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ABSTRACT

According to an estimate of an incomplete dairy demand system using supermarket scanner data, own-price elasticities of demand are relatively inelastic and vary little across demographic groups. Even a 10 percent ad valorem tax on the percentage of fat would reduce fat consumption by less than a percentage point. Given that the demand for most dairy products is inelastic, a fat tax is an effective means to raise revenue. However, these fat taxes are unattractive because they are extremely regressive, and the elderly and poor suffer much greater welfare losses from the taxes than do younger and richer consumers.

Key words: fat tax, incomplete demand system, welfare measures

JEL: H2, I18

A Fat Tax Does Not Cut Fat Consumption and Is Regressive

People like cheese, ice cream, butter, and other foods with high fat content; but that fat may kill them by greatly increasing their cholesterol and obesity levels and raising their risk of heart disease. Consequently, many jurisdictions throughout the world have passed or are contemplating imposing taxes on fatty foods to save people from themselves.[1] Half the states already have taxes or restrictions on foods with high levels of sugars or fats. Because more than half of all fat consumed comes from dairy products, we estimate an incomplete dairy demand system to examine whether a fat tax will cause various demographic groups to substitute lower-fat foods, whether such taxes are effective tax fund raisers, whether they are regressive, and how they affect consumer welfare.

To predict the effects of a fat tax, we need accurate estimates of the demand for fatty foods. If the point of the tax is to influence behavior, then a very low elasticity of derived demand for fat is disappointing because the tax will have little effect on reducing fat consumption. However, if the point of the tax is to raise tax revenue (possibly to pay for the harms of fat consumption), then a very low elasticity is desirable—such a tax could raise billions of dollars of tax revenue.[2] However, such taxes may be regressive and reduce consumer welfare by a comparable amount.

Much of the work examining the demand functions for food products relies on complete demand systems—that is, they beg the question of how income is allocated to food and to other expenditures. In contrast, we use an incomplete demand system to provide more accurate estimates of the own- and cross-price elasticities for the major categories of dairy products based on grocery store scanner data. We then simulate a fat tax and determine the estimated changes in consumption patterns for different demographic groups. The simulations allow us to examine the effectiveness of a dairy products' fat tax to reduce the intake of fat through these products, and the welfare implications for consumers.

We begin with a review of the literature on the health effects of fat, the potential effectiveness of a fat tax on dairy products, and the estimation of dairy product demand functions. We then describe our theoretical model and statistical approach to estimating the demand functions of various dairy products, and the resulting elasticities and welfare measures. A brief description of the data follows. Finally, we report the demand system estimates and the simulation analyses with respect to consumption, taxes, and welfare effects.

Fats, Obesity, and Disease

Fat intake has been a public health concern for more than 40 years. The intake of fat may contribute to serious health problems including heart disease and obesity.

One billion adults worldwide are overweight and at least 300 million are clinically obese (WHO). Among OECD countries, The United States has the highest level of overweight people, 65 percent, followed by Mexico, 62 percent, and the United Kingdom, 61 percent (Loureiro and Nayga). The percentage of overweight and obese Americans rose from 45 percent to 65 percent from 1960 to 2002.[3] Weight problems vary by demographic group. In 1999-2000, 60 percent of U.S. black males, 68 percent of white males, and 74 percent of Mexican-American males were overweight or obese.[4] The corresponding fractions for women were 78 percent for blacks, 58 percent for whites, and 72 percent of Mexican-Americans.

According to the American Heart Association over 13 million Americans suffer from coronary heart disease, which includes heart attack, angina pectoris, and other heart problems. Coronary heart disease resulted in over 2 million inpatient hospital visits and 500,000 deaths in 2001. Approximately 6.9 percent of white, 7.1 percent of black, and 7.2 percent of Mexican-

American males have coronary heart disease. Nearly 5.5 percent of white, 9.0 of black, and 6.8 percent of Mexican-American women suffer from the disease.

In the United States, health care for overweight and obese individuals costs an average of 37 percent more than for normal weight people, so that overweight raises the per person average annual medical bill by $732 (Loureiro and Nayga). The direct costs of coronary heart disease health care and indirect costs, due to the loss of productivity exceed $133 billion (Willett), and obesity related medical expenditures are $75 billion or 9 percent of all U.S. health expenditures (Finkelstein et al.).

Studies of the link between fat intake and heart disease (Ascherio et al.; Hu et al.; and Willett) or obesity (Bray et al.) conclude that not all types of fat have identical effects on health. Recent research demonstrates that monounsaturated and polyunsaturated fats increase the levels of HDL (good) cholesterol and reduce the levels of LDL (bad) cholesterol. Saturated fat increases the levels of both types cholesterol, but the overall effect is negative. Trans fats raise particular health concerns as they decrease levels of HDL and raise levels of LDL.[5] These findings suggest that saturated and trans fats are more likely to lead to heart disease, and trans fats may also be more likely to result in obesity than other types of fat.[6]

The main sources of saturated fats in American diets include whole milk, butter, cheese, ice cream, red meat, and coconut products. Trans fats come from many types of margarine, vegetable shortening, and partially hydrogenated vegetable oils (Willett). Consequently, dairy products are of particular concern when examining fat intake and a possible fat tax.

Popkin et al. examined the trend in American fat intake over time. In 1965, the daily total fat intake for adults averaged over 91 grams. Fat consumption fell to nearly 71 grams from 1989-1991, but rose again to almost 75 grams from 1994-1996. However, the percentage of daily calories made up of total fat continually declined from 39 percent in 1965 to 33 percent during 1994-1996. Examination of the percent of total fat contributed by several food categories reveals that the percent attributable to dairy and eggs fell from 17 percent in 1965 to 13 percent in 1996. The added fat category, which includes butter and margarine, declined from 15 percent to 10 percent of total fat intake. However, the fat intake from the two categories of lower fat milk products and cheese rose by 2 percent during this period.

Jeffery, et al. were among the first to examine price as a public health tool to influence food choices. They found, not surprisingly, that fruit and salad purchases greatly increased in a cafeteria when the prices of these items fell 50 percent. The declining price (Cawley) and time costs of food (Cutler et al.) have also contributed to increased obesity rates. The increase in the number of restaurants, the decrease in food prices and the amount of food consumed at home, have also been linked to higher levels of obesity. Other work (Jeffery et al., French et al. 1997 and 2001) suggest that low-fat vending snacks are more often purchased when the price of these items is reduced.

The growing emphasis on changing the food environment as a means to reduce fat intake has lead to a debate on fat taxes. State and local taxes on soft drinks and snack foods date back to at least 1925 (Jacobson and Brownell).[7] Table 1 shows that many U.S. jurisdictions have or are considering laws regulating sugar, snack foods, and fats. Half the states and a couple of U.S. cities have such laws. In addition, many other countries have or are considering such laws including Australia, Canada, and the United Kingdom.

In recent years, various public health experts and politicians in many countries have proposed imposing a tax on fat—"Twinkie Taxes" or "McTaxes"—as a public health tool to fight obesity (Brownell; Marshall; and Nestle). However, others view such a tax as an unnecessary government imposition (The Economist) that might have unintended consequences that would reduce its effectiveness (Kuchler et. al. 2005). In addition in the last few years, the fast food industry has been hit with a sequence of lawsuits for providing excessive fats and causing obesity.

Previous Dairy Demand Studies

Because dairy products contain roughly half of all fat, we focus on this sector. To determine the effects of a fat tax on dairy products we need to determine how changes in prices are likely to affect demand. Several previous studies estimated the demand elasticities of dairy products. These studies typically find that the own-price elasticities are small and that the elasticities vary across income groups.

Heien and Wessells (1988) used a Heckman two-step procedure to estimate an almost ideal demand system (AIDS). They found large negative own-price elasticities and substantial positive cross-price elasticities; but in a subsequent study (Heien and Wessells 1990), they found that demand elasticities for milk, cheese, cottage cheese, butter, margarine, and ice cream are all inelastic.

Park et al. and Huang and Lin estimated demand elasticities for consumers with various income levels for several categories of food products using the Nationwide Food Consumption Survey data. Park et al. used a Heckman procedure similar to Heien and Wessells (1990) and found the elasticity for cheese and milk for poverty status households averages -0.009 and -0.529 respectively, and -0.243 and -0.472 for households above poverty status. Huang and Lin used an AIDS model and found that low-income consumers have an elasticity for dairy products of -0.78 and an income elasticity of -0.77.

Bergtold, Akobundu and Peterson used household level scanner data and a flexible and separable translog multistage demand system. They included many more product categories and found elasticities near -0.6 for sour cream, -0.7 for non-shredded cheese and skim or low-fat milk, -0.9 for shredded cheese, whole milk, ice cream and yogurt, and –1.9 for imitation cheese and cheese spreads.

Incomplete Demand System

Our approach differs from most previous studies in that we adjust for food taxes; we use an instrumental variable technique to control for endogeneity; and we estimate an incomplete demand system because we do not have data on all goods that consumers purchase. Most previous studies have estimated "complete" demand systems where they excluded unobserved goods or aggregated them without sound theoretical justification. Instead, we use an incomplete system that is consistent with utility theory and hence which provides consistent estimates of elasticities and welfare measures.

We use a generalized Almost Ideal Demand System (AIDS) that is linear and quadratic in prices and linear in income; hereafter, the LQ-IDS (LaFrance, 1990, 2004). This model is flexible with respect to both price and income effects. The theoretical subsystem of demand equations for the LQ-IDS model can be written as

(1) $$\boldsymbol{q} = \alpha + \boldsymbol{As} + \boldsymbol{Bp} + \gamma\left(m - \alpha'\boldsymbol{p} - \boldsymbol{p}'\boldsymbol{As} - \tfrac{1}{2}\boldsymbol{p}'\boldsymbol{Bp}\right),$$

where $\boldsymbol{q}$ is the vector of quantities demanded, α and γ are vectors of parameters, $\boldsymbol{A}$ is a matrix of parameters, $\boldsymbol{B} = \boldsymbol{B}'$ is a symmetric, negative definite matrix of parameters, $\boldsymbol{p}$ is the vector of normalized final consumer prices for dairy products, m is normalized income, and $\boldsymbol{s}$ is a vector of demographic variables.[8] All prices and income have been normalized by a linear homogeneous function of the prices of other goods, $\pi(\tilde{\boldsymbol{p}})$, where $\tilde{\boldsymbol{p}}$ is a vector of market prices other than those for dairy products. The class of normalized expenditure functions that generates this demand model is

(2) $$e(\boldsymbol{p}, \tilde{\boldsymbol{p}}, \boldsymbol{s}, u) = \alpha' \boldsymbol{p} + \boldsymbol{p}' \boldsymbol{A} \boldsymbol{s} + \tfrac{1}{2} \boldsymbol{p}' \boldsymbol{B} \boldsymbol{p} + \theta(\tilde{\boldsymbol{p}}, \boldsymbol{s}, u) e^{\gamma' \boldsymbol{p}},$$

where $\theta(\tilde{\boldsymbol{p}}, \boldsymbol{s}, u)$ is increasing in u but otherwise cannot be identified (LaFrance 1985; LaFrance and Hanemann 1989). Equivalently, the class of indirect utility functions theoretically consistent with this demand model is

(3) $$v(\boldsymbol{p}, \tilde{\boldsymbol{p}}, m, \boldsymbol{s}) = \upsilon\left[\left(m - \alpha' \boldsymbol{p} - \boldsymbol{p}' \boldsymbol{A} \boldsymbol{s} - \tfrac{1}{2} \boldsymbol{p}' \boldsymbol{B} \boldsymbol{p}\right) e^{-\gamma' \boldsymbol{p}}, \tilde{\boldsymbol{p}}, \boldsymbol{s}\right].$$

Either of these claims can be verified by applying Hotelling's lemma to (2) or Roy's identity to (3) to produce the incomplete demand system in (1).

Price and Income Elasticities

The matrix of derivatives of the demands with respect to the deflated prices is

(4) $$\frac{\partial \boldsymbol{q}}{\partial \boldsymbol{p}'} = \boldsymbol{B} - \gamma\left(\alpha' + \boldsymbol{s}' \boldsymbol{A}' + \boldsymbol{p}' \boldsymbol{B}\right),$$

with typical element,

(5) $$\frac{\partial q_i}{\partial p_j} = \beta_{ij} - \gamma_i \left(\alpha_j + \sum_{k=1}^{K} \alpha_{jk} s_k + \sum_{k=1}^{n} \beta_{jk} p_k\right).$$

The own- and cross-price elasticities of demand are therefore defined by

(6) $$\varepsilon_{q_i}^{p_j} = \frac{p_j}{q_i} \frac{\partial q_i}{\partial p_j} = \frac{p_j}{q_i}\left[\beta_{ij} - \gamma_i \left(\alpha_j + \sum_{k=1}^{K} \alpha_{jk} s_k + \sum_{k=1}^{n} \beta_{jk} p_k\right)\right] \quad \forall\ i, j = 1, \ldots, n.$$

In matrix notation, we let $P = \text{diag}[p_i]$, $Q = \text{diag}[q_i]$ represent $n \times n$ matrices with main diagonal elements p_i and q_i respectively for i=1,…, n and all the off-diagonal elements equal to zero. We also define $E_q^p = [\varepsilon_{q_i}^{p_j}]$ as an $n \times n$ matrix of price elasticities. The diagonal elements are own-price elasticities, when $i = j$, and the off-diagonal elements are the cross-price elasticities, when $i \neq j$. Using the matrix notation we can write (6) in the form

(7) $$\boldsymbol{E}_{\boldsymbol{q}}^{p} = \boldsymbol{Q}^{-1} \frac{\partial \boldsymbol{q}}{\partial \boldsymbol{p}'} \boldsymbol{P} = \boldsymbol{Q}^{-1} \left[\boldsymbol{B} - \gamma \left(\alpha' + \boldsymbol{s}' \boldsymbol{A}' + \boldsymbol{p}' \boldsymbol{B} \right) \right] \boldsymbol{P} .$$

Similarly, the derivatives of the demands with respect to deflated income are $\partial \boldsymbol{q} / \partial m = \gamma$, so that the income elasticities of demand are

(8) $$\varepsilon_{q_i}^{m} = \frac{m}{q_i} \frac{\partial q_i}{\partial m} = \frac{\gamma_i m}{q_i} \quad \forall \ i = 1, \ldots, n .$$

If we define the vector $\mathrm{e}_{\boldsymbol{q}}^{m} = [\varepsilon_{q_1}^{m} \cdots e_{q_n}^{m}]'$, then we can rewrite (8) in matrix notation as

(9) $$\varepsilon_{\boldsymbol{q}}^{m} = m \boldsymbol{Q}^{-1} \gamma .$$

Welfare Measurement

To determine the impact of a change in the prices of dairy products on consumer welfare, we need to compare the scalar quasi-utility level at the initial prices, $\theta_0 \equiv \theta(\tilde{\boldsymbol{p}}, \boldsymbol{s}, u_0)$, where

(10) $$\theta(\tilde{\boldsymbol{p}}, \boldsymbol{s}, u_0) \equiv \left[m - \left(\alpha_0^{'} \boldsymbol{s} + \alpha' \boldsymbol{p}_0 + \boldsymbol{s}' \boldsymbol{A}' \boldsymbol{p}_0 + \tfrac{1}{2} \boldsymbol{p}_0^{'} \boldsymbol{B} \boldsymbol{p}_0 \right) \right] e^{-\gamma' \boldsymbol{p}_0} ,$$

with initial prices for dairy products equal to $\boldsymbol{p}_0$, to the scalar quasi-utility level at the final prices, $\theta_1 \equiv \theta(\tilde{\boldsymbol{p}}, \boldsymbol{s}, u_1)$, where

(11) $$\theta(\tilde{\boldsymbol{p}}, \boldsymbol{s}, u_1) \equiv \left[m - \left(\alpha_0^{'} \boldsymbol{s} + \alpha' \boldsymbol{p}_1 + \boldsymbol{s}' \boldsymbol{A}' \boldsymbol{p}_1 + \tfrac{1}{2} \boldsymbol{p}_1^{'} \boldsymbol{B} \boldsymbol{p}_1 \right) \right] e^{-\gamma' \boldsymbol{p}_1} ,$$

with final prices for dairy products equal to $\boldsymbol{p}_1$. Given that consumer prices for dairy products change from $\boldsymbol{p}_0$ to $\boldsymbol{p}_1$, the equivalent variation, *ev*, is the change in income at the original price vector, $\boldsymbol{p}_0$, that is just necessary to bring the consumer to the new quasi-utility level at the final price vector, $\boldsymbol{p}_1$,

(12) $$\theta_1 = \left(m - \alpha' \boldsymbol{p}_1 - \boldsymbol{p}_1^{'} \boldsymbol{A} \boldsymbol{s} - \tfrac{1}{2} \boldsymbol{p}_1^{'} \boldsymbol{B} \boldsymbol{p}_1 \right) e^{-\gamma' \boldsymbol{p}_1} = \left(m + ev - \alpha' \boldsymbol{p}_0 - \boldsymbol{p}_0^{'} \boldsymbol{A} \boldsymbol{s} - \tfrac{1}{2} \boldsymbol{p}_0^{'} \boldsymbol{B} \boldsymbol{p}_0 \right) e^{-\gamma' \boldsymbol{p}_0} .$$

Solving for *ev* then gives

(13) $$ev = \left(m - \alpha' \boldsymbol{p}_1 - \boldsymbol{p}_1^{'}\boldsymbol{As} - ½\boldsymbol{p}_1^{'}\boldsymbol{Bp}_1\right)e^{\gamma'(\boldsymbol{p}_0 - \boldsymbol{p}_1)} - \left(m - \alpha' \boldsymbol{p}_0 - \boldsymbol{p}_0^{'}\boldsymbol{As} - ½\boldsymbol{p}_0^{'}\boldsymbol{Bp}_0\right).$$

The compensating variation for this model can be shown to satisfy $cv = ev \times e^{\gamma'(\boldsymbol{p}_1 - \boldsymbol{p}_0)}$. As a result, we focus on the equivalent variation measure of consumer welfare.

Effects of Demographics on Elasticities and Welfare

To evaluate the impacts of a marginal change in a demographic variable on the price elasticities of demand for dairy products, we must take two separate forces into account. Any change in a demographic variable both shifts and rotates the demand function for each dairy product when it is depicted in the usual way with price on the vertical axis and quantity on the horizontal axis. To see why, first note that the rate of change in the demand for the i^{th} good with respect to the i^{th} price is

(14) $$\frac{\partial q_i}{\partial p_i} = \beta_{ii} - \gamma_i\left(\alpha_i + \sum\nolimits_{k=1}^{K}\alpha_{ik}s_k + \sum\nolimits_{j=1}^{n}\beta_{ij}p_j\right).$$

Using (14) and the elasticity definition from Equation (6), the own-price elasticity of demand is

(15) $$\varepsilon_{p_i}^{q_i} = \frac{p_i}{q_i}\frac{\partial q_i}{\partial p_i} = \frac{p_i}{q_i}\left[\beta_{ii} - \gamma_i\left(\alpha_i + \sum\nolimits_{k=1}^{K}\alpha_{ik}s_k + \sum\nolimits_{j=1}^{n}\beta_{ij}p_j\right)\right].$$

The *shift* in the demand curve is the rate of change in the demand for the i^{th} good with respect to the k^{th} demographic variable,

(16) $$\frac{\partial q_i}{\partial s_k} = \alpha_{ik} - \gamma_i\sum\nolimits_{j=1}^{n}\alpha_{jk}p_j\ .$$

Depending on the relative sign and size of the elements of the matrix $\boldsymbol{A}$, the relative levels of the dairy product prices $\boldsymbol{p}$, and the sign and size of the income coefficients γ, an individual demand function's shift can be positive, negative, or zero at any given data point.

We also need to examine how the demand curve rotates. The second-order cross effect of the i^{th} price and the k^{th} demographic variable on the i^{th} good is

(17) $$\frac{\partial^2 q_i}{\partial p_i \partial s_k} = -\gamma_i \alpha_{ik} .$$

This term shows the *rotation* in the demand curve. The sign of this term depends on the sign of the i^{th} income coefficient and the coefficient for the k^{th} demographic variable in the demand equation for the i^{th} good. For example, if the good is normal and $\alpha_{ik} > 0$, then $\partial^2 q_i/\partial p_i \partial s_k < 0$. In general the shift and rotation effects could (but need not) work in opposite directions and offset each other at a given point in ($\boldsymbol{q}$, $\boldsymbol{p}$, m, $\boldsymbol{s}$) space.

The net impact of a marginal change in the demographic variable s_k on the i^{th} own-price elasticity of demand, $\varepsilon_{p_i}^{q_i}$, can be expressed simply in terms of the percentage change in the own-price elasticity with respect to a percentage change in the demographic variable,

$$\frac{s_k}{\varepsilon_i^i}\frac{\partial \varepsilon_{p_i}^{q_i}}{\partial s_k} = \frac{s_k}{\varepsilon_i^i}\left[\frac{p_i}{q_i}\left(\frac{\partial^2 q_i}{\partial p_i \partial s_k}\right) - \frac{p_i}{q_i^2}\left(\frac{\partial q_i}{\partial p_i}\right)\left(\frac{\partial q_i}{\partial s_k}\right)\right]$$

(18) $$= \underbrace{s_k \cdot \left(\frac{\partial^2 q_i/\partial p_i \partial s_k}{\partial q_i/\partial p_i}\right)}_{\text{\% rotation}} - \underbrace{\frac{s_k}{q_i} \cdot \left(\frac{\partial q_i}{\partial s_k}\right)}_{\text{\% shift}}.$$

Thus, the sign and size of the percentage change in the own-price elasticity of demand due to a change in a demographic variable depends on the net difference between the *percentage rotation* and the *percentage shift*. In general, this difference can be positive, negative, or zero for a given dairy product at any given point in ($\boldsymbol{q}$, $\boldsymbol{p}$, m, $\boldsymbol{s}$) space.

On the other hand, the marginal effect of a change in the k^{th} demographic variable on the equivalent variation for the change in dairy product prices from $\boldsymbol{p}_0$ to $\boldsymbol{p}_1$ is

(19) $$\frac{\partial ev}{\partial s_k} = \sum_{j=1}^{n} \alpha_{jk}\left[p_{j0} - p_{j1}e^{\gamma'(\boldsymbol{p}_0 - \boldsymbol{p}_1)}\right].$$

This marginal effect depends on all of the coefficients on s_k in the subsystem of demands for dairy products, the relative prices changes, and the vector of income coefficients. Because equations (16)–(19) are functions of the demographic variables, we expect that the elasticities of demand will vary differently than the welfare effects as the prices consumers pay for dairy products change. That is what we find in our empirical work.

Data and Variables

We use weekly Information Resources Incorporated's (IRI) Infoscan™ scanner data from January 1, 1997 through December 30, 1999 for 23 U.S. cities.[9] The city populations range from 50,000 to several million, and each region has several cities. IRI records purchase price and quantity information at the Universal Product Code (UPC) level for a panel of customers for a number of grocery stores in each city. We aggregate these household data to city-level average household quantities purchased per week. We aggregated the thousands of individual dairy UPC codes into 14 dairy product categories: non-fat milk, 1 percent milk, 2 percent milk, whole milk, dairy cream including half and half, coffee creamers, butter and margarine, ice cream including frozen yogurt and ice milk, cooking yogurt (plain and vanilla yogurt), flavored yogurt (all other yogurt that is not categorized as cooking yogurt), cream cheese, shredded and grated cheese, American and other processed cheese, and natural cheese. We aggregate across households within a city to avoid having to estimate a large system of demand equations with a very large number of zero observations.

The dependent variable in the incomplete demand system is the average quantity of the sample of households in each city for each dairy product in each week. The average household quantity for each dairy product is the sum of quantities of each UPC code in the category divided by the number of households that purchased any product in the category during a given week.

For each of the dairy product categories in each city and for each week, we calculate a fixed quantity-weighted average price to represent the average weekly price for each product category. For a generic city, the formula for the j^{th} product category in the t^{th} week is

$$(20) \qquad p_{jt} = \sum_{i_j=1}^{n_j} \left(\frac{\overline{q}_{i_j}}{\Sigma_{k_j=1}^{n_j} \overline{q}_{k_j}} \right) p_{i_j t}, \; j = 1,\ldots,14 ,$$

where, p_{jt} is the average price for dairy product category j in week t, n_j is the number of unique UPC codes for that product category, $\overline{q}_{i_j}$, $i_j = 1,\ldots, n_j$, is the average quantity purchased in the given city of UPC code i_j in product category j throughout all of the weeks in the sample period, and $p_{i_j t}$ is the retail price of good i_j in week t. Each of these average prices is then multiplied by one plus the respective state's retail sales tax on food items to adjust the price for these tax effects. These price indices are then deflated by the 2006=100 regional after-tax consumer price index for all items less food for all urban consumers, not seasonally adjusted (hereafter, nonfood CPI).[10] Because we are estimating a demand system with weekly average deflated expenditures on these dairy product categories as left-hand side dependent variables, it is appropriate to select a price deflator that does not include any of the prices of the goods whose specific UPC codes are included as part of these dependent variables. We also assume that individual households are price takers, so that the aggregate prices for dairy product categories and the nonfood CPI can be taken to be exogenous.

Our data set also includes each household's income bracket. There are eight income brackets with midpoints ranging from \$7,500 to \$200,000 (before deflation).[11] We constructed a weekly estimate of the city-level average household income by taking the sum of the products of the proportion of households in each income bracket times the midpoint of that income bracket. In each city and week in the sample, the population proportions that were used to calculate the city-level income distribution were calculated as the fractions of households who had purchased at least one dairy product in that city during that week. We deflated the city-level average household income with the after-tax nonfood CPI. Finally, we divided these weekly measures of deflated average annual household income by 52 to construct estimates of the deflated average weekly income per household for each city and week in our sample.

The data set also includes several demographic characteristics for each household. We constructed city-level aggregate measures of these demographic variables similar to the weekly average income per household variable. That is, if a household purchased any dairy product in a given week, we included that household's demographic characteristics to calculate city-level aggregates, so that the demographic variables vary week-to-week and city-by-city as averages of dairy-product purchasing households' demographic characteristics.

Variables included in the model include the proportions of households by ethnic group, home ownership, employment status, occupation, and educational attainment, households with children under 18, with young children (ages 0-5.9), medium aged children (ages 6-11.9), or older children (ages 12-17.9), and city-level weekly averages of the number of young, medium and older children for all households, the number of children in each of the three age groups, years of education, household weekly income, number of members in each household, the ages of the heads of household, and city dummy variables. Table 2 shows the sample means and standard errors of the continuous explanatory variables and the proportions of households for the binary variables (except the city dummies) that are included in the demand system.

Demand System Estimates

We estimate the incomplete demand system, Equation (1), by nonlinear three stage least squares (NL3SLS) to account for the joint determination of city-level average quantities and prices. The instruments that we use in the first-stage price equations include city-level fixed effects, the demographic and income variables in the demand equations, the current and lagged deflated wholesale price of milk by city, the Herfindahl-Hirschman market power index (HHI) for the city, the squares of average household income, the wholesale milk price, and the HHI, and interactions between the race, home ownership, and income variables with the wholesale milk price and the HHI. This set of instruments produced coefficients of multiple determination in our sample ranging from 0.691 to 0.956 for the deflated average prices.[12]

It follows from (1) that each structural parameter enters each demand equation through the supernumerary income term, $m - \alpha'\boldsymbol{p} - \boldsymbol{p}'\boldsymbol{A}\boldsymbol{s} - \tfrac{1}{2}\boldsymbol{p}'\boldsymbol{B}\boldsymbol{p}$. It also is clear from this expression that market prices interact with each parameter. Amemyia (1985) showed that best NL3SLS estimators are obtained if (and only if) the set of instrumental variables can be expressed as a linear combination of the expected values of the partial derivatives of the structural equations with respect to the structural parameters, conditional on the instrument set. To meet this requirement, we need a set of instrumental variables for each demand equation that includes a constant, city-level fixed effects dummies, demographic variables including average weekly household income, predicted prices, own- and cross-product second-order interactions between predicted prices, and interactions between predicted prices and the city dummies and the demographic variables. Thus we need 856 instruments for the 819 structural parameters with a total of 3,583 cross-section/time-series observations per demand equation and 14 demand equations, for a total of 50,162 observations. We use TSP© version 4.5 to estimate the NL3SLS system and use White's robust heteroskedasticity consistent standard errors for all of the parameter estimates, elasticities, and hypothesis tests.

Table 3 presents summary statistics for each of the 14 dependent variables and the individual equations' regression error variances and goodness of fit measures. Because the empirical model is nonlinear in the parameters and the right-hand-side explanatory variables, the reported R^2 measure is the squared correlation between the observed and predicted dependent variables. Given the high R^2 measures, we conclude that this demand model fits the data reasonably well.

Coefficients

Because we estimate the LQ-IDS demand model for 14 dairy product categories using a large number of demographic variables, it is not practical to report all of the coefficient estimates in a table. Many of the demographic coefficients are statistically significantly different from zero at the 5 percent level in some but not all equations and are collectively strongly statistically significant. Rather than try to describe the effects of all of the demographic variables on the quantities demanded variable by variable, we turn to their effects on price elasticities of demand and the equivalent variation measure of the welfare effects of marketing orders.

Dairy Elasticities

As the prices of dairy products change due to milk marketing orders, consumers alter the mix of dairy products that they demand. Table 4 shows the own- and cross-price elasticities for various categories of dairy products calculated at the mean of the explanatory variables (Table 2). Each cell shows the price elasticity for a change in the product listed at the top of the column. Because the fraction of each product that is fat is a fixed constant, the elasticity of fat within a dairy product with respect to that product's price is the same as the product's price elasticity.

All of the own-price elasticities are negative, statistically significant, and inelastic with the exception of 1 percent milk. The own-price elasticity of 1 percent milk is –2.05. The magnitudes of our other own-price elasticity point estimates are similar to those in previous literature. The own-price elasticities of demand for the four types of fresh milk (1 percent, 2 percent, no-fat, and whole) range from –0.628 for no-fat milk to -2.05 for 1 percent milk. The other dairy products are generally even less elastic. The least elastic product is butter, which has an own elasticity of -0.295. There are roughly equal numbers of positive and negative cross-price elasticities of demand, but all of these elasticities are very close to zero—generally below 0.15 in absolute value, and none larger than 0.3 in absolute value. Indeed, most of the cross-price elasticities are not statistically different from zero at a 5 percent level of significance.

Even though the coefficients on many of the demographic variables are significantly different from zero at the 5 percent level, the own-price elasticities of demand do not vary much across demographic groups. We calculated the elasticities for a variety of different demographic groups and compared them. In almost no case did the elasticities vary by more than a few percentage points. As we discussed in the theory section, a change in a demographic variable may cause a demand curve to shift and rotate in such a way that the elasticities do not vary substantially, which is what happens here.

Table 5 reports the income elasticities evaluated at the mean. All of the income elasticities are negative and 8 are statistically different from zero at the 5 percent significance level. By inspection, we again conclude that the income elasticities vary only slightly across demographic characteristics. Our income elasticity estimates fall generally in the range of other estimated income elasticities for dairy products. But, as one would expect, they tend to differ from the previous estimates of food expenditure elasticities for dairy product demands in a conditional (that is, in a weakly separable) system of demand equations.

Fat Tax

Many possible fat taxes have been applied or proposed (Table 1). However, if the intent is to discourage fat consumption, we presumably want a tax that varies with the fat content of foods such as an ad valorem tax on the percentage of fat—analogous to the carbon tax used to control pollution. If the tax rate on fat is τ, then the tax rate for a given product is τ times the fraction of that good that is fat. Table 6 shows the proportion of fat in each dairy category, which ranges from 0 for no-fat milk to over 77 percent for butter.

Effects of a Fat Tax on Food and Fat Consumption

If a product is competitively supplied with a horizontal supply curve, this fat tax will have a proportional effect on the final retail price. Given these assumptions and the price elasticities in Table 4, we calculate the quantity effects of a 10 percent and of a 50 percent fat tax on the consumption of dairy products (Table 7). Because the elasticities do not vary substantially across demographic groups, we report only average effects. The effect of the tax is proportional: The 50 percent tax effects are almost exactly 5 times the effects for the 10 percent tax. Thus, we only discuss the 10 percent tax henceforth. For some relatively low-fat items, the tax increases demand; whereas for most high-fat goods, the tax lowers demand.

Because the price elasticities are relatively inelastic, the tax on any one good has relatively small effects on total quantity.[13] Although it is nonetheless possible that the tax could have a more substantial effect on fat consumption due to substitution between goods, it does not.

The second column of Table 7 shows the estimated percentage change in the quantity of the good demanded for each category for the 10 percent tax, while the third column shows the change in fat grams per household per week. We divide by the average family size, 2.82 members, to get the per person effect. Without a fat tax, individuals in our sample daily consume

77.61 grams of fat from dairy product. Imposing a 10 percent fat tax on dairy products reduces the daily fat intake to 76.94 grams, a drop of only two-thirds of a gram, or less than one percentage point (0.86 percent) of total dairy fat.[14]

This reduction in fat is negligible. For example, this reduction would not have a noticeable effect on a person's weight. Because a gram of fat contains about 9 calories, the tax would reduce a person's average daily calorie consumption by only 6. (Even a 50% tax would only cut daily calorie consumption by 30.) It takes a reduction of about 100 calories a day for the average person to lose one pound of body weight in a month.

Short-Run Tax and Welfare Effects

According to most proponents, the main justification for a fat tax would be to increase the health of overweight consumers—whether they want it or not. Presumably people would live longer and be healthier, which would have desirable long-term effects on their well-being.

If convinced of the wisdom of this recommendation, people could increase their health and presumably their utility by reducing their fat intake voluntarily. However, if a tax is used to induce them to reduce fat consumption, consumers will view themselves as being worse off at least in the short run, as they have to pay more for food and do not see an immediate health benefit.

How great is this welfare loss? Table 8 shows the equivalent variations for various groups based on our estimates. The first column shows the mean for all variables except for the variable shown on the rows. The first row of the first column shows the mean for all variables. The equivalent variation loss of the typical (mean of the explanatory variables) family, $40.34, is the annual change in income that the family is willing to accept instead of experiencing a 10 percent fat tax. Black families with average income suffer a relatively small loss, $36.34, which may be due to their relatively high level of lactose intolerance. By multiplying the annual average individual household's welfare loss by 111 million households, we obtain an estimate of the national welfare loss of $4.48 billion.

One justification of the fat tax is to raise tax revenues—according to some proponents, to be spent on promoting health. Table 9 shows that the annual tax burden from a 10 percent fat tax on dairy products for a typical household is $40.10, and national tax revenues are $4.45 billion.

Thus, the tax revenues are almost as much as the consumers' welfare loss. The government raises $40.10 from the average family compares to a welfare loss of $40.34. The comparable national figures are $4.48 billion versus $4.45 billion.

However, this tax is extremely regressive. Almost the entire burden of the fat tax falls on poor families. We define the tax's regulatory burden as the annual equivalent variation associated with the tax divided by a household's annual income. The regulatory burden for the average family declines rapidly with income. For an otherwise typical household, the burden is 0.24 percent at $20,000. It falls to 0.15 percent at $30,000, 0.10 percent at $40,000, 0.077 percent at $50,000, and 0.024 at $10,000. Thus, the burden at $20,000 is nearly 10 times larger than that at $100,000. The regulatory burden curves associated with different ethnicities do not vary much from the average household. The burdens by income for white, black, and Asian families are slightly below these averages, and those for Hispanic families lie slightly above these averages.

Similarly, the welfare effects are comparably regressive as Table 8 shows. The welfare loss, $24.29, of relatively well-to-do families with an income of $100,000 is only about half the loss of poor families with an average income of only $20,000, $47.38.

Summary and Conclusions

We study the effect of a fat tax on dairy goods because over half of all fat consumed comes from dairy. Using supermarket scanner data, we estimate an incomplete demand system to determine the effects of taxing the fat content of dairy products on various demographic groups. We calculate the price elasticities and the equivalent variations associated with price changes.

The own elasticities of demand for dairy products and for fat are inelastic and vary little across demographic groups. Consequently, the tax has almost no behavioral effect. A 10 percent tax on fat content has relatively little effect on the quantity of dairy products consumed of any group. Such a tax results in less than a 1 percent reduction in average fat consumption. To have a substantial effect, the tax rate would have to be extremely high. Even a 50 percent tax would only lower fat consumption by a little over 3 percent.

Clearly in the short run, a 10 percent fat tax would not raise welfare. People could reduce their consumption of fattier dairy products without government intervention. Forcing them to do so by raising prices lowers their short-run welfare. The welfare effects vary much more than do the elasticities across demographic groups.

Because the demands are relatively inelastic, the fat tax raises tax revenue relatively efficiently in the sense that the welfare loss is only slightly greater than the revenue raised. Nationally, the 10 percent tax would raise $4.45 billion annually, but consumers would suffer a welfare loss of $4.48 billion. However, the tax is extremely regressive, falling almost entirely on poor consumers. Similarly, the welfare loss to a family earning $20,000 is nearly double that of a family earning $100,000. Moreover, families in their sixties suffer roughly double the welfare loss of families in their twenties.

Presumably the main justification of a fat tax is from long-run health increases, which hopefully offset the consumers' welfare losses from higher prices by allowing them to live longer (and possibly, reductions in healthcare expenses). If some people over-consume (by their own reckoning) unhealthy fatty foods, while other people do not over-consume, then O'Donoghue and Rabin (2003, 2005) argue that imposing optimal (possibly very large) "sin taxes" on unhealthy items and returning the proceeds to consumers without control problems can increase social surplus and can cause Pareto improvements. Given the limited current medical knowledge about the link between fat ingestion and length of life and the very small effect on fat consumption, calculating such gains is not feasible at this time. However, because even moderate fat taxes do little to reduce fat intake, long-run health increases are unlikely to materialize. Thus, consumers—particularly the poor and the elderly—will bear the burden of the fat tax as well as bad health.

Footnotes

[1] These calls from nutritionists, politicians, and others are reported in the popular press in many countries. See for example, *Newsweek* June 25, 2000; *Roll Call* June 1, 2000; *Reuters News Service* June 3, 2000, *Associated Press* June 10, 2000, *Seattle Post-Intelligencer* April 30, 2002; *Australian IT* August 16, 2002, and **www.eas.asu.edu/~nfapp/html/july98.htm** in Australia.

[2] Jacobson and Brownell argued that a "steep" tax would probably reduce the consumption of the taxed foods and could be used to generate funding to subsidize healthful foods; however they also noted that a small tax may be more politically feasible because it would not be noticed by the public but would raise substantial revenues, which could be used to subsidize healthy foods and raise awareness. He estimated that a 1¢ national tax per unit would raise tax revenues of $1.5 billion annually on soft drinks (per 12-ounce), while a 1¢ per pound tax would raise $70 million on candy, $54 million chips, and $190 million on other snack foods or fats and oils. They cite a poll suggesting that 45 percent of U.S. adults would support such a tax.

[3] Cutler et al.; www.cdc.gov/nchs/products/pubs/pubd/hestats/obese/obse99.htm.

[4] **www.obesity.org/subs/fastfacts/Obesity_Minority_Pop.shtml**.

[5] Trans fat is created by vegetable shortening, cracker, cookie, snack food, other food manufacturers when they add hydrogen to vegetable oil—the hydrogenation process—to increase the shelf life and flavor stability of foods.

[6] More generally, about three-quarters of heart disease deaths are attributed to ischemic heart disease (IHD). Roughly a third of the cases of IHD among persons 65 and younger in the United States are due to dietary and lifestyle factors (Strnad 2004).

[7] Maine, the District of Columbia, California, and Maryland have recently repealed snack food taxes. In the application of these taxes, no distinction is made between the levels of fat found in each product. The taxes are simply an equal percent increase in snack food prices.

[8] The two primary differences between an incomplete and a complete demand system are that the budget constraint is an inequality and the demand for the n+1[st] good is not forced to have exactly the same functional form as the goods that are included in the formal model. Incomplete systems can be made complete by identifying the demand for expenditure on other goods, y, through the budget identity, $y = m - \boldsymbol{p}'\boldsymbol{q}$. In the present case, we have

$$y = -\tfrac{1}{2}\boldsymbol{p}'\boldsymbol{Bp} + (1 - \gamma'\boldsymbol{p})(m - \alpha'\boldsymbol{p} - \boldsymbol{p}'\boldsymbol{As} - \tfrac{1}{2}\boldsymbol{p}'\boldsymbol{Bp}).$$

This demand equation also belongs to the generalized AIDS class.

[9] Atlanta, Boston, Cedar Rapids (IA), Chicago, Denver, Detroit, Eau Claire (WI), Grand Junction (CO), Houston, Kansas City, Los Angeles, Memphis, Midland (TX), Minneapolis/St. Paul, New York, Philadelphia, Pittsburgh, Pittsfield (MA), San Francisco/Oakland, Seattle/Tacoma, St. Louis, Tampa/St. Petersburg, and Visalia (CA).

[10] If the general ad valorem retail sales tax rate in the state is τ, then the after-tax nonfood CPI is $(1 + \tau)$CPI. Retail sales tax rates are taken from the Council of State Governments and the regional nonfood CPI's are from the Bureau of Labor Statistics. We linearly interpolate monthly nonfood CPI data to obtain weekly series. We matched each of our IRI cities to one of four CPI regions: Northeast, South, Midwest, and West.

[11] The last category is top coded as income at or above $100,000 (nominal) per year. We arbitrarily set $200,000 as the conditional mean of the top income category. This amount is roughly the mean income level of all U.S. households that earned at least $100,000 per year in the years 1997-1999. We calculated this national average conditional mean income using the full

household income samples in the March supplement of the Continuing Population Survey for each of these three years.

[12] We also tried additional instruments, such as the market shares of each of the eight largest firms in each city and the squared market share variables, with similar results.

[13] A similar point is made in Kuchler et al. with respect to an ad valorem tax on snack foods.

[14] The authors looked at the question of total fat intake from all food categories versus the fat intake from dairy products alone. We found that if a 10 percent fat tax is imposed on all foods that contain fat, the fat intake falls only an extra 0.42 grams. Thus, we can see that the effects of a 10 percent tax on fat intake for dairy products only or on all food products are minimal, and that a tax on dairy products captures most of the ability of a fat tax to reduce fat consumption. Further details are available from the authors upon request.

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Table 1
Laws and Proposed Laws Regulating Foods Containing Sugar and Fats

Jurisdiction	Law/Proposed Law
Arkansas	$2.00 per gallon of soft drink syrup $.21 per gallon for each gallon of bottled soft drinks $.21 per gallon of liquid soft drink produced from powder (*a*) *"Junk food tax" of 1% on items that contain less that 20% of the RDI of a list of vitamins and minerals, either per serving or per 100 calories – exempts beverages, fruits, vegetables, and foods with 4 or more grams of protein per serving, and foods that contain yogurt. The bill is currently inactive.*(a)
Chicago	Fountain drinks are taxed at 9 percent on sales of soft drink syrups
California	Carbonated soft drinks are excluded from sales tax exemption for food. *A bill proposed and excise tax on soft drinks and soft drink syrup:* *$2.00 per gallon of soft drink syrup* *$.21 per gallon for each gallon of bottled soft drinks* *$.21 per gallon of liquid soft drink produced from powder* (*c*)
Connecticut	Exempts from food sales tax exclusions: Soft drinks, soda, candy, and confectionery unless sold in school cafeterias, college dining halls, sororities and fraternities, hospitals, residential care homes, assisted living facilities, senior centers, day care centers, convalescent homes, nursing homes, or rest homes, or unless sold from a vending machine for less than 50 cents (*b*)
Detroit	*Tax fast-food at 2% in addition to a 6% general tax on restaurant food*
Idaho	*Excise tax on soft drinks: 1¢/12 fluid ounces (or fraction) on each bottled soft drink, $1 and in like ratio on each part gallon thereof on each gallon of soft drink syrup, 1¢ on each ounce by weight of dry mixture or fraction thereof used for making soft drinks.*(*c*)
Illinois	Excludes soda from lower sales tax rate for food (*b*)
Indiana	Excludes candy, confectionery, chewing gum, soft drinks, vending machine sales, and prepared food from sales tax exemption (*c*)
Kentucky	Excludes candy, soft drinks, sales from vending machines, and prepared food from sales tax exemption (*c*)
Maine	Excludes soft drinks, iced tea, soda or beverages such as are ordinarily dispensed at bars or soda fountains or in connection with bars or soda fountains, water, including mineral bottled and carbonated waters and ice, candy and confections, and prepared food from sales tax exemption (*b*) *Tax soda: $2 per gallon of syrup or .2 cents per gallon of soft drink. Exempts products of 10 percent or more fruit juice, as well as sales to the government and state exports. Creates a Health Promotion fund with the proceeds to be distributed as follows: 1) 50% on a per-student basis to schools that adopt "polices that prohibit the advertising and sale of soft drinks and candy on all school property and that make available on a daily basis Maine dairy products and fresh in-season farm products for sale as snack foods and as part of regular school meal programs." 2) 50% to go to a dental health residency program at qualifying hospitals* (*a*)
Maryland	*Sales tax (5%) on potato chips, nuts, and other salty snacks* (*c*)
Minnesota	Excludes prepared food sold by retailer, soft drinks, candy, all food sold through vending machines from sales tax exemption (*b*)
Missouri	Inspection fee of $0. 003 per gallon of soft drinks manufactured or sold in the state, up to a maximum of $0.04 per month per case of 24 bottles or cans of a manufacturer's bottling capacity (*a,b*)
Montana	*Tax of 5¢ for each bottle, can or 12 ounces of bulk items of soft drink manufactured or imported by the bottler or importer of soft drinks* (*a*)
Nebraska	*Tax for vending machine items and for bakery goods, candy, snack foods, and soft drinks (a)*
New Jersey	Not exempt from regular sales and use tax: candy and confectionery, and carbonated soft drinks and beverages whether or not sold in liquid form (*b*)
New York	Not exempt from regular sales and use tax: candy confectionery, fruit drinks less than 70% natural fruit juice, soft drinks, and sodas and beverages such are ordinarily dispensed at soda fountains or in connection therewith (other than coffee, tea, and cocoa); all items excluded from the exemption shall be exempt when sold through a vending machine for less than 75¢ (*b*) *Additional 0.25% sales tax on a) food and drink currently taxed, except for bottled water, b) sale and rental of video and computer games, and video game equipment and, sale and rental of video and DVD movies; would require a one percent sales tax on a) food and drink defined as sweets or snacks in the USDA`s National Nutrient Database for Standard Reference and b) admission to movie theaters funds from revenues raised by these provisions to be used in the NYS Childhood Obesity Prevention Program* (*c*)
North Carolina	*Tax (3¢) per container tax on soft drinks to provide funds for education* (*a*)
North Dakota	Excludes from regular sales and use tax exemption: candy or chewing gum, carbonated beverages, beverage commonly referred to as soft drinks containing less that 70% fruit juice, powdered drink mixes, coffee and

	coffee substitutes, cocoa and cocoa products (*b*)
Oklahoma	*Soft drink tax code would levy a tax of $2 per gallon of syrup used to make soft drinks or 21 cents per gallon for bottled soft drinks—exempting exports to other states, sales to the government and any item that contains over 10 percent fruit juice* (*a*)
Rhode Island	Tax of 4¢ on each case (12 24 oz. cans) of beverage containers (soda, carbonated soft drinks, mineral water) (*a,b*)
Tennessee	1.9% of gross receipts derived from manufacturing, producing and selling, or importing and selling, bottled soft drinks (*a,b*)
Texas	Excluded from sales tax exemption: carbonated and noncarbonated packaged soft drinks, diluted juices, ice and candy; and foods and drinks (which include meals, milk and milk products, fruit and fruit products, sandwiches, salads, processed meats and seafood, vegetable juices, ice cream in cones or small cups) served, prepared, or sold ready for immediate consumption in or by restaurants, lunch counters, cafeterias, vending machines, hotels, or like places of business or sold ready for immediate consumption from push carts, motor vehicles, or any other form of vehicle (*a,b*) *A bill would levy a snack tax of 3 percent in addition to the sales tax on all snacks, which include cookies, candy, chips and soft drinks not consumed in restaurants (c).*
Vermont	*A bill would add soft drinks as a taxable item. The revenues would be used in a new Dairy Farm Income Stabilization Fund.* *Extend the sales tax to snack food (long list) (a)*
Virginia	Excise tax on gross receipts from carbonated soft drink sales as follows: • $50 if gross receipts are $100,000 or less • $100 if gross receipts are between $100,000 and $250,000 • $250 if gross receipts are between $250,000 and $500,000 • $750 if gross receipts are between $500,000 and $1 million • $1,500 if gross receipts are between $1 million and $3 million • $3,000 if gross receipts are between $3 million and $5 million • $4,500 if gross receipts are between $5 million and $10 million • $6,000 if gross receipts exceed $10 million (*a,b*)
Washington	$1 per gallon (proportionate for fractional amounts) on each wholesale sale of syrup (concentrate added to water to produce carbonated soda); excludes carbonated beverages, ice, bottled water from sales tax exemption (a,b) *Eliminate state sales tax exemption for candy* (b)
West Virginia	Excise tax on sales, handling, use, or distribution of bottled soft drinks and soft drink syrup: • 1¢ on each bottle of 16 9/10ths fluid ounces or half a liter or fraction of bottled soft drink • 80¢ on each gallon of bottled soft drink • 84¢ on each four liters of soft drink syrup • 1¢ on each ounce or 28. 35 grams of dry mix used to make soft drinks Tax cannot be collected more than once with respect to any bottled soft drink or soft drink syrup made, sold, used, or distributed in the state; revenues to build four-year school of medicine, dentistry, and nursing (a) *Extend soft drink tax to include bottled water, and to change the tax from 1¢ to 5¢s on each 16 9/10ths fluid ounces, from 80¢ to $4.00 per gallon of syrup* (a)

Sources: (a) National Conference of State Legislatures Health Promotion Database; (b) Lohman, Judith S. "Taxes on Junk Food," OLR Research Report, available at: **www.cga.ct.gov/2002/olrdata/fin/rpt/2002-R-1004.htm**; (c) media reports and State Legislature websites.

Table 2
Summary Statistics of the Households that Purchase Dairy Products

Variable	*Mean*	*Standard Error*
Household (HH) Size	2.816	0.176
Weekly Income	854.03	153.289
Own House	0.826	0.074
Race/Ethnicity		
Share White	0.880	0.110
Share Black	0.054	0.075
Share Hispanic	0.045	0.063
Share Asian	0.014	0.032
Male Head of Household		
Age	54.200	2.080
Years of Education	12.900	0.492
Share Unemployed	0.030	0.012
Share Employed Part Time	0.037	0.010
Share Employed Full Time	0.650	0.051
Share Nonprofessional Occupation	0.356	0.113
Technical Education	0.110	0.058
Female Head of Household		
Age	53.551	2.124
Years of Education	13.373	0.398
Share Unemployed	0.226	0.046
Share Employed Part Time	0.170	0.035
Share Employed Full Time	0.366	0.051
Share Nonprofessional Occupation	0.430	0.076
Share Technical Education	0.068	0.039
Children		
Children present in HH	0.350	0.058
Average Number of Young Children Ages 0-5.9	0.133	0.041
Average Number of Middle Children Ages 6-11.9	0.249	0.050
Average Number of Older Children Ages 12-18	0.307	0.064
Share of HH with children with Young Children	0.309	0.059
Share of HH with children with Middle Children	0.524	0.039
Share of HH with children with Older Children	0.562	0.060

Table 3
Equation Summary Statistics

Dairy Product	*Average Quantity Purchased*		*Regression Equation*	
	Mean (ounces)	*Standard Error*	*Error Variance*	R^2
Milk 1%	151.409	77.692	3553.0	.41
Milk 2%	137.592	24.049	107.7	.81
Milk No-Fat	127.630	25.798	101.8	.85
Milk Whole	121.439	27.128	169.4	.77
Fresh Cream	15.298	3.080	3.9	.59
Coffee Additives	30.249	5.194	12.6	.53
Natural Cheese	13.417	2.418	2.2	.63
Processed Cheese	15.780	2.255	2.1	.68
Shredded Cheese	11.834	1.759	1.1	.64
Cream Cheese	11.405	1.641	1.9	.30
Butter	18.302	3.929	11.0	.29
Ice Cream	79.484	12.936	90.1	.46
Yogurt Cooking	22.060	5.937	25.9	.26
Yogurt Flavored	33.882	4.480	9.7	.52

Table 4
Price Elasticities of Demand for Dairy Products Calculated at the Mean of the Explanatory Variables

Dairy Product	*Milk 1%*	*Milk 2%*	*Milk No-Fat*	*Milk Whole*	*Fresh Cream*	*Coffee Additives*	*Natural Cheese*	*Processed Cheese*	*Shredded Cheese*	*Cream Cheese*	*Butter*	*Ice Cream*	*Yogurt Cooking*	*Yogurt Flavored*
Milk 1%	-2.052*	0.019	0.110*	0.168*	-0.038	-0.046*	0.051	0.016	-0.043	0.011	0.095	0.016	-0.113*	0.011
Milk 2%	0.018	-0.742*	0.079*	0.022	-0.050*	-0.045	0.163*	0.105*	0.025	-0.013	0.032*	-0.098*	0.045	-0.031
Milk No-Fat	0.115*	0.084*	-0.628*	-0.022	0.089*	0.091*	-0.048	-0.098*	0.008	-0.013	-0.062*	-0.023	0.211*	0.000
Milk Whole	0.181*	0.025	-0.022	-0.652*	-0.036	-0.072*	-0.222*	-0.098*	-0.047	0.006	0.001	0.023	-0.069	0.030
Fresh Cream	-0.063	-0.084*	0.139*	-0.056	-0.407*	0.022	0.101	0.274*	0.118*	0.173*	0.004	-0.016	-0.139	0.035
Coffee Additives	-0.071*	-0.070	0.130*	-0.103*	0.020	-0.496*	-0.014	0.007	-0.056	-0.082*	-0.016	0.137*	0.019	0.144*
Natural Cheese	0.042	0.140*	-0.039	-0.176*	0.052	-0.007	-0.641*	0.132*	0.040	-0.015	0.014	0.104	-0.035	0.052
Processed Cheese	0.013	0.094*	-0.083*	-0.082*	0.147*	0.004	0.137*	-0.734*	-0.009	-0.122*	-0.019	0.275	0.057	-0.028
Shredded Cheese	-0.038	0.020	0.006	-0.038	0.060*	-0.031	0.039	-0.008	-0.404*	-0.082*	0.022	0.036	0.068	0.044
Cream Cheese	0.014	-0.019	-0.018	0.006	0.149*	-0.076*	-0.026	-0.194*	-0.138*	-0.515*	0.064*	0.128*	-0.225*	-0.012
Butter	0.093	0.033*	-0.056*	0.001	0.003	-0.009	0.019	-0.019	0.029	0.045*	-0.295*	0.136*	0.047	-0.038*
Ice Cream	0.010	-0.062*	-0.013	0.013	-0.006	0.058*	0.077	0.196*	0.028	0.057*	0.087*	-0.741*	0.187*	0.090*
Yogurt Cooking	-0.196*	0.079	0.348*	-0.111	-0.147	0.023	-0.071	0.113	0.142*	-0.276*	0.084	0.520*	-0.911*	-0.070
Yogurt Flavored	0.011	-0.035	-0.001	0.029	0.023	0.103*	0.066	-0.034	0.057	-0.009	-0.044*	0.154*	-0.044	-0.808*

Notes: The table shows the price elasticity given that the price of the good shown in the column changes. An asterisk shows that we can reject the null hypothesis that the elasticity is zero at the 5% significance level.

Table 5
Income Elasticities for Dairy Products

Dairy Product	*Income Elasticity*	*Standard Error*
Milk 1%	-0.558	0.468
Milk 2%	-0.221*	0.058
Milk No-Fat	-0.239*	0.059
Milk Whole	-0.484*	0.075
Fresh Cream	-0.205*	0.098
Coffee Additives	-0.071	0.087
Natural Cheese	-0.209*	0.077
Processed Cheese	-0.040	0.066
Shredded Cheese	-0.115	0.068
Cream Cheese	-0.109	0.091
Butter	-0.676*	0.127
Ice Cream	-0.406*	0.082
Yogurt Cooking	-0.327	0.182
Yogurt Flavored	-0.151*	0.071

Note: An asterisk shows that we can reject the null hypothesis that the elasticity is zero at the 5% significance level.

Table 6
Serving Size and Fat Content for Dairy Product Categories

Dairy Product	*Serving Size*	*Fat grams*	*Percentage Fat*
Milk 1%	1 cup	2.5	1.10
Milk 2%	1 cup	5	2.20
Milk No-Fat	1 cup	0	0
Milk Whole	1 cup	8	3.51
Fresh Cream	1 tablespoon	4.5	31.61
Coffee Additives	1 tablespoon	2	14.05
Natural Cheese	1 ounce	9	31.61
Processed Cheese	0.7 ounces	4.5	23.68
Shredded Cheese	1 ounce	9	31.61
Cream Cheese	2 tablespoons	10	35.12
Butter	1 tablespoon	11	77.27
Ice Cream	½ cup	8	7.02
Yogurt Cooking	6 ounces	1.5	0.88
Yogurt Flavored	6 ounces	1.5	0.88

Notes: We recorded the fat content and serving size information from their labels for many products within each category. We then selected as a representative product for each category the one that most closely matched the average fat content/serving size unit for the category.

Table 7
Changes Due to a Fat Tax on Dairy Products and the Fat Elasticity

	10% Fat Tax			*50% Fat Tax*		
Dairy Product	*Price*[a]	*Quantity*[a]	*Fat*[b]	*Price*[a]	*Quantity*[a]	*Fat*[b]
Milk 1%	0.11	0.46	0.22	0.55	2.30	1.09
Milk 2%	0.22	0.59	0.51	1.10	2.94	2.52
Milk No-Fat	0.00	-0.44	0.00	0.00	-2.21	0.00
Milk Whole	0.35	-1.44	-1.75	1.76	-7.23	-8.78
Fresh Cream	3.16	0.64	0.88	15.81	3.19	4.39
Coffee Additives	1.40	-1.18	-1.43	7.02	-5.91	-7.14
Natural Cheese	3.16	-1.31	-1.58	15.81	-6.54	-7.90
Processed Cheese	2.37	-1.22	-1.24	11.84	-6.11	-6.20
Shredded Cheese	3.16	-1.10	-1.17	15.81	-5.48	-5.84
Cream Cheese	3.51	-1.84	-2.10	17.56	-9.21	-10.51
Butter	7.73	-1.86	-7.50	38.64	-9.32	-37.53
Ice Cream	0.70	1.21	1.92	3.51	6.02	9.57
Yogurt Cooking	0.09	-0.03	0.00	0.44	-0.13	-0.01
Yogurt Flavored	0.09	0.19	0.02	0.44	0.94	0.08
All Dairy Products			13.24			66.24

[a] Percentage change.
[b] Change in fat grams per household per week.

Table 8
Equivalent Variation ($/Year) from a 10% Fat Tax for Various Demographic Groups

			Only Child's Age Bracket		
Demographic Group	*Mean*	*No Children*	0-5.9	6-11.9	12-18
Mean	-40.34	-38.95	-49.79	-34.23	-40.13
White	-40.13	-41.45	-48.98	-33.41	-39.31
Black	-36.34	-37.67	-45.20	-29.63	-35.53
Asian	-48.22	-49.54	-57.07	-41.50	-47.40
Hispanic	-38.75	-40.07	-47.62	-32.04	-37.96
Income=$20,000	-47.38	-46.00	-56.85	-41.27	-47.18
Income=$30,000	-44.50	-43.12	-53.96	-38.39	-44.29
Income=$40,000	-41.61	-40.23	-51.07	-35.50	-41.41
Income=$50,000	-38.72	-37.34	-48.19	-32.61	-38.52
Income=$60,000	-35.84	-34.46	-45.30	-29.73	-35.63
Income=$70,000	-32.95	-31.57	-42.41	-26.84	-32.75
Income=$100,000	-24.29	-22.91	-33.75	-18.18	-24.09
10 Years of Education	-32.69	-33.99	-41.54	-25.97	-31.87
16 Years or Education	-46.35	-47.68	-55.21	-39.64	-45.54
HH Heads 25 Years Old	-24.89	-26.19	-33.74	-18.17	-24.07
HH Heads 35 Years Old	-30.21	-31.53	-39.06	-23.49	-29.39
HH Heads 60 Years Old	-43.55	-44.85	-52.40	-36.82	-42.73
No Children	-38.95				
Young Family[a]	-31.49				
Childless Couple[b]	-41.72				

[a] The young family' household heads are 25 years old, they have a real income of $30,000, the wife is not employed, the husband works in a non-professional occupation, they have two children under 6 years of age, and they rent their dwelling.

[b] The Childless couple's household heads are 40 years old, they have a real income of $60,000, both are working professionals, and they own their dwelling.

Table 9
Annual Tax Revenue Raised from a 10% Fat Tax on Dairy Products

Dairy Product	*Average Household* ($)	*National* ($ million)
Milk 1%	0.19	20.89
Milk 2%	0.36	39.69
Milk No-Fat	0.00	0.00
Milk Whole	0.51	56.42
Fresh Cream	3.12	345.80
Coffee Additives	1.46	15.33
Natural Cheese	5.84	647.73
Processed Cheese	4.24	471.18
Shredded Cheese	5.99	665.50
Cream Cheese	3.87	429.39
Butter	12.50	1,387.40
Ice Cream	1.82	201.63
Yogurt Cooking	0.09	9.39
Yogurt Flavored	0.13	14.62
All Dairy Products	40.10	4,451.60