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Partial versus General Equilibrium Calorie and Revenue Effects Associated with a Sugar-Sweetened Beverage Tax

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Taxes on sugar-sweetened beverages have been widely proposed to combat the U.S. obesity crisis. Most previous work has found the effects of a SSB tax to be small to moderate. We address three limitations. First, we incorporate the supply side via a stochastic equilibrium displacement model. Second, we account for uncertainty in the underlying elasticities using probability distributions associated with elasticities. Third, we address industry revenue effects. We find that assumptions about the supply side are more important than assumptions about substitution. Ignoring supply side severely overestimates quantity and calorie effects and slightly underestimates revenue effects.

Key words: calorie effects, general equilibrium, partial equilibrium, revenue effects, sugar-sweetened beverage tax

Background

Various studies have demonstrated that increased consumption of sugar-sweetened beverages (SSBs) has contributed to the current obesity crisis in the United States (e.g., Qi et al., 2012; de Ruyter et al., 2012; Ebbeling et al., 2012; Kaiser et al., 2013). Naturally, these findings have generated discussions about alternative policy solutions. One alternative that has been widely proposed is an excise or sales tax on sugar-sweetened beverages (see Jacobson and Brownell, 2000; Brownell et al., 2009; Chaloupka, Powell, and Chriqui, 2009). As expected, new taxes in an industry are politically sensitive and thus the debate on the efficacy of a "soda tax" ultimately comes down to tradeoffs between monetary outcomes (e.g., tax revenue, market revenue) and health-related outcomes (e.g., caloric intake, body weight). We presently know more about possible health effects—specifically calorie and body weight changes—than monetary effects.

The empirical literature on evaluating the impact of a soda tax can be divided into two groups, one focusing on the effect of taxes while incorporating (or not incorporating) substitution effects and the second focusing on price changes versus tax differences. The early literature ignored substitution (cross-price effects) by using only own-price demand effects to estimate changes in caloric intake,

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Review coordinated by Hayley Chouinard.

weight reduction, and tax revenue (Jacobson and Brownell, 2000; Brownell et al., 2009; Andreyeva, Chaloupka, and Brownell, 2011). The assumed tax rate is usually a one cent tax per ounce coupled with an own-price elasticity, falling in the -0.8 to -1.2 range, leading to calorie reductions between 600 and 1,500 calories per month, which Andreyeva, Chaloupka, and Brownell (2011) estimate would lead to a weight reduction of up to five pounds per year. In terms of tax revenue, the estimates from this literature range from $1.5 billion (Jacobson and Brownell, 2000) up to $15.8 billion per year (Andreyeva, Chaloupka, and Brownell, 2011).

Recent literature has taken into account substitution effects (i.e., cross-price effects). Finkelstein et al. (2010) consider the effects of a SSB tax and estimate that a 20% price increase would decrease total caloric intake by about 200 calories per month with a predicted $1.5 billion in tax revenue.[1] Several other studies (Smith, Lin, and Lee, 2010; Lin et al., 2011; Zhen et al., 2011; Dharmasena and Capps, 2012) take the theoretically appealing demand system approach in estimating the calorie, weight, and revenue (if done) effects, which include both own-price and cross-price effects (i.e., substitution/complement effects). Similar to Finkelstein et al. (2010), it is assumed that the price of SSBs would increase by 20%. Though these analyses use more than the own-price elasticities, it is worth noting that the own-price elasticities in these analyses also tend to be higher (e.g., -0.95 to -1.29 in Lin et al. 2011; -1.06 to -1.54 in Zhen et al. 2011; -2.26 in Dharmasena and Capps 2012) than in the analyses that exclude cross-price effects. However, these cross-price inclusion analyses (including Finkelstein et al., 2013, , although standard own- and cross-price elasticities are not reported) find that calorie reduction per person per month falls in the 600 to 1,410 range, which translates into a range of 1 to 5 pound reduction per person per year; these ranges are similar to those where cross-price effects are excluded. Those studies that do estimate tax revenue have estimates that seem to be smaller on average than from the cross-price exclusion studies ($5.8 billion per year, Lin, et al. 2011; $1.9 billion long run per year, Zhen et al. 2011).[2]

Rather than considering a price change, an alternative approach is to look at differences across states in terms of soft drink tax rates and model differences in caloric intake and weight associated with different tax rates. Several authors have also pursued this approach, and the general results are that differences in tax rates have a small to insignificant effect on consumption and weight, with the differences being mainly due to subpopulation differences (Fletcher, Frisvold, and Tefft, 2010b,a; Sturm et al., 2010). While these analyses do take into account substitution effects in various ways, they do not estimate any revenue impacts.

While including substitution effects is certainly an important conceptual contribution, the empirical results—especially for calorie and weight reduction—are surprisingly not that different when substitution effects are included and excluded. However, all of these analyses have been conducted using a demand side only approach, where the supply is assumed to be perfectly elastic. Simply put, there is 100% pass through of the tax to consumers. Indeed, that is what allows one to model the effects by either considering a change in the consumer's price or a change in the tax rate, as these are equivalent. This situation may explain the lack of a very detailed analysis of the monetary implications because when supply is perfectly elastic and there is 100% pass through, the revenue impacts are rather straightforward. However, it is well known that market and tax revenues depend critically on both demand and supply elasticities, and drawing conclusions about weak revenue effects—as do Fletcher, Frisvold, and Tefft (2010b, p. 973)—can be very misleading. If supply is actually not perfectly elastic, then the tax and industry revenue impacts become more involved and could indeed be substantially different. More importantly, if supply is imperfectly elastic, then the

[1] As a reviewer pointed out, Finkelstein et al. (2010) simulate a 20% price increase on store-purchased SSBs (in Homescan data) and do not account for SSBs purchased at food service restaurants in calculating these effects.

[2] Zhen et al. (2011) assume a half-cent per ounce excise tax on store-purchased SSBs in Homescan; Lin et al. (2011) assume a 20% sales tax on SSBs from stores and food service reported in NHANES. If the cross-price exclusion studies used a penny per ounce tax on all SSBs, it would explain the lower-end estimates of Zhen et al. (2011) and Lin et al. (2011) with or without accounting for cross-price effects (thanks to a reviewer for pointing this out).

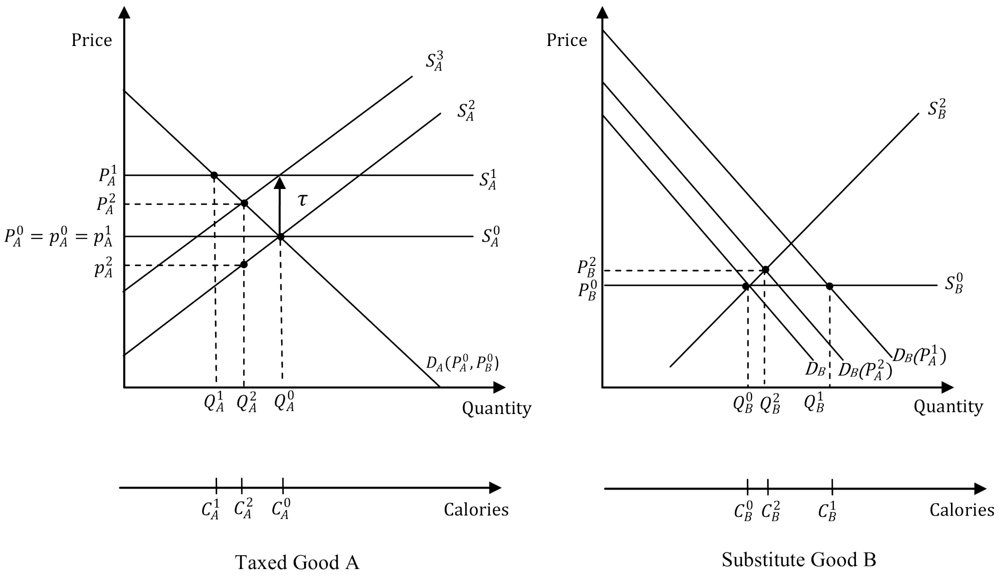


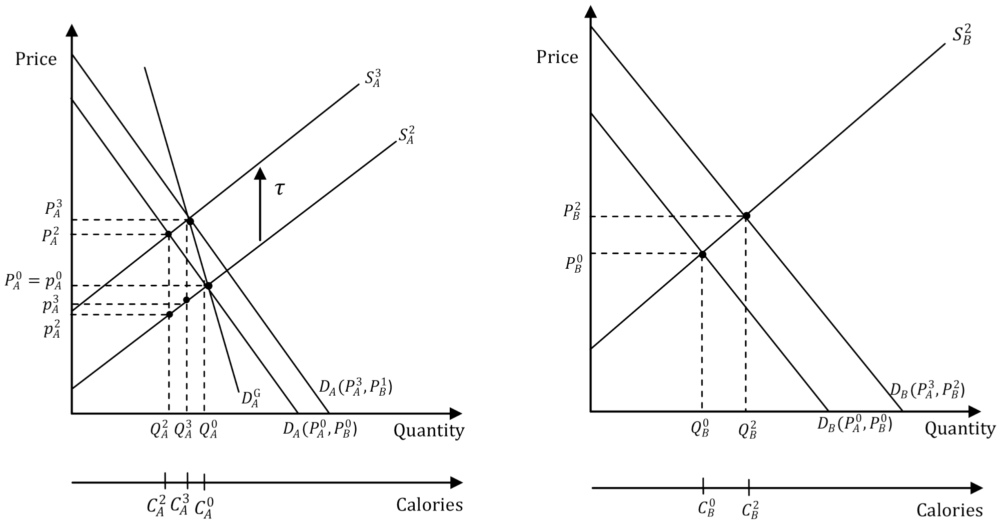
Figure 1. Partial Equilibrium Effects of a Tax on Sugar-Sweetened Beverages

more recent analyses that include substitution effects may be underestimating the change in caloric intake because the cross-price (substitution) effects on nontaxed beverages may be overestimated.[3]

Consider a two-good market where good A is taxed at a per unit rate of τ and there is a substitute good B, as shown in figure 1. The introduction of the tax shifts the supply curve(s) up in a parallel fashion in market A, creating a wedge between the producer price p_A and the consumer price P_A (i.e., $P_A = p_A + \tau$). The graphical analytics in comparing the perfectly elastic and imperfectly elastic equilibrium changes are well known so can be concisely stated. In the taxed market A, comparing the perfectly elastic supply case to the imperfectly elastic supply case, consumer and producer prices will be higher (i.e., $P_A^1 > P_A^2$ and $p_A^1 > p_A^2$, respectively), the market quantity lower ($Q_A^1 < Q_A^2$), and tax revenues lower ($\tau \times Q_A^1 < \tau \times Q_A^2$). The market revenue differences are ambiguous because (while the sellers receive a higher price in the perfectly elastic case) the quantity sold is lower than in the imperfectly elastic supply case. In the nontaxed market B, the demand curve will shift out further if the supply curve in market A is perfectly elastic rather than imperfectly elastic (i.e., $D_B(P_A^1)$ vs. $D_B(P_A^2)$, because $P_A^1 > P_A^2$). So in comparing the perfectly elastic supply case to the imperfectly elastic supply case, the market quantity is greater ($Q_B^1 > Q_B^2$) but consumer and producer prices will be lower (i.e., $P_B^0 < P_B^2$). Consequently, the market revenue difference is ambiguous because, though the price does not change in the perfectly elastic case, the quantity effect is larger.

The caloric intake (C) implications are more involved because caloric intake is a linear combination of all quantities consumed: $C = \mu_A Q_A(P_A, P_B) + \mu_B Q_B(P_A, P_B) \equiv C_A + C_B$, where μ is the conversion factor from quantity to calories and for simplicity C_A and C_B denote calories from goods A and B, respectively. Because of this scalar multiplication, calories can be denoted on the bottom axes as scaled quantities. In the simple case where supply is assumed to be perfectly elastic and no cross-price effects are considered, the new calorie intake after the tax will be C_A^1. If supply is still assumed to be perfectly elastic but cross-price effects are also taken into account, as in the more recent work, the new caloric intake after the tax will be $C_A^1 + C_B^1 = C^1$, so caloric intake will be greater since $C_B^1 > 0$. However, if supply is actually imperfectly elastic and cross-price effects are taken into account, then the new calorie intake after the tax will be $C_A^2 + C_B^2 = C^2$. Note that C^1

[3] As one reviewer pointed out, aside from neglecting the supply side, the wide range of tax revenue estimates in the literature also depends on a variety of other factors such as the assumed size of the tax, the categories of beverages covered by the tax, whether beverages purchased at food service are subject to the tax, etc.



Taxed Good A Substitute Good B

Figure 2. General Equilibrium Effects of a Tax on Sugar-Sweetened Beverages

could be greater than, equal to, or less than C^2. Stated alternatively, if supply is actually imperfectly elastic but is assumed to be perfectly elastic, the caloric intake effects of a tax may be under- or overestimated, even after taking substitution effects in a partial equilibrium analysis into account.

Of course, once one allows for an upward sloping supply curve in both markets then the partial equilibrium analysis is no longer complete. As the price in market B increases from P_B^0 to P_B^2, this effect will feed back into the taxed good market A, leading to a general equilibrium demand function that is generally more inelastic than the partial equilibrium demand curve (e.g., Buse, 1958; Thurman and Wohlgenant, 1989), as shown in figure 2. The relative inelasticity of the general equilibrium demand curve in the taxed good market A implies the consumer and producer prices will be higher (i.e., $P_A^3 > P_A^2$ and $p_A^3 > p_A^2$, respectively), the market quantity greater ($Q_A^2 < Q_A^3$), tax revenues greater ($\tau \times Q_A^2 < \tau \times Q_A^3$), and market revenue greater ($p_A^2 \times Q_A^2 < p_A^3 \times Q_A^3$) in the general equilibrium case than in the partial equilibrium case. Furthermore, the calorie effects of the tax will be attenuated in the general equilibrium case relative to the partial equilibrium case because $Q_A^2 < Q_A^3$.

The more general point from figures 1 and 2 is that alternative supply assumptions may either attenuate or exacerbate changes due to assumptions about cross-price effects. And while the intuition is easy to follow and see in the two good substitute case, the results become more ambiguous as the number of goods increases and substitute and complementary relationships are allowed. There would seem to be four main dimensions of the tax effects that are of interest: quantity effects, industry revenue effects, tax revenue effects, and calorie effects. Variations in assumptions will certainly affect these outcomes, but the effects will likely vary across outcomes of interest and so the importance of the assumptions will in turn vary by the different interest group objectives.

The purpose of this article is threefold. First, as shown above, results will differ depending on the underlying assumptions about the market structure so a more comprehensive analysis of a tax on SSBs that contrasts results by different analytical assumptions is desirable. In short, how much do the different assumptions about the market matter? Second, elasticity estimates are the ultimate linchpin that drives all of the results in these analyses and, as seen in the literature review, the elasticity estimates vary even within a partial equilibrium, demand side only analysis. Of course, elasticity estimates—and therefore results—vary for multiple reasons because analyses differ in multiple dimensions: different data sets, different time periods, different model specifications, different evaluations points, etc. The uncertainty of the elasticity estimates is a legitimate criticism raised by Fletcher, Frisvold, and Tefft (2010b) of some previous analyses. Indeed, in table 2 of their systematic review of the literature, Powell et al. (2013) report a range of elasticity estimates for SSBs from -0.41 to -3.87, depending on the drink type and degree of aggregation. Using any single point estimate could give extreme results when the range is this wide. Rather than attempting to reconcile these differences piecemeal (e.g., functional form, time period, data type, aggregation scheme), a more comprehensive and appealing approach is to use simulation methods that incorporate distributions on elasticity estimates, rather than point estimates, with all the advantages of distributions. For example, from the distributions measures of central tendencies, ranges, and standard deviations can be calculated that take into account uncertainty in elasticity values regardless of the reason for the difference in the elasticity. Third, there is naturally interest in estimates of industry revenue effects as well.

These objectives are achieved by using a stochastic equilibrium displacement model (SEDM)[4] (Davis and Espinoza, 1998) in the analysis. The SEDM is a very flexible modeling approach that has been used in numerous applications and allows the researcher to systematically take into account the inherent uncertainty in demand and supply elasticity estimates, generate empirical distributions of outcomes rather than point estimates, and explore different market structure effects. Our SEDM is defined by demand and supply equations for ten nonalcoholic beverages: isotonics, regular soft drinks, fruit drinks (these three are considered SSBs), diet soft drinks, high-fat milk (whole and 2% milk), low-fat milk (1% and skim milk), fruit juice, bottled water, coffee, and tea. The supply and demand equations are supplemented with tax and market revenue equations and calorie intake equations. Assuming a 10% *ad valorem* tax, we use this SEDM to compare results under four analytical scenarios: (1) perfectly elastic supply curves with no cross-price effects, (2) perfectly elastic supply curves including cross-price effects, (3) imperfectly elastic supply curves with cross-price effects from the tax markets but not from the nontaxed markets (i.e., no feedback effects from nontaxed markets), and (4) imperfectly elastic supply curves with cross-price effects from the all markets (feedback effects from all markets). In comparing the four scenarios we find that the average percent decrease in consumption of regular soft drinks is 23%, 25%, 9%, and 7% respectively; the average monthly reduction in net calories is 293, 227, 97, and 92, respectively; the average monthly industry revenue (taxed + nontaxed markets) decreases by 579, 7, 621, and 614 million dollars, respectively; and the monthly tax revenue gained by the government in taxing all SSBs is 499, 472, 563, and 576 million dollars, respectively. Simply put, assumptions matter, especially in terms of intake and calories. Partial equilibrium analyses ignoring the supply side tend to severely overestimate quantity and calorie effects but are closer in terms of revenues.

The Equilibrium Displacement Model (EDM)

Suppose there are n goods (beverages) in the system and k of these goods are subject to an *ad valorem* tax τ_k such that the price relationship is $P_k = p_k(1 + \tau_k)$, where P_k is the consumer price and p_k is the producer price. The system of market equations for the EDM in differential form is

[4] A reviewer had a question about the suitability of using an equilibrium displacement model (EDM) to investigate beverage tax issues. Equilibrium displacement models are extremely flexible, easy-to-estimate tools used to model diverse economic phenomena. They have been applied in a variety of economic studies such as Sumner and Wohlgenant (1985), studying the effects of federal excise tax on cigarettes and tobacco in the United States, Zhao et al. (2000) for the Australian beef industry, Mounter et al. (2008) for the Australian sheep and wool industry, Brester, Marsh, and Atwood (2004) for the U.S. meat industry, McCorriston, Morgan, and Rayner (2001) for imperfectly competitive down-stream market power and price transmission, and Ahn and Lee (2010) for the Korean infant formula market (EDM for oligopoly market analysis), just to name a few. With respect to our paper, although our demand-side elasticity estimates come from Dharmasena and Capps (2012), we assume a range of supply-side elasticities for simulation of quantity, calorie, and revenue (industry and tax) effects of a sugar-sweetened beverage tax (SSB). As a result, especially in the absence of estimated supply-side elasticities, use of EDM is deemed appropriate to ascertain the impacts of SSB tax.

then written as

(1) $$DQ_i = \sum_{j=1}^{(n-k)} \eta_{ij} DP_j + \sum_{m=(n-k)+1}^{n} \eta_{im} DP_m : \quad \text{Demand System;}$$

(2) $$DQ_i = \varepsilon_{ii} Dp_i : \quad \text{Supply System;}$$

(3) $$DP_j = Dp_j : \quad \text{Nontaxed Price Relation;}$$

(4) $$DP_m = Dp_m + \tau_m : \quad \text{Taxed Price Relation.}$$

For any variable Z, DZ denotes log change and η and ε denote demand and supply elasticities, respectively. As written, the first $n-k$ goods in the system are not taxed and the remaining $n-k+1,\ n-k+2,\ \ldots,\ n$ are taxed. Equation (4) takes this form if the initial tax rate is zero (as it is assumed to be). The market revenue and calorie effects are estimated by supplementing the system (1)–(4) with the equations[5]

(5) $$DR_j = DP_j + DQ_j : \quad \text{Nontaxed Markets Revenue Effects;}$$

(6) $$DR_m = Dp_m + DQ_m : \quad \text{Taxed Markets Revenue Effects;}$$

(7) $$DC = \sum_{i=1}^{n} s_i DQ_i : \quad \text{Calorie Intake Effects.}$$

The last equation comes from expressing in log differential form the more general linear technology that converts quantities to calories discussed earlier ($C = \sum_{i=1}^{n} \mu_i Q_i$; s_i is the share of calories from the ith good.

Procedurally, results for equations (5)–(7) are obtained by solving the system (1)–(4) and substituting appropriately into (5)–(7). All the scenarios discussed are nested within the EDM as special cases if certain restrictions are imposed on the system. Scenario (1) of perfectly elastic supply curves with no cross-price effects can be obtained by removing the supply equations represented by equation (2) and setting $\eta_{ij} = 0 \ \forall \ i \neq j$, $DP_m = \tau_m$ implying $Dp_m = 0$. Scenario (2) with perfectly elastic supply curves but including cross-price effects is the same as scenario (1) except $\eta_{ij} \neq 0 \ \forall \ i \neq j$. Scenario (3) with imperfectly elastic supply curves and cross-price effects from the tax markets but not from the nontaxed markets (i.e., no feedback effects from nontaxed markets) is obtained by including the supply equations (2) with $0 < \varepsilon_{ii} < \infty$ and $\eta_{ii} \neq 0 \ \forall \ i \in [(n-k)+1,\ \ldots,\ n]$, $\eta_{ij} = 0 \ \forall \ j \ \in [1,\ \ldots,\ (n-k)+1]$, and $\eta_{ij} \neq 0 \ \forall \ i \in [(n-k)+1,\ \ldots,\ n]$. Finally, scenario (4) with imperfectly elastic supply curves with cross-price effects from the all markets (feedback effects from all markets) is the same as scenario (3) except $\eta_{ij} \neq 0 \ \forall \ i, j$.

The Stochastic Equilibrium Displacement Model (SEDM)

As discussed in Davis and Espinoza (1998), a stochastic equilibrium displacement model (SEDM) involves essentially four steps: specifying the EDM, assuming distributions for the elasticities, sampling from the assumed distributions T times, and solving the EDM T times. The EDM represented by equations (1)–(4) can be written in matrix notation as

(8) $$\begin{bmatrix} \boldsymbol{I} & -\boldsymbol{\eta} & \boldsymbol{O} \\ \boldsymbol{I} & \boldsymbol{O} & -\boldsymbol{\varepsilon} \\ \boldsymbol{O} & \boldsymbol{I} & -\boldsymbol{I} \end{bmatrix} \begin{bmatrix} \boldsymbol{DQ} \\ \boldsymbol{DP} \\ \boldsymbol{Dp} \end{bmatrix} = \begin{bmatrix} \mathbf{0} \\ \vdots \\ \mathbf{0} \\ \boldsymbol{\tau} \end{bmatrix},$$

[5] The percentage change estimate for the tax revenue cannot be given since the starting tax revenue is zero.

where the matrices are $\boldsymbol{I}: n \times n$, $\boldsymbol{O}: n \times n$, $\boldsymbol{\eta} = [\eta_{ij}]: n \times n$, $\boldsymbol{\varepsilon} = diag[\varepsilon_{ii}]: n \times n$, $\boldsymbol{\tau} = [\tau_{(n-k)+1}, \ \ldots, \ \tau_n]'$, and $\boldsymbol{DQ}$, $\boldsymbol{DP}$, and $\boldsymbol{Dp}$ are all $n \times 1$. For convenience let this system be written in standard notation as $\boldsymbol{AY} = \boldsymbol{X}$. As discussed above the four different scenarios that will be considered amount to alternative specifications for this system or $\boldsymbol{A}_s\boldsymbol{Y}_s = \boldsymbol{X}_s$, where $s = 1, 2, 3, 4$ refers to the scenario. So each s system will be solved T times based on T draws from the elasticity distributions and substituted in to equations (5)–(7) to obtain T values for each of these variables for each s system (i.e., empirical distributions for all outcomes of interest).

The basis for the demand elasticity distributions is the recent work of Dharmasena and Capps (2012).[6] Using Nielsen Homescan scanner data for expenditures and quantities for isotonics (sports drinks), regular soft drinks, diet soft drinks, high-fat milk, low-fat milk, fruit juices, fruit drinks, bottled water, coffee, and tea from January 1998 through December 2003 they estimated a quadratic almost ideal demand system (QUAIDS). This system is more disaggregated than considered by others (e.g., Smith, Lin, and Lee, 2010) and by aggregation analysis it is to be expected that the Dharmasena and Capps (2012) estimates will be more elastic in general than those from a more aggregate analysis, which they are. It should be noted that Dharmasena and Capps (2012) did not account for the elasticity uncertainty in their analysis.[7] In addressing the elasticity (parameter) uncertainty issue in general, Davis and Espinoza (1998) assumed all elasticity estimates were independent. We extend their approach by incorporating the fact that the estimates from our demand system are correlated.

Following Krinsky and Robb (1986), given initial estimates of a parameter vector $\boldsymbol{\beta}$ of the QUAIDS model, a corresponding variance-covariance matrix $\boldsymbol{\Sigma}$, and the nonlinear demand elasticity function:

$$\eta_{ij} = f_{ij}(\boldsymbol{\beta}), \tag{9}$$

we then take random drawings (500 drawings for each) from a multivariate normal distribution parameterized with underlying variance-covariance matrix $\boldsymbol{\Sigma}$ and mean μ where $\mu_i = E(\beta_i)$. As described in Johnson (1987), the procedure is operationalized as follows. If p-dimensional random (parameter) vector $\boldsymbol{\beta} = (\beta_1, \ \ldots, \ \beta_p)'$ is defined to be distributed multivariate normal (i.e., $\beta \sim N_p(\boldsymbol{\mu}\,\boldsymbol{\Sigma})$), this distribution of $\boldsymbol{\beta}$ can be represented as a linear transformation of p independent normal deviates in $\boldsymbol{Z} = (Z_1, \ Z_2, \ \ldots, \ Z_p)'$ and mean parameter estimates $\boldsymbol{\mu} = E(\beta)$:

$$\beta = AZ + \mu, \tag{10}$$

where $\boldsymbol{A}$ is any lower-diagonal $p \times p$ matrix from a Cholesky decomposition or $\boldsymbol{AA'} = \boldsymbol{\Sigma}$. As a result, the operation performed in equation (10) makes the parameter vector $\boldsymbol{\beta}$ stochastic. Finally, these stochastic parameter estimates are then used to generate own-price and cross-price elasticities using the elasticity formulas for the QAIDS model (the specific forms of equation (9)) evaluated at the last year of observations, thereby generating a distribution for each elasticity.

For scenarios 3 and 4, we need own-price supply elasticity distributions. We are unaware of any supply elasticity estimates for these beverages so we assume the supply elasticities fall within the

[6] It should be noted that Dharmasena and Capps (2012) used Nielsen Homescan scanner data on store-purchased nonalcoholic beverages to estimate own-price and cross-price elasticities for ten nonalcoholic beverages (of which three are considered SSBs: isotonics, regular soft drinks, and fruit drinks). As a reviewer pointed out (as well as Zhen et al., 2009), Homescan can underreport food-at-home expenditures compared to Consumer Expenditure Survey data (diary survey of the United States Bureau of Labor Statistics), specifically for food categories containing more random-weight products without universal product codes. However, the effect of this is not considered a limiting factor for our study because all nonalcoholic beverages being considered have specific reporting UPCs and are not purchased at random weight level. Additionally, the Consumer Expenditure Survey in particular does not provide a rich delineation of beverage categories necessary for our study.

[7] Point estimates and standard errors in Dharmasena and Capps (2012) address the statistical uncertainty conditional on model and data choices. However, there are other uncertainties that could affect the estimated coefficients, hence elasticities. They are use of different functional forms (dynamic demand, unconditional demand etc), use of different estimation techniques (maximum likelihood estimator vis-á-vis instrumental variables), data limitations, etc. Moreover, Bryant and Davis (2008) show the effects of model specification uncertainty in estimating aggregate U.S. meat demand using a Bayesian model averaging approach, hence addressing uncertainties in parameter estimates akin to different model specifications.

Table 1. Means and Standard Deviations of Simulated Demand and Supply Elasticities

		Isotonics	Regular Soft Drinks	Diet Soft Drinks	High-Fat Milk	Low-Fat Milk	Fruit Drinks	Fruit Juices	Bottled Water	Coffee	Tea
Isotonics	D[a]	−3.86	−0.12	2.21	−0.86	0.52	−2.47	1.98	0.37	1.06	−0.002
		(0.88)	(1.40)	(1.48)	(0.95)	(0.84)	(0.80)	(1.16)	(0.81)	(0.82)	(0.45)
	S	1.25									
		(0.43)									
Reg. Soft Drinks	D	−0.01	−2.26	−0.62	0.04	0.24	−0.17	1.03	−0.05	0.22	0.06
		(0.06)	(0.27)	(0.19)	(0.11)	(0.10)	(0.10)	(0.17)	(0.11)	(0.11)	(0.07)
	S		1.25								
			(0.43)								
Diet Soft Drinks	D	0.15	−0.86	−1.27	0.39	−0.17	0.37	−0.10	0.25	−0.01	−0.01
		(0.10)	(0.29)	(0.33)	(0.16)	(0.14)	(0.14)	(0.19)	(0.14)	(0.14)	(0.08)
	S			1.25							
				(0.43)							
High-Fat Milk	D	−0.05	0.20	0.44	−0.76	0.30	−0.22	−0.56	0.02	−0.02	−0.15
		(0.06)	(0.18)	(0.16)	(0.22)	(0.20)	(0.08)	(0.13)	(0.09)	(0.09)	(0.05)
	S				1.25						
					(0.43)						
Low-Fat Milk	D	0.06	0.64	−0.20	0.44	−0.92	−0.14	−0.47	−0.15	−0.02	−0.08
		(0.08)	(0.23)	(0.21)	(0.30)	(0.30)	(0.10)	(0.16)	(0.10)	(0.11)	(0.06)
	S					1.25					
						(0.43)					
Fruit Drinks	D	−0.29	−0.34	0.64	−0.45	−0.20	−0.69	0.08	−0.34	0.47	−0.09
		(0.09)	(0.26)	(0.24)	(0.15)	(0.12)	(0.20)	(0.21)	(0.17)	(0.19)	(0.10)
	S						1.25				
							(0.43)				
Fruit Juices	D	0.11	1.28	−0.01	−0.43	−0.24	0.07	−1.17	−0.08	−0.25	−0.08
		(0.06)	(0.21)	(0.16)	(0.10)	(0.09)	(0.10)	(0.20)	(0.11)	(0.12)	(0.07)
	S							1.25			
								(0.43)			
Bottled Water	D	0.06	0.03	0.59	0.07	−0.18	−0.34	−0.15	−0.75	−0.05	0.20
		(0.10)	(0.31)	(0.26)	(0.17)	(0.13)	(0.18)	(0.26)	(0.29)	(0.21)	(0.13)
	S								1.25		
									(0.43)		
Coffee	D	0.12	0.70	0.10	0.02	0.01	0.49	−0.46	−0.03	−1.65	0.24
		(0.08)	(0.27)	(0.21)	(0.14)	(0.11)	(0.17)	(0.22)	(0.17)	(0.24)	(0.11)
	S									1.25	
										(0.43)	
Tea	D	0.002	0.34	0.01	0.42	−0.15	−0.12	−0.30	0.24	0.39	−0.91
		(0.08)	(0.27)	(0.21)	(0.14)	(0.11)	(0.15)	(0.22)	(0.18)	(0.18)	(0.15)
	S										1.25
											(0.43)

Notes: Standard errors of simulated values are in parentheses. Supply elasticity means and standard deviations are only the same because of the large sample drawn for each elasticity ($N = 500$). Though the underlying distribution is assumed to be the same across supply elasticities the seed is not so the supply elasticities are not equal in a given draw.
[a] D indicates demand and S indicates supply.

interval 0.5 to 2.0 and are distributed uniformly over this range. This situation allows for inelastic as well as elastic supply responses. Summary statistics for 500 iterations each for demand and supply elasticities are generated (see table 1). Though the supply elasticity estimates all have the same mean and standard deviation to the second decimal point, this is simply a matter of the size of the draw; we did not restrict the seed to be the same for all draws, so the actual supply elasticities differ across beverages for each draw. Using the estimates from these 500 draws, the system as exemplified in equation (8), is then solved 500 times to generate 500 estimates of the outcomes of interest: quantities, calories, and revenue effects of a tax on SSBs under the partial equilibrium and general equilibrium framework. This simulation exercise was carried out using SIMETAR statistical software (Richardson, Schumann, and Feldman, 2008).

Results and Discussion

This section compares and contrasts the stochastic partial and general equilibrium outcomes in terms of quantities consumed, revenue responses, and calorie intake across all four scenarios for a 10% tax on all SSBs (i.e., isotonics, regular soft drinks, and fruit drinks).[8]

Quantity Outcomes

Table 2 gives the means and 95% percentile ranges for the quantity effects for all beverages across the four scenarios for a 10% tax on SSBs. Regardless of the scenario, across the taxed beverages the largest quantity decreases are for isotonics, followed by regular soft drinks and then fruit drinks. For the nontaxed beverages, the largest changes are increases in consumption of fruit juice, coffee, and low-fat milk. Across scenarios, the effects initially increase from scenario 1 to 2, then decrease as we allow supplies to be upward sloping (scenario 3) and upward sloping supplies with feedback effects (scenario 4), consistent with the graphical example given earlier. For example, for regular soft drinks the average quantity reduction across scenarios is 23% (scenario 1), 25% (scenario 2), 9% (scenario 3), and 7% (scenario 4). This finding is more easily seen in figure 3, where the empirical distributions across the four scenarios are shown for the SSBs.

Figure 3 demonstrates that ignoring cross-price effects (scenario 1) tends to underestimate the quantity effects on SSBs compared to analysis incorporating cross-price effects (scenario 2) when supply is ignored (i.e., assumed to be perfectly elastic). But ignoring the supply side of the market appears more important. When the supply side (upward sloping supply) is incorporated, the effects of the tax are greatly attenuated—cut at least in half on average—even in a partial equilibrium model that includes cross-price effects (scenario 3). There is even more attenuation when feedback effects are allowed (scenario 4).

Industry Revenue Outcomes

Table 3 gives the change in market revenues, expressed in millions of dollars, across all four scenarios. As expected, market revenues in the taxed markets decrease regardless of scenario and, given the distributions, the numbers are rather consistent across scenarios, with market revenue decreasing between $580 million and $922 million. While market revenues increase in the nontaxed markets, there are big differences between scenario 2 and scenarios 3 and 4. In scenario 2 (cross-price effects considered but no supply effect), the mean increase in market revenues is $841 million. However, once supply is considered in scenario 3 (cross-price and partial equilibrium supply effect), the increase in market revenue of $301 million is about a third of that in scenario 2. In scenario 4

[8] We also considered rates of 5% and 20% as well; unsurprisingly, the results were approximately proportional to those reported here.

Table 2. Quantity Percentage Changes from a 10% *ad Valorem* Sugar-Sweetened Beverages Tax (Average and 95th Percentile Range)

	Taxed			Nontaxed						
	Isotonics	**Regular Soft Drinks**	**Fruit Drinks**	**Diet Soft Drinks**	**High-Fat Milk**	**Low-Fat Milk**	**Fruit Juice**	**Bottled Water**	**Coffee**	**Tea**
Scenario 1	−39	−23	−7	NA	NA	NA	NA	NA	NA	NA
	(−55,−23)	(−28,−17)	(−10,−3)							
Scenario 2	−69	−25	−14	−3	−0.7	6	15	−1	13	2
	(−99,−45)	(−31,−19)	(−20,−8)	(−10,4)	(−4,3)	(0.5,11)	(10,20)	(−6,4)	(6,20)	(−2,9)
Scenario 3	−27	−9	−6	−0.3	−0.8	1.4	5	−1.4	6	0.5
	(−41,−14)	(−12,−5)	(−9,−4)	(−3,3)	(−2,0.7)	(−0.7,4)	(3,8)	(−4,1.3)	(3,9)	(−1.4,3)
Scenario 4	−19	−7	−4	−0.8	−2	0.7	4	−3	2	−1
	(−53,0)	(−13,−1.3)	(−8,0)	(−6,5)	(−7,1)	(−4,5)	(−0.7,9)	(−16,2)	(−3,8)	(−7,3)

Notes: 95th percentile ranges of values are in parentheses.

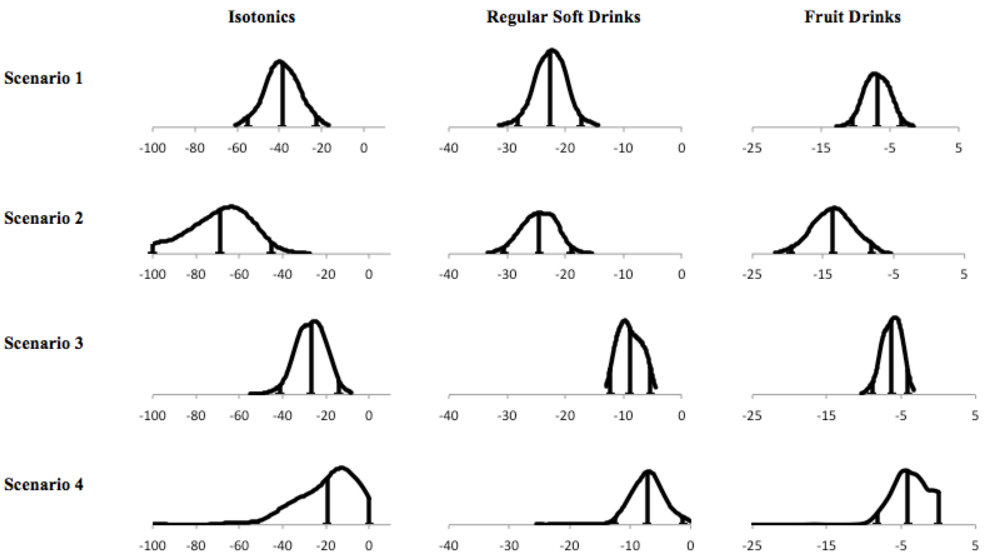


Figure 3. Probability Density Approximations of Simulated Percentage Changes in Quantities From 10% *ad Valorem* Sugar-Sweetened Beverages Tax

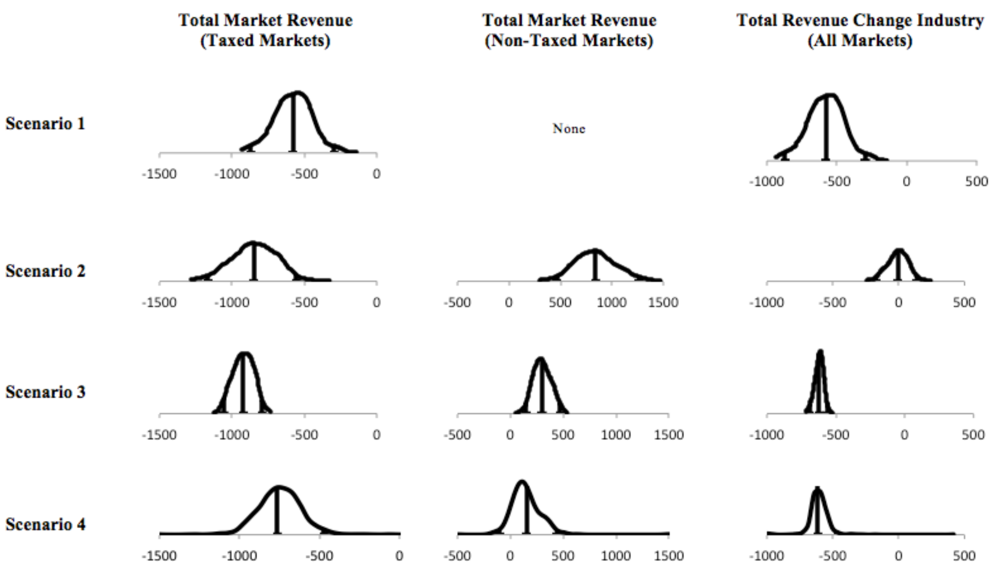


Figure 4. Probability Density Approximations of Simulated Revenue Changes in Taxed Markets, Nontaxed Markets, and All Markets from a Sugar-Sweetened Beverages 10% *ad Valorem* Tax

Table 3. Market Revenue Changes from a 10% *ad Valorem* Sugar-Sweetened Beverage Tax (Average and 95th Percentile Range in Millions of Dollars)

	Taxed Markets	Nontaxed Markets	All Markets
Scenario 1[a]	−579	0	−579
	(−871,−297)		(−871,−297)
Scenario 2	−848	841	−7
	(−1165,−559)	(466,1267)	(−171,141)
Scenario 3	−922	301	−621
	(−1056,−794)	(149,471)	(−690,564)
Scenario 4	−765	151	−614
	(−1071,−473)	(−101,443)	(−761,−462)

Notes: 95th percentile ranges of values are in parentheses.

Table 4. Tax Revenue from a 10% *ad Valorem* Sugar-Sweetened Beverage Tax (Average and 95th Percentile Range in Millions of Dollars)

	Isotonics	Regular Soft Drinks	Fruit Drinks	Total Tax Revenue
Scenario 1	16	340	143	499
	(12,20)	(315,363)	(137,148)	(470,527)
Scenario 2	8	331	133	472
	(7,15)	(305,355)	(123,141)	(440,501)
Scenario 3	20	399	144	563
	(16,23)	(385,415)	(140,147)	(545,581)
Scenario 4	22	407	147	576
	(13,27)	(383,433)	(141,153)	(543,605)

Notes: 95th percentile ranges of values are in parentheses.

(cross-price and general equilibrium supply effect) the increase in market revenue of $151 million is about a fourth of that in scenario 2. These differences then have important implications for the total industry revenue effects (taxed + nontaxed markets) and demonstrate the importance of the assumptions on the supply side. Including cross-price effects but ignoring the supply effects (scenario 2) leads to an almost revenue-neutral effect across all markets, with a $7 million dollar decline in all market revenue. However, when the supply side is considered the loss in all market revenue is in the $620 million range, which is similar to that estimated simply using own-price effects and no supply side (scenario 1). Figure 4 gives a visual representation of these scenarios, and it is clear that the industry market revenue effects (last column) are actually much closer once supply is considered to the analysis that only considers own-price effects and no supply response than is the analysis that considers cross-price effects but ignores the supply side.

Tax Revenue Outcomes

The tax revenue in millions of dollars generated by the tax is shown in table 4 across beverages and scenarios. Regardless of scenario, the largest tax revenue comes from regular soft drinks, followed by fruit drinks and then isotonics. Across scenarios the pattern is consistent with that suggested

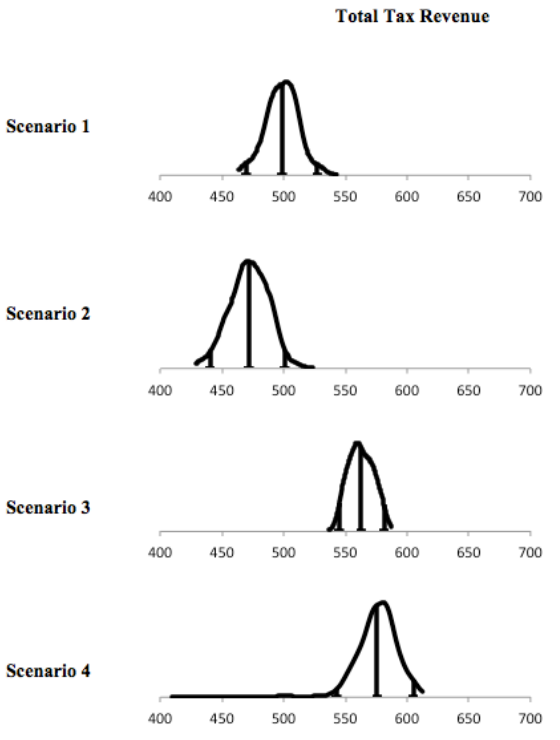


Figure 5. Probability Density Approximations of Simulated Change in Tax Revenue from Sugar-Sweetened Beverages due to a 10% *ad Valorem* Tax

Notes: 95th percentile ranges of mean values are in parentheses.

by the graphical analysis for every beverage. Including cross-price effects without considering the supply side (scenario 2) tends to reduce the tax revenue estimates, but allowing for cross-price and supply effects tends to increase tax revenues (scenario 3) and allowing for feedback effects (scenario 4) leads to the highest tax revenue estimates. The total tax revenue estimates are lowest for scenario 2 ($472 million) and highest for scenario 4 ($576 million). Figure 5 gives the density approximations and indicates that there is little difference in scenarios 3 and 4, but there is little overlap in these distributions and those for scenarios 1 and 2.

Calorie Outcomes

Perhaps most importantly, there are large differences in the calorie effects from the simulated tax across scenarios as shown in table 5 and figure 6, with the largest differences occurring with respect to changing the assumption on supply. Only considering own-price effects (scenario 1) leads to the largest calorie reduction of 293 calories per person per month. The 227 calorie reduction estimate from including cross-price effects with no supply effects (scenario 2), while smaller, is within the ninety-fifth percentile range of scenario 1. However, scenarios 3 and 4 have much smaller decreases in calorie intake, −97 and −92 respectively, and while their distributions are similar there is very little overlap with the distributions that ignore supply effects (scenarios 1 and 2).

Table 5. Calorie Percentage Changes per Person per Month from a 10% *ad Valorem* Sugar-Sweetened Beverages Tax (Average and 95th Percentile Range)

	Calories
Scenario 1	−293
	(−364, −222)
Scenario 2	−227
	(−269, −185)
Scenario 3	−97
	(−130, −66)
Scenario 4	−92
	(−158, −28)

Notes: 95th percentile ranges of values are in parentheses.

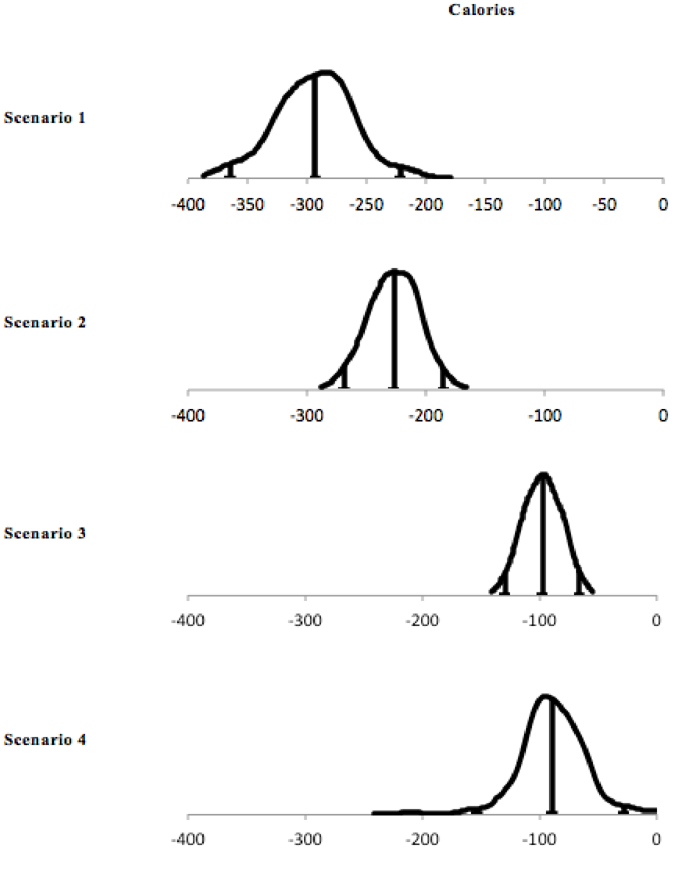


Figure 6. Probability Density Approximations of Simulated Change in Calories per Person per Month Consumed from Sugar-Sweetened Beverages due to a 10% *Ad Valorem* Tax

Notes: 95th percentile ranges of mean values are in parentheses.

Conclusions

Taxing SSB consumption continues to be a recommended policy option in the fight against obesity. Previous research has found the quantity, caloric intake, and weight effects will be small, but the revenue impacts may be substantial. Three limitations of previous analyses are addressed in this paper. First, the analysis considers the supply side of the market as well by allowing the elasticity of supply to vary from inelastic to elastic responses within a stochastic equilibrium displacement model (SEDM). Second, uncertainties in the underlying elasticity values are taken into account by the SEDM-generated distributions of effects and not just point estimates. Third, while previous work has reported consumption, calorie, and tax revenue effects, little attention has been given to market revenue effects.

Our analysis demonstrates that modeling the supply side of the market has larger impacts on the results than whether or not substitution of tax effect is taken into account. Indeed, in general, there is a much larger difference in the results by taking into account the supply side than taking into account substitution effects. The decreases in the consumption of SSBs are much smaller, the decreases in market revenues are much larger, the tax revenue generated is slightly larger, and the caloric intake is much smaller when the supply side of the market is considered versus when it is ignored. Simply stated, ignoring the supply side tends to overestimate the consumption and caloric impacts and underestimate the revenue impacts. The general finding of previous studies is that the effects of a SSB tax on consumption and calories is small, and this research adds to this conclusion by finding that the impact on consumption and caloric intake will likely be even smaller than has been estimated in the past due to supply side responses. We consider a 10% increase in the tax rate and find that tax revenue likely would be in the \$500–\$600 million range, but the decrease in market revenue would likely be in the \$600–\$620 million range. Also, we find that the caloric reduction would likely be in the 60–300 calorie range. If our results were extrapolated to a 20% increase, as has been considered in the previous literature, then the tax revenue and calorie reduction estimates would be on the lower end of those found in the literature (i.e., about \$1 billion tax revenue and 600 calories per person per month). All of our results then provide further support to the notion that the ultimate effectiveness of SSB tax is at best questionable.

It should be emphasized that this paper addresses three major questions not addressed in the extant literature (i.e., ascertaining supply side effects, elasticity uncertainty, and industry revenue effects) in partial and general equilibrium framework, allowing for not only direct and indirect effect of an *ad valorem* tax on SSBs but also allowing for feedback effects. General welfare measurement of SSB tax (as suggested by one of reviewers) can be an add-on to this article; however, a discussion on general welfare is not the major object of the current paper. Given the richness and complexity of interactions among beverages studied in this paper, predicting the effects of stochastic partial and general equilibrium welfare measures of an *ad valorem* tax is nontrivial. These welfare extensions are fruitful work for future research. Additionally, perfectly competitive supply-side market structure was assumed in this paper in ascertaining supply-side effects of the SSB tax. Implications of imperfect competition on supply side (as suggested by a reviewer) and how this imperfect competition assumption affects the results of this paper is suggested as future research.

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References

Ahn, B. I., and H. Lee. "An Equilibrium Displacement Approach to Oligopoly Market Analysis: An Application to Trade in the Korean Infant Formula Market." *Agricultural Economics* 41(2010):101–109.

Andreyeva, T., F. J. Chaloupka, and K. D. Brownell. "Estimating the Potential of Taxes on Sugar-Sweetened Beverages to Reduce Consumption and Generate Revenue." *Preventive Medicine* 52(2011):413–416.

Brester, G. W., J. M. Marsh, and J. Atwood. "Distributional Impacts of Country-of-Origin Labeling in the U.S. Meat Industry." *Journal of Agricultural and Resource Economics* 29(2004):206–227.

Brownell, K. D., T. Farley, W. C. Willett, B. M. Popkin, F. J. Chaloupka, J. S. Thompson, and D. S. Ludwig. "The Public Health and Economic Benefits of Taxing Sugar-Sweetened Beverages." *New England Journal of Medicine* 361(2009):1–7.

Bryant, H. L., and G. C. Davis. "Revisiting Aggregate U.S. Meat Demand with a Bayesian Averaging of Classical Estimates Approach: Do We Need a More General Theory?" *American Journal of Agricultural Economics* 90(2008):103–116.

Buse, R. C. "Total Elasticicities. A Predictive Device." *Journal of Farm Economics* 40(1958):881–891.

Chaloupka, F. J., L. M. Powell, and J. F. Chriqui. "Sugar-Sweetened Beverage Taxes and Public Health." Research brief, Robert Wood Johnson Foundation and University of Minnesota School of Public Health, Princeton, NJ, 2009. Available online at http://www.rwjf.org/content/dam/farm/reports/issue_briefs/2009/rwjf43487.

Davis, G. C., and M. C. Espinoza. "A Unified Approach to Sensitivity Analysis in Equilibrium Displacement Models." *American Journal of Agricultural Economics* 80(1998):868–879.

de Ruyter, J. C., M. R. Olthof, J. C. Seidell, and M. B. Katan. "A Trial of Sugar-Free or Sugar-Sweetened Beverages and Body Weight in Children." *New England Journal of Medicine* 367(2012):1397–1406.

Dharmasena, S., and O. Capps. "Intended and Unintended Consequences of a Proposed National Tax on Sugar-Sweetened Beverages to Combat the U.S. Obesity Problem." *Health Economics* 21(2012):669–694.

Ebbeling, C. B., H. A. Feldman, V. R. Chomitz, T. A. Antonelli, S. L. Gortmaker, S. K. Osganian, and D. S. Ludwig. "A Randomized Trial of Sugar-Sweetened Beverages and Adolescent Body Weight." *New England Journal of Medicine* 367(2012):1407–1417.

Finkelstein, E. A., C. Zhen, M. Bilger, J. Nonnemaker, A. M. Farooqui, and J. E. Todd. "Implications of A Sugar-sweetened Beverage (SSB) Tax when Substitutions to Non-Beverage Items are Considered." *Journal of Health Economics* 32(2013):219–239.

Finkelstein, E. A., C. Zhen, J. Nonnemaker, and J. E. Todd. "Impact of Targeted Beverage Taxes on Higher- and Lower-Income Households." *Archives of Internal Medicine* 170(2010):2028–2034.

Fletcher, J. M., D. Frisvold, and N. Tefft. "Can Soft Drink Taxes Reduce Population Weight." *Contemporary Economic Policy* 28(2010a):967–974.

Fletcher, J. M., D. E. Frisvold, and N. Tefft. "The Effects of Soft Drink Taxes on Child and Adolescent Consumption and Weight Outcomes." *Journal of Public Economics* 94(2010b):967–974.

Jacobson, M. F., and K. D. Brownell. "Small Taxes on Soft Drinks and Snack Foods to Promote Health." *American Journal of Public Health* 90(2000):854–857.

Johnson, M. E. *Multivariate Statistical Simulation*. Wiley Series in Probability and Statistics. New York: Wiley, 1987.

Kaiser, K. A., J. M. Shikany, K. D. Keating, and D. B. Allison. "Will Reducing Sugar-Sweetened Beverage Consumption Reduce Obesity? Evidence Supporting Conjecture Is Strong, but Evidence when Testing Effect Is Weak." *Obesity Reviews* 14(2013):620–633.

Krinsky, I., and A. L. Robb. "On Approximating the Statistical Properties of Elasticities." *Review of Economics and Statistics* 68(1986):715–719.

Lin, B. H., T. A. Smith, J. Y. Lee, and K. D. Hall. "Measuring Weight Outcomes for Obesity Intervention Strategies: The Case of a Sugar-Sweetened Beverage Tax." *Economics & Human Biology* 9(2011):329–341.

McCorriston, S., C. W. Morgan, and A. J. Rayner. "Price Transmission: The Interaction between Market Power and Returns To Scale." *European Review of Agricultural Economics* 28(2001):143–159.

Mounter, S. W., G. R. Griffith, R. R. Piggott, E. M. Fleming, and X. Zhao. "An Equilibrium Displacement Model of the Australian Sheep and Wool Industries." Economic Research Report 38, NSW Department of Primary Industries, Armidale, Austrlaia, 2008. Available online at http://purl.umn.edu/37663.

Powell, L. M., J. F. Chriqui, T. Khan, R. Wada, and F. J. Chaloupka. "Assessing the Potential Effectiveness of Food and Beverage Taxes and Subsidies for Improving Public Health: A Systematic Review of Prices, Demand and Body Weight Outcomes." *Obesity Reviews* 14(2013):110–128.

Qi, Q., A. Y. Chu, J. H. Kang, M. K. Jensen, G. C. Curhan, L. R. Pasquale, P. M. Ridker, D. J. Hunter, W. C. Willett, E. B. Rimm, D. I. Chasman, F. B. Hu, and L. Qi. "Sugar-Sweetened Beverages and Genetic Risk of Obesity." *New England Journal of Medicine* 367(2012):1387–1397.

Richardson, J. W., K. D. Schumann, and P. A. Feldman. "SIMETAR, Simulation for Applied Risk Management." 2008.

Smith, T. A., B. H. Lin, and J. Y. Lee. "Taxing Caloric Sweetened Beverages: Potential Effects on Beverage Consumption, Calorie Intake, and Obesity." Economic Research Report ERR-100, U.S. Department of Agriculture, Economic Research Service, Washington, DC, 2010. Available online at http://www.ers.usda.gov/publications/err-economic-research-report/err100.aspx.

Sturm, R., L. M. Powell, J. F. Chriqui, and F. J. Chaloupka. "Soda Taxes, Soft Drink Consumption, And Children's Body Mass Index." *Health Affairs* 29(2010):1052–1058.

Sumner, D. A., and M. K. Wohlgenant. "Effects of an Increase in the Federal Excise Tax on Cigarettes." *American Journal of Agricultural Economics* 67(1985):235–242.

Thurman, W. N., and M. K. Wohlgenant. "Consistent Estimation of General Equilibrium Welfare Effects." *American Journal of Agricultural Economics* 71(1989):1041–1045.

Zhao, X., J. D. Mullen, G. R. Griffith, W. E. Griffiths, and R. R. Piggott. "An Equilibrium Displacement Model of the Australian Beef Industry." Economic Research Report 4, NSW Agriculture, Orange, Australia, 2000. Available online at http://purl.umn.edu/28007.

Zhen, C., J. L. Taylor, M. K. Muth, and E. Leibtag. "Understanding Differences in Self-Reported Expenditures between Household Scanner Data and Diary Survey Data: A Comparison of Homescan and Consumer Expenditure Survey." *Review of Agricultural Economics* 31(2009):470–492.

Zhen, C., M. K. Wohlgenant, S. Karns, and P. Kaufman. "Habit Formation and Demand for Sugar-Sweetened Beverages." *American Journal of Agricultural Economics* 93(2011):175–193.