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# WHEN DO FAT TAXES INCREASE CONSUMER WELFARE?

JAYSON L. LUSK[a,*] and CHRISTIANE SCHROETER[b]

[a]*Department of Agricultural Economics, Oklahoma State University, OK, USA*
[b]*Department of Agribusiness, California Polytechnic State University, San Luis Obispo, CA, USA*

ABSTRACT

Previous analyses of fat taxes have generally worked within an empirical framework in which it is difficult to determine whether consumers benefit from the policy. This note outlines on simple means to determine whether consumers benefit from a fat tax by comparing the ratio of expenditures on the taxed good to the weight effect of the tax against the individual's willingness to pay for a one-pound weight reduction. Our empirical calculations suggest that an individual would have to be willing to pay about $1500 to reduce weight by one pound for a tax on sugary beverages to be welfare enhancing. The results suggest either that a soda tax is very unlikely to increase individual consumer welfare or that the policy must be justified on some other grounds that abandon standard rationality assumptions. 

KEY WORDS: obesity; fat tax; sugary beverage; willingness to pay

## 1. INTRODUCTION

Given the rapid rise in obesity, academics and policymakers have proposed a variety of options to improve public health. One of the most studied mechanisms is the fat tax, which uses the state's taxing power to alter relative prices in an attempt to encourage healthier eating. Economists have been at the forefront of determining the effects of fat taxes, in large part because of the need to estimate demand elasticities to project consumption and weight changes. Examples of studies that have used demand estimates to simulate weight or health effects of fat taxes include those of Cutler *et al*. (2003), Cash *et al*. (2005), Kuchler *et al*. (2005), Chouinard *et al*. (2007), and Allais *et al*. (2009) among others (see Cash and Lacanilao, 2007, or Etilé, 2011, for reviews).

Although such studies have provided important insights into the potential effects of fat taxes, they often stop short of explicitly calculating the welfare effects of a tax. These studies typically estimate price elasticities from demand curves, which are conceptually derived from constrained utility maximization, given prices and a budget constraint. A difficulty arises from the fact that higher prices (from fat taxes) can only lower individual welfare within this conventional framework; the estimated demand curves arise from a system in which utility and, thus, demand are unaffected by health or weight. Presumably, however, fat taxes are studied because of an underlying belief that it is at least theoretically possible to improve consumer welfare by raising the prices of certain foods. Although many of the aforementioned studies allude to the potential existence of externalities associated with public health care costs, such potential benefits are *outside* the modeling framework used to estimate food demand. In short, previous economic work on fat faxes has lacked transparency in formally identifying the conditions under which fat taxes increase individual consumer welfare.

*Correspondence to: Department of Agricultural Economics, Oklahoma State University, Stillwater, OK 74078, USA. E-mail: jayson.lusk@okstate.edu

The purpose of this note is to provide a simple framework to determine whether a fat tax improves consumer welfare at the individual level. We adopt the framework introduced by Philipson and Posner (1999) and further explored by Schroeter *et al*. (2008), who include weight as an argument of the utility function. We show the conditions under which a fat tax can increase consumer welfare within this framework and provide some empirical calculations on whether a tax on sugary beverages increases welfare at the individual level.

Our analysis does not rule out the possibility that a fat tax might be beneficial at the *societal* level even if it is not at the *individual* if there are externalities (see Bhattacharya and Sood, 2011 for a discussion of this issue). Moreover, there are other frameworks that come from behavioral economics that could be used to describe how consumers might individually benefit from a fat tax. Our objective here is to provide a simple framework that is internally consistent in so far as being able to analyze the effects of a fat tax in a situation where it is at least theoretically possible that consumers can benefit from the policy. We touch on some of these other modeling alternatives in the conclusions.

## 2. MODEL

Following Schroeter *et al*. (2008), we use a simple two-good model where consumers derive utility from consuming a high-calorie food, $F^H$, and a low-calorie food, $F^L$, in addition to their weight, $W$. Weight is a function of the quantity of foods consumed and exercise, $E$: $W = W(F^H, F^L, E)$. Weight is increasing in food intake, $\partial W/\partial F > 0$ and decreasing in exercise, $\partial W/\partial E < 0$. The consumers' utility function is $U(W(F^H, F^L, E), F^H, F^L, E)$, which is increasing at a decreasing rate in $F^H$ and $F^L$. Utility is assumed to be increasing in $W$ at levels below an individual's subjective, ideal weight, $W^I$, and is decreasing thereafter. Given that the majority of people in the USA are overweight, it is likely that $\partial U/\partial W < 0$ for most individuals.

Consumers choose levels of food intake and exercise to maximize utility. Given prices of high-calorie and low-calorie food, and exercise, $P^H$, $P^L$, and $P^E$, and income, $I$, maximization leads to Marshallian demands for food and exercise, $F^{H*}(P^H, P^L, P^E, I)$, $F^{L*}(P^H, P^L, P^E, I)$, $E^*(P^H, P^L, P^E, I)$, which can be substituted into the weight equation to determine economically optimal weight, $W^*(P^H, P^L, P^E, I)$. The economically optimal weight $W^*$ may not necessarily coincide with the ideal weight $W^I$ or even weight that is optimal for the health of the individual.

Substituting each of these functions back into objective function yields the indirect utility function:

$$V\left(P^H, P^L, P^E, I, W\left(P^H, P^L, P^E, I\ \right).\right. \tag{1}$$

Now, imagine a policy that implements an *ad valorem* tax of $t$ to the high-calorie food, increasing the price from $P^H$ to $P^H(1 + t)$. The individual consumer welfare effects of the tax can be calculated by determining the consumer's equivalent variation, $EV$, or the amount of money that must be added to income to make the consumer indifferent to the tax hike. The welfare change is determined by the following equality:

$$V(P^H(1+t), P^L, P^E, I + EV, W(P^H(1+t), P^L, P^E, I + EV)) = V(P^H, P^L, P^E, I, W(P^H, P^L, P^E, I)) \tag{2}$$

The left-hand side of the equality in Equation (2) describes the consumer's utility in the case where the fat tax is imposed and where $EV$ has been added to income to offset the disutility of the tax, and the right-hand side represents the consumer's utility in the status quo before implementing the fat tax.

The welfare effects of the policy can be determined by taking a linear approximation around the equality in Equation (2) and re-arranging the terms:

$$EV = \left(\frac{-P^H t}{\frac{\partial V}{\partial I} + \frac{\partial V \partial W^*}{\partial W^* \partial I}}\right)\left(\frac{\partial V}{\partial P^H} + \frac{\partial V}{\partial W^*}\frac{\partial W^*}{\partial P^H}\right). \tag{3}$$

Equation (3) shows that the welfare effects of a fat tax involve a trade-off between the disutility consumers receive from higher prices given by $\frac{\partial V}{\partial P^H}$ and the added utility individuals receive from decreasing body weight as a result of the tax implementation, which is given by $\frac{\partial V}{\partial W^*}\frac{\partial W^*}{\partial P^H}$. It is useful to consider the special case in which $\frac{\partial W^\dagger}{\partial I} = 0$, which is likely to hold for small marginal changes in income. In this case, Equation (3) can be re-written as:

$$EV = P^H t \left( \frac{-\frac{\partial V}{\partial P^H}}{\frac{\partial V}{\partial I}} - \frac{\frac{\partial V}{\partial W^*}}{\frac{\partial V}{\partial I}} \frac{\partial W^*}{\partial P^H} \right). \tag{4}$$

Equation (4) can be further simplified by noting that the first term in parentheses, $\frac{-\frac{\partial V}{\partial P^H}}{\frac{\partial V}{\partial I}}$, is equal to $F^{H^*}$ because of Roy's identity, where the $^*$ superscript indicates utility maximizing levels. The second term in parentheses, $\frac{\frac{\partial V}{\partial W^*}}{\frac{\partial V}{\partial I}}$, is the marginal utility of weight gain divided by the marginal utility of income, which is equal to the individual's willingness to pay (WTP) to reduce weight by one pound, $WTP^W$, multiplied by negative one. Thus, Equation (4) can be re-written as follows:

$$EV = P^H t \left( F^{H*} + WTP^W \left( \frac{\partial W^*}{\partial P^H} \right) \right). \tag{5}$$

Equation (5) shows that the welfare effects of a fat tax, as indicated by the level of compensation that must be given to an individual to offset the increased price, *EV*, is increasing in the size of the tax, *t*, and the consumption level of the taxed good, $F^{H^*}$. However, *EV* is falling in $WTP^W$ because $\frac{\partial W^*}{\partial P^H} < 0$. This means that with this simple framework, in which weight is included as an argument in the utility function, it is possible to see how consumers could be made better off from the tax: a condition, which occurs if $EV < 0$ or if $F^{H*} < -WTP^W \frac{\partial W^*}{\partial P^H}$. The higher the value an individual places on losing weight, the more likely is the condition to hold.

In a traditional economic model, weight is excluded as an argument of the utility function, which means Equation (5) reduces to $P^H F^{H^*} t$, which is simply the change in expenditure on the high-calorie good resulting from the tax: a value, which can only be positive. That is, in the traditional economic framework, *EV* can only be positive, meaning consumers are worse off from the tax (they must be with compensated a positive dollar amount to offset the disutility of the tax). Equation (5) generalizes this result to allow the benefits of weight loss to be balanced against the costs of the tax.[1]

## 3. EMPIRICAL CONSIDERATIONS

A fat tax is beneficial to a consumer in this framework if $F^{H*} < -WTP^W \frac{\partial W^*}{\partial P^H}$. The first term, $F^{H^*}$, is easily observed as it is an individual's level of consumption of the high-calorie good. The weight reductions occurring from the price change, $\frac{\partial W^*}{\partial P^H}$, might initially appear difficult to determine; however, Schroeter *et al*. (2008) show that the value can be straightforwardly calculated using own-price and cross-price elasticities of demand along with weight-consumption elasticities, which can be determined using energy accounting. In particular, their results imply that $\frac{\partial W^*}{\partial P^H} = (\varepsilon^{HH}\eta^H + \varepsilon^{LH}\eta^L + \varepsilon^{EH}\eta^E) \frac{W^*}{P^H}$, where $\varepsilon^{HH}$ is the own-price elasticity of demand for the high-calorie food, $\varepsilon^{LH}$ and $\varepsilon^{EH}$ are cross-price elasticities of demand for low-calorie food and exercise with respect to the price of high-calorie food, and $\eta^k$ is the percentage change in weight resulting from a 1% increase in consumption of good *k* = *H*, *L*, and *E*, high-calorie food, low-calorie food, and exercise, respectively.

[1]Our model ignores any possible benefits that might be derived from the income the government raises through taxation. Ultimately, one would have to conduct a cost–benefit analysis on specific programs funded by the extra tax revenue to determine whether and to what extent they benefit the individual.

The term that is most uncertain in Equation (5), in the sense that there are not many well-established values in the literature, is an individual's WTP for a one-pound weight reduction, $WTP^W$. As such, it might be useful to use existing values of $F^{H*}$ and calculated values of $\frac{\partial W^*}{\partial P^H}$ to infer the value of $WTP^W$ that would be required for an individual to benefit from the fat tax. Such a procedure can at least provide an intuitive feel for the likelihood of a fat tax being welfare enhancing and can be compared with existing evidence on the extent to which people value weight reduction (e.g. see Cawley, 2004, 2008; Narbo and Sjöström, 2000).

Re-writing the welfare-enhancing condition in terms of weight WTP yields the following:

$$EV < 0 \text{ } if \text{ } WTP^W > F^{H*} / \left( - \frac{\partial W^*}{\partial P^H} \right), \tag{6}$$

and substituting the equation for $\frac{\partial W^*}{\partial P^H}$ given above and rearranging yields our key result:

$$EV < 0 \text{ } if \text{ } WTP^W > F^{H*} P^H / \; W \; \varepsilon^{HH} \eta^H + \varepsilon^{LH} \eta^L + \varepsilon^{EH} \eta^E \quad . \tag{7}$$

The numerator, $F^{H*} P^H$, is simply the expenditure on the high-calorie food, and the denominator, $W(\varepsilon^{HH} \eta^H + \varepsilon^{LH} \eta^L + \varepsilon^{EH} \eta^E)$, is the change in weight (in pounds) that results from a 1% increase in the price of the high-calorie food, $P^H$.

Equation (7) provides a convenient means of calculating whether a fat tax is welfare enhancing by employing the type of data that are normally used to simulate the weight effects of a fat tax. For example, consider the results in Dharmasena and Capps (2011) related to a tax on sugary sweetened beverages—a target of many fat tax advocates. Their results suggest that a 1% increase in the price of regular soft drinks, sports drinks, and fruit drinks would lead to a weight loss of 0.077 lbs annually at average consumption levels.

Using Nielsen data from 2006, Zhen *et al*. (2011) reported that both low-income and high-income households spend, on average, a little less than \$115/year on regular soft drinks, sports drinks, and fruit drinks. Plugging the average values into Equation (7), we can see that the 'average' household would have to be willing to pay at least 115/0.077 = \$1493 per pound of weight lost for a fat tax to improve their individual welfare.[2]

There are other studies aside from that of Dharmasena and Capps (2011) that have estimated how consumption of soft drinks varies with changes in drink prices such as Zhen *et al*. (2011) and Smith *et al*. (2010). Using the price elasticities provided in these alternative studies would, of course, lead to different estimates of the minimum welfare-enhancing WTP. One advantage of using the results provided by Dharmasena and Capps (2011) is that they translate the consumption changes to weight changes—providing the precise number needed to plug into the denominator of Equation (7). Although Dharmasena and Capps (2011) used a flexible functional form to estimate sugary drink demand, accounting for endogeneity of expenditures, and imposed theoretical restrictions such as symmetry and homogeneity, it should be noted that alternative functional forms or assumptions about demand interrelationships might lead to different results.

According to Jensen's inequality, a non-linear function evaluated at the mean will not equal the mean of the function. As a result, \$1493 should not be interpreted as the mean WTP in a population of heterogeneous individuals. To provide some indication of the sensitivity of the estimate to variation in household expenditures on sugary beverages and to the uncertainty in the weight-loss effect from the fat tax, we constructed Table I and Figure 1. The data reported in Zhen *et al*. (2011) suggest that the SD of expenditures on regular soft drinks, sports drinks, and fruit drinks is at least \$20/year. Thus, we calculate Equation (7) at 1 SD above and below the average of \$115/year. There also is potential variability in the effects of a sugar tax. Dharmasena and Capps (2011) reported results for 'heavy' drinkers of sugary beverages, and their estimates imply that a 1% increase in the price of regular soft drinks, sports drinks, and fruit drinks would lead to a weight loss of 0.125 lbs annually

[2]In this calculation, the numerator is expenditures in units of dollars per year. The denominator is the amount of weight lost in units of pounds per year. The division produces a measure in the units of dollars per pound. Time cancels out of the equation. In reality, the timing of the WTP (the cost) may not equal the timing of the weight loss (which happens over some period in the future). This is an issue we abstract away from in this paper. The statistics reported here can be thought of as the total amount one is willing to pay for an immediate, one-time weight loss.

Table I. Relationship between minimum welfare-enhancing willingness to pay, weight impacts of a fat tax, and annual expenditures for the case of a tax on sugary beverages

| Scenario | Annual weight impacts from a 1% increase in price of sugary beverages[a] | Annual expenditures on sugary beverages[b] | Willingness-to-pay per pound of weight loss needed for tax to enhance individual welfare |
|---|---|---|---|
| 1 | Low (0.029-lb loss) | Low ($95/year) | $3276 |
| 2 | Average (0.077-lb loss) | Low ($95/year) | $1234 |
| 3 | High (0.125-lb loss) | Low ($95/year) | $760 |
| 4 | Low (0.029-lb loss) | Average ($115/year) | $3966 |
| 5 | Average (0.077-lb loss) | Average ($115/year) | $1494 |
| 6 | High (0.125-lb loss) | Average ($115/year) | $920 |
| 7 | Low (0.029-lb loss) | High ($135/year) | $4655 |
| 8 | Average (0.077-lb loss) | High ($135/year) | $1753 |
| 9 | High (0.125-lb loss) | High ($135/year) | $1080 |

[a]Average and high effects are inferred from the estimates in Dharmasena and Capps (2011). The low effect is calculated based on linear interpolation.
[b]The average expenditure is taken from Zhen *et al*. (2011). The high and low values are approximately 1 SD above and below the mean.

for this group. We used linear interpolation between the mean effect (0.077 lbs/year) and the high effect (0.125 lbs/year) to calculate a ‘low’ weight effect of 0.077 – (0.125 – 0.077) = 0.029 lbs/year resulting from a 1% increase in the price of sugary beverages.

As shown in Table I and Figure 1, the minimum welfare-enhancing WTP is highest for households spending the most on sugary beverages. However, WTP is relatively more influenced by the calculated weight effects of the tax. The more effective the tax is at reducing weight, the lower the minimum welfare-enhancing WTP. Even under the most optimistic scenario considered here (high weight effect and low expenditures), households would have to be willing to pay $760 per pound of weight lost for the policy to enhance their welfare.

Systematic evidence on how much people are willing to pay to lose weight is sparse, but previous literature provides some indication of plausible values. Among a sample of obese individuals (with an average BMI of 39.6) in Sweden, Narbo and Sjöström (2000) asked a hypothetical open-ended question related to how much individuals were willing to pay ‘for a treatment that would relieve them from overweight-related problems’. The average value was $3280, and the median was $1330. The data in Narbo and Sjöström (2000) suggest that individuals in their sample would have to lose about 100 lbs to move from their current average BMI of 39.6 down to normal range BMI of 24.9 holding height constant. Thus, the per-pound

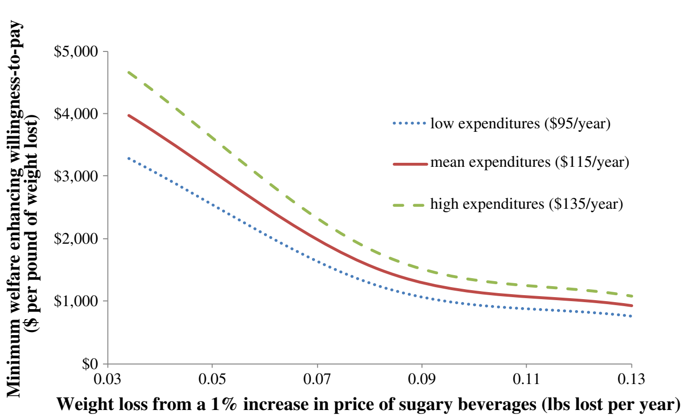


Figure 1. Relationship between minimum welfare-enhancing willingness to pay, weight impacts of a fat tax, and annual expenditures for the case of a tax on sugary beverages

WTP for weight loss implied by Narbo and Sjöström (2000) is \$32.80/lb at the average or \$13.30/lb at the median.

Cawley (2008) used a double-bounded dichotomous choice referendum question to ask New York residents how much they were willing to pay to 'reduce youth obesity in your town by 50%', The average WTP observed among their sample of respondents was \$46.41/household/year. Although this statistic is informative and useful, it is impossible to put this figure on a per-pound of weight lost basis given that the question asked about WTP to reduce obesity in a group of individuals (of varying sizes and varying obesity rates). Moreover, the question asked about a 'societal' WTP, which might differ from the individual-WTP described by Equation (7).

One final piece of evidence related to people's values for weight reduction comes from hedonic wage analysis. Several studies suggest that obese individuals receive wage discounts compared with normal weight individuals, and conceptually, someone should be willing to pay an amount at least as high as the wage discount associated with overweightedness. Among white female subjects, Cawley (2004) showed that an increase in weight of about 64 lbs from the mean is associated with a 9% wage decline. The average wage of female subjects in Cawley's (2004) sample was about \$8.40/hour (in 1998–1999). Thus, the implied wage-discount from being 64 lbs overweight is about \$0.756/hour. For someone working 40 hours a week, 52 weeks a year, this amounts to \$1572/year in lost income because of being 64 lbs overweight–or \$24.57/lb/year.

More work is needed to more accurately determine people's WTP for weight reduction. However, the extant evidence cited above suggests that most people would not be willing to pay the 'break even' WTP value calculated in relation to the sugary beverage tax, which was \$1493 per lb of weight lost for an 'average' household. Stated differently, within the framework analyzed here, it is rather unlikely that a tax on sugary beverages would be welfare-enhancing at the individual level.

## 4. SUMMARY AND CONCLUSIONS

This note provided a convenient means to determine whether a fat tax is welfare enhancing at the individual level. By including weight as an argument to the utility function, we show that a fat tax can be welfare enhancing if the amount individuals are willing to pay for a one-pound weight reduction is greater than the ratio of the expenditure on the taxed good to the weight loss produced by the tax. Our empirical calculations based on data and estimates in Dharmasena and Capps (2011) and Zhen *et al.* (2011) suggest that the 'average' household would have to be willing to pay about \$1500 per pound of body weight lost for a tax on sugary beverages to be welfare enhancing at the individual level. What consumers are actually willing to pay for weight reduction is uncertain and is an area in need of additional research. Future studies along these lines would do well to precisely measure the amount of weight loss associated with the WTP amount. It also might be useful to determine whether WTP varies non-linearly with weight loss. Although \$1500 seems like a large amount to pay to lose a single pound, it does not seem unreasonable to believe that some people might be willing to pay \$15 000 over time to lose 10 lbs if the weight loss was permanent.

The few existing studies on WTP for weight loss suggest that individuals are unlikely to be willing to part with \$1500/lb of weight lost. This conclusion can be interpreted in one of two ways. First, one can conclude that the sugary beverage tax will not improve welfare within the individual-specific welfare context of the model developed in this paper. An alternative conclusion is that a soda tax policy would have to be justified on some other grounds.

There are other conceptual models, which might be used to motivate a fat tax. For example, many argue that obesity causes an externality. Finkelstein *et al.* (2004), for example, calculate that each obese individual increases the cost of Medicare by \$1486, the cost of Medicaid by an extra \$864, and private insurance by an additional \$423 annually. Bhattacharya and Sood (2011) argue that most of the costs of obesity are borne at the individual level, casting some doubt on the externality argument; however, this is a matter that remains debatable in academic circles. If an externality exists, it might not have to be particularly large for a policy to be welfare enhancing because the deadweight loss of a tax can be offset by the mitigation of third-party cost borne by the non-obese. A model arguing that the existence of externalities justifies a fat tax would need to link the externality costs imposed on individuals to the offsetting benefits from others' weight reductions.

An alternative modeling approach might rely on behavioral economics to motivate a fat tax. For example, O'Donoghue and Rabin (1999, 2000) argue that people have self-control problems when dealing with intertemporal decisions that involve choices between immediate benefits (e.g. tasty food) and future costs (e.g. obesity). In such a model, a fat tax could serve to improve individual welfare by moving some of the future costs to the present.

Although it is clearly *possible* to justify a fat tax by pointing to externalities of behavioral economics, the problem is that few authors have worked out the steps to actually empirically determine whether a fat tax is welfare enhancing within these frameworks. As fat taxes move closer to being actually implemented, it would seem imperative for authors to actually calculate the welfare consequences of a fat tax rather than making vague reference to a justification based on externalities or behavioral economics. This note provided one simple framework in which such a calculation is possible.


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