are given below (Alston, Foster, and Green, 1994)

Own-price elasticity: $S_{ii} = -1 + \frac{\beta_{ii}}{w_i^*} - w_i^*$

Cross-price elasticity: $S_{ij} = \frac{\beta_{ij}}{w_i^*} + w_j^*$

The above formulae estimate the required elasticities of sugar and HFCS, which were used in the latter analysis to compute the amount of the excise tax to be imposed in order to reduce the sweetener consumption to the AHA-recommended level.

Results and Discussion

Table 2 presents the parameter estimates of the time-series AIDS model. All the parameter estimates are significant at least at the 95% level, except the expenditure coefficient of sugar. Based on the parameter estimates, sugar and honey are luxury goods, whereas HFCS is an inferior good.

Table 2. Parameter estimates of expenditure and price coefficients

	Parameter Estimates			
	γ_{ij}			β_i
	Sugar	HFCS	Honey	Expenditure
Sugar	0.185* (0.014)[a]	–0.150* (0.012)	–0.035* (0.006)	0.033 (0.081)
HFCS		0.160* (0.012)	–0.010* (0.005)	–0.121** (0.072)
Honey			0.045* (0.004)	0.088* (0.040)

[a] Standard errors in parentheses: *significant at the 95% confidence level and **significant at the 90% confidence level.

The own-price elasticities, cross-price elasticities, and expenditure elasticities are shown in Table 3. The negative sign of the own-price elasticities of sugar and HFCS are consistent with the standard economic theory, but the own-price elasticity of honey is positive. The positive sign of the cross-price elasticities of sugar and HFCS indicate that they are substitutes and are consistent with the theory.

Table 3. Own-price, cross-price, and expenditure elasticities

	Sugar	HFCS	Honey	Expenditure
Sugar	–1.475*** (0.020)[a]	0.029* (0.017)	–0.013 (0.008)	1.045*** (0.111)
HFCS	0.092* (0.052)	–0.553*** (0.050)	–0.009* (0.021)	0.484 (0.306)
Honey	–0.274 (0.173)	–0.063* (0.142)	0.267** (0.119)	3.517*** (1.148)

[a] Standard errors in parentheses, *significant at the 90% confidence level, **significant at the 95% confidence level, and ***significant at the 99% confidence level.

Final results suggest that a tax of 12 cents per pound is imposed on both sugar and HFCS consumers to reduce sweetener consumption to the AHA-recommended level of 6 teaspoons per day (or 23.8 pounds per annum) (Table 4). On the other hand, a tax of 95 cents per pound would need to be imposed on the producers of HFCS in contrast to a tax of 25 cents per pound on sugar producers. The tax on sugar producers and HFCS producers is different due to their difference in supply elasticities. Based on the supply elasticity of HFCS (0.07 in Table 1) used in our study, it is inferred that it is near inelastic. Hence, the tax is high for HFCS producers compared to sugar producers. To obtain the same amount of tax on HFCS producers as sugar producers (i.e., 25 cents per pound), the supply elasticity of HFCS has to be 0.22 instead of 0.07.

Results for a 9 teaspoons of sweetener consumption recommendation per day (or 35.71 pounds consumption per year) suggest that a tax as low as 2 cents per pound and 4 cents per pound are needed to be imposed on sugar consumers and producers, respectively. Government revenue of $8.71, or $2.10 per capita, per year, is generated from taxing sugar, depending on the recommendation level adopted. An HFCS tax would generate government revenue of about $25.51 per capita, per annum.

Table 4. Final results of the excise tax and government revenue

Taxed Agent	Sugar		HFCS
	Es = 0.72, Ed =-1.475		Es = 0.07, Ed = -0.55
	23.8 lbs (6 tsp)	35.71 lbs (9 tsp)	23.8 lbs (6 tsp)
Consumer ($/lb)	0.12	0.02	0.12
Producer ($/lb)	0.25	0.04	0.95
Total Tax ($/lb)	0.37	0.06	1.07
Government Revenue ($/head/year)	8.71	2.10	25.51

*tsp is teaspoon, lb or lbs = pound or pounds.

On November 4, 2014, Berkeley, California, passed a one-cent-per-fluid-ounce soda tax on sugar-sweetened drinks. Consider an example of a soft-drink nutrition facts label for a detailed analysis of Berkeley's soda tax. One serving (i.e., 12 fluid ounces) of Coca-Cola or Pepsi consists of about 40 grams of sugar/sweetener. This amounts to 7.94 ounces (0.5 pound or 225.2 grams) of sugar/sweetener in a 67.6 fluid ounce soda bottle (2 liter bottle). Hence, Berkeley's soda tax amounts to 135 cents per pound of sweetener used. Results in our study recommend a total tax of 37 cents (25 cents on the producer and 12 cents on the consumer) per pound of sugar used and a total of 107 cents (95 cents on the producer and 12 cents on the consumer) per pound of HFCS used as sweetener input (Table 4).

The SWEET Act, introduced by US House Representative Rosa DeLauro, recommends a penny per 4.2 grams on added sugar-sweetened products. This translates into a 53.62 cents tax on a 2 liter or 67.6 fluid ounce bottle, which is

equivalent to a tax of 107.24 cents per pound of sugar-sweetened product. The sweetener tax results of our study are less than the tax proposed by Berkeley's soda tax, and the tax proposed in the SWEET Act.

Finally, our results are compared to the recent study by MBJ (2012) study. The results of their study concentrated on alternative tax policies targeted to reduce 10% quantity of sweeteners. For sweeteners, they used an own-price elasticity of -0.5 with a minimum and a maximum elasticity of -2.63 and -0.05, respectively. Their study found a consumption tax rate of about 39.29% on sweeteners and an individual input tax rate of 61.24% on sugar and 156.85% on corn sweeteners. Our study used an own-price elasticity of -1.475 estimated through AIDS model. The average of the maximum and the minimum values of own-price elasticities of MBJ (2012) equals to about -1.34, which is closer to the own-price elasticity (-1.475) used for sugar in our study.

Consider our results for a 6 tsp recommendation; a tax rate of 25.6% has to be imposed for sugar in order to reduce its consumption by 37% to achieve the recommended level. For a 9 tsp recommendation, a tax rate of 4% has to be imposed for sugar in order to reduce its consumption by 5%. Similarly, for a 6 tsp recommendation, a tax rate of 68% has to be implemented on HFCS in order to reduce its consumption by 26%. Our tax results are less regressive compared to their study especially in case of HFCS. For instance, approximately with the same own-price elasticity, our study found a tax rate of 68%, which is enough to

reduce its consumption by 26%, whereas MBJ (2012) found a 156.8% tax rate on corn sweeteners to reduce its consumption by 10% (sugar equivalent).

One of the limitations of our study is the accuracy and reliability of supply elasticities used for sugar and HFCS. Therefore, a sensitivity table is constructed with varying supply elasticities and demand elasticities for sugar and HFCS as shown in Table 5. The results of the sensitivity table suggest that a consumer tax of 8 cents/lb to 88 cents/lb on sugar is imposed based on the demand elasticities. On the other hand, a consumer tax of 3 cents/lb to 33 cents/lb on HFCS consumers. Also, a producer tax of 8 cents/lb to $2.53/lb of sugar and 3 cents/lb to 95 cents/lb of HFCS used in food additives.

Table 5. Sensitivity Table for 6 tsp/day/person (~23.8 lbs/year/person)

	Sugar	HFCS
E_d= demand elasticity, E_s= Supply Elasticity	Consumer Tax ($/lb), Producer Tax ($/lb),	Consumer Tax ($/lb), Producer Tax ($/lb)
E_d= –0.2, E_s= 2.0	0.88, 0.08	0.33, 0.03
E_d= –0.5, E_s= 1.5	0.35, 0.11	0.13, 0.04
E_d= –0.7, E_s= 1.0	0.25, 0.17	0.09, 0.06
E_d= –1.0, E_s= 0.7	0.17, 0.25	0.06, 0.09
E_d= –1.2, E_s= 0.5	0.14, 0.35	0.05, 0.13
E_d= –1.5, E_s= 0.2	0.11, 0.88	0.04, 0.33
E_d= –2.0, E_s= 0.07	0.08, 2.53	0.03, 0.95

Conclusions

This study evaluates the excise tax policy of the major caloric sweeteners in the Unites States. Sugar and HFCS are the major caloric sweeteners analyzed in the study. Current sweetener consumption is very high compared to the recommended level. The American Heart Association (AHA) recommends about

6 teaspoons per day based on 1800 calories of energy per day for females and 9 teaspoons per day based on 2000 calories per day for males. This study uses a supply and demand framework for the sweetener tax policy analysis. Our results suggest a total tax of 37 cents (25 cents on the producer and 12 cents on the consumer) per pound of sugar used and a total of 107 cents (95 cents on the producer and 12 cents on the consumer) per pound of HFCS used in sugar-sweetened products. These results are compared to other tax policies proposed recently—Berkeley's soda tax, the SWEET Act proposed by US House Representative Rosa DeLauro, and the recent study by Miao, Beghin and Jensen (2012). On comparison, we found that our tax results are less regressive and targeted to decrease greater quantity intake. Overall, the sweetener tax proposed in our study is less than the other proposed or introduced tax policies. Finally, we also conducted a sensitivity analysis with varying supply elasticities and demand elasticities.

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