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The Effects of a Fat Tax on Dairy Products

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Abstract

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DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS AND POLICY
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ABSTRACT:
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Key words: fat tax, incomplete demand system

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The Effects of a Fat Tax on Dairy Products

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. We estimate an incomplete dairy demand system to examine whether a fat tax will cause various demographic groups to substitute lower-fat foods and how much the tax will affect their short-run consumer surplus.

Previous work examining the means to reduce obesity and heart disease have noted the failure of public health interventions focused on reducing biological susceptibility, such as education and behavioral-skills training. Millions of Americans participate in diet programs; however, the levels of heart disease and obesity continue to rise. Several researchers now recommend a policy shift away from the individual and human biology to focus on the food environment. They suggest that an increase in the price of fat may result in reduced fat intake, though the validity of that claim depends on the price elasticity of demand for foods rich in fat.

Accurately knowing the elasticity of demand is crucial in predicting the effects of the program. If the point of the tax is to influence behavior, then a very low elasticity of demand is disappointing because the tax will have little effect on behavior. However, if the point of the tax is to raise tax revenue, then a very low elasticity of demand is desirable.

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 price elasticities for several categories of dairy products. 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 related to 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 type of data used to implement the model follows. We interpret the results of the model in order to provide insight on the appropriateness of a fat tax to reduce the consumption of fat rich dairy products.

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. According to the American Heart Association (2003) over 13 million Americans suffer from coronary heart disease, which includes heart attack, angina pectoris, and other heart problems. 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, 6.8 percent of Mexican-American, and 9 percent of black women suffer from the disease. Coronary heart disease resulted in over 2 million inpatient hospital visits and 500,000 deaths in 2001. The direct costs of coronary heart disease health care and indirect costs, due to the loss of productivity exceed $133 billion (Willet), and obesity related medical expenditures are $75 billion (Finkelstein, Fiebelkorn, and Wang).

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 both types of cholesterol levels, but the overall effect is negative. Trans fats raise particular health concerns as they decrease levels of HDL and raise levels of LDL.[1] 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.[2]

The main sources of saturated fats in American diets include whole milk, butter, cheese, ice cream, red meat and coconut products, and 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. (2001) examine 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 percent of daily calories made up of total fat continually declined from 39 percent in 1965 to 33 percent

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[1] 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.

[2] 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).

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.

The percent of overweight and obese Americans rose from 45 percent to 65 percent from 1960 to 2002.[3] In 1999-2000, 60 percent of black males, 68 percent of white males, and 74 percent of Mexican-American males were overweight or obese.[4] The corresponding fractions were 78 percent for black, 58 percent for white, and 72 percent of Mexican-American women.

Many explanations have been suggested for the increase in the weight. Employment issues including employment status (Ruhm), income levels, hours worked, participation in the work force by various demographic groups (Chou, Grossman and Saffer), and job strenuousness (Lakdawalla and Philipson) have been related to increased levels of obesity. The declining price (Cawley) and time costs of food (Cutler, Glaeser and Shapiro) 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. Several researchers (Battle and Brownell; Jeffery) suggest that changing these types of environmental characteristics may prove more effective at influencing the level of fat intake than policies directed at modifying individual food choices through education or other public health instruments.

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[3] Culter, Glaeser and Shapiro; **www.cdc.gov/nchs/products/pubs/pubd/hestats/obese/obse99.htm.**

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

Jeffery, French, Raether, and Baxter (1994) 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. Other work (French, Jeffery, Story, Breitlow, Baxter, Hannan and Snyder; French, Jeffery, Story, Hannan and Snyder) 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). Maine, the District of Columbia, California, and Maryland have recently repealed snack food taxes.[5] Table 1 shows that many U.S. jurisdictions have or are considering laws regulating sugar and snack foods (fats). 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. Some of the earliest calls for a fat tax are: Brownell; Ahmad; Marshall; Nestle; and Rosin.[6] However, others view such a tax as an unnecessary government imposition (The Economist) that might have unintended consequences that mitigates its effectiveness (Kuchler,

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[5] 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.

[6] These calls occur 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, 20002, and **www.eas.asu.edu/~nfapp/html/july98.htm** in Australia.

et. al, 2005). In addition, the fast food industry has been hit with a sequence of lawsuits for providing excessive fats and causing obesity.

Previous Dairy Demand Studies

To determine the effects of a fat tax on dairy products we need to determine how changes in prices are likely to affect demand (and possibly supply). Several previous studies estimated the demand elasticities of dairy products. Heien and Wessells (1988) used a Heckman two-step procedure to estimate an almost ideal demand system (AIDS). They determined that as the average household member ages, and the proportion of meals eaten at home increased the amount of dairy products purchased decreased. They found large negative own-price elasticities and substantial positive cross-price elasticities. In a subsequent study, Heien and Wessells (1990) found that demand elasticities for milk, cheese, cottage cheese, butter, margarine, and ice cream are all inelastic when using the censored equation.

Park et al. (1996) and Huang and Lin (2000) 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 -.009 and -.529 respectively, and -.243 and -.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 -.78 and an income elasticity of -.77.

In an attempt to provide more accurate elasticity measures, Bergtold, Akobundu and Peterson (2004) used household level scanner data and a flexible and separable translog multistage demand system. They included many more product categories and found elasticities near -.6 for sour cream, -.7 for non-shredded cheese and skim or low-fat milk, -.9 for shredded cheese, whole milk, ice cream and yogurt, and –1.9 for imitation cheese and cheese spreads.

Incomplete Demand System

We use a generalized Almost Ideal Demand System (AIDS) that is linear and quadratic in prices and linear in income (hereafter, the LQ-IDS). The structure of this model was introduced in LaFrance (1990) and recently has been shown to be a special case of a very general extension of the AIDS model to incomplete systems (LaFrance 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

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

where $\boldsymbol{q}$ is the vector of quantities demanded, α and γ are vectors of parameters, $\boldsymbol{A}$ is a matrix of parameters, $\boldsymbol{B} = \boldsymbol{B}^{\top}$ (a superscript $^{\top}$ denotes the transpose of a matrix or vector) is a symmetric 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. 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

$$e(\boldsymbol{p}, \tilde{\boldsymbol{p}}, \boldsymbol{s}, u) = \alpha^{\top}\boldsymbol{p} + \boldsymbol{p}^{\top}\boldsymbol{As} + \tfrac{1}{2}\boldsymbol{p}^{\top}\boldsymbol{Bp} + \theta(\tilde{\boldsymbol{p}}, \boldsymbol{s}, u)e^{\gamma^{\top}\boldsymbol{p}}, \tag{2}$$

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

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

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

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

with typical element,

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

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

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

In matrix notation, if we let $\boldsymbol{P} = \mathbf{diag}[p_i]$, $\boldsymbol{Q} = \mathbf{diag}[q_i]$, and $\boldsymbol{E}_{\boldsymbol{q}}^{\boldsymbol{p}} = [\varepsilon_{q_i}^{p_j}]$ then we can write (6) in the form

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

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

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

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

$$\boldsymbol{\varepsilon}_{\boldsymbol{q}}^{m} = m\boldsymbol{Q}^{-1}\gamma. \tag{9}$$

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

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

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

$$\theta(\tilde{\boldsymbol{p}}, \boldsymbol{s}, u_1) \equiv \left[m - \left(\boldsymbol{\alpha}_0^{\top} \boldsymbol{s} + \boldsymbol{\alpha}^{\top} \boldsymbol{p}_1 + \boldsymbol{s}^{\top} \boldsymbol{A}^{\top} \boldsymbol{p}_1 + \tfrac{1}{2} \boldsymbol{p}_1^{\top} \boldsymbol{B} \boldsymbol{p}_1 \right) \right] e^{-\boldsymbol{\gamma}^{\top} \boldsymbol{p}_1}, \tag{11}$$

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, $\boldsymbol{p}_1$,

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

Solving for *ev* then gives

$$ev = \left(m - \boldsymbol{\alpha}^{\top} \boldsymbol{p}_1 - \boldsymbol{p}_1^{\top} \boldsymbol{A} \boldsymbol{s} - \tfrac{1}{2} \boldsymbol{p}_1^{\top} \boldsymbol{B} \boldsymbol{p}_1 \right) e^{\boldsymbol{\gamma}^{\top} (\boldsymbol{p}_0 - \boldsymbol{p}_1)} - \left(m - \boldsymbol{\alpha}^{\top} \boldsymbol{p}_0 - \boldsymbol{p}_0^{\top} \boldsymbol{A} \boldsymbol{s} - \tfrac{1}{2} \boldsymbol{p}_0^{\top} \boldsymbol{B} \boldsymbol{p}_0 \right). \tag{13}$$

The compensating variation for this model can be shown to satisfy $cv = ev \times e^{\boldsymbol{\gamma}^{\top} (\boldsymbol{p}_1 - \boldsymbol{p}_0)}$. As a result, we focus here 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. The reason is that 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 this, first note that the rate of change in the demand for the i^{th} good with respect to the i^{th} price is

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

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

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

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,

$$\frac{\partial q_i}{\partial s_k} = a_{ik} - \gamma_i \sum_{j=1}^{n} a_{jk} p_j \ . \tag{16}$$

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 $\boldsymbol{\gamma}$, 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

$$\frac{\partial^2 q_i}{\partial p_i \partial s_k} = -\gamma_i a_{ik} \ . \tag{17}$$

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 $a_{ik} > 0$, 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,

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

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

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

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

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 elasticities of demand will behave differently than 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.[7] The city populations range from 50,000 to several million. Each region of the country is represented with 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 this household data to city-level weekly average household expenditures.

The dependent variable in the incomplete demand system is the average expenditure of the sample of households in each city for each dairy product in each week, deflated by a state-level consumer price index for non-food items. We also aggregated the thousands of individual dairy UPC codes into 14 product categories: non-fat milk, 1% milk, 2% 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. The average household expenditure for each category is the sum of the expenditures for each UPC code within that category divided by the number of households that purchased any product in the category.

For each of the dairy product categories in each city and for each week, we calculated 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

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

where, p_{jt} is the average price for dairy product category j in week t, n_j is the number of unique

[7] 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).

UPC codes for that product category, $\bar{q}_{i_j}$, $i_j = 1,\ldots,n_j$, 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 regional after-tax consumer price index for all items less food for all urban consumers, not seasonally adjusted (hereafter, nonfood CPI).[8] 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.[9] 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

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[8] If the general ad valorem retail sales tax rate in the state is α, then the after-tax nonfood CPI is $(1 + \alpha)$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.

[9] The last category is top coded as income at or above \$100,000 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.

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.

Table 2 shows the sample means and standard errors of the continuous variables and the proportions of households with the discrete characteristics that are included in the demand system. Not shown in the table, but also included in the empirical model, are dummy variables to incorporate city-level fixed effects. 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, and the ages of the heads of household.

Demand System Estimates

Table 3 presents summary statistics for the equation 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 R^2 measure that we report is the squared correlation between the observed and predicted dependent variables. The R^2 indicated that this demand model fits the data reasonably well.

Coefficients

We estimated the LQ-IDS demand model for the 14 dairy product categories using a large number of demographic variables. It therefore is not practical to report all of the coefficient estimates in a table.[10] Thus, we report in Table 4 a subset of the demographic coefficients for each equation: the ethnicity variables, the average age of male heads of household (these results are similar to those for the average age of female heads of household), the share of home ownership, and the share of households with children under 6 years of age.

For the 1% and 2% milk equations, we can reject the null-hypothesis that the coefficients are zero at the 0.05 level for all but one coefficient. Families with young children demand less low-fat milks: The fraction of households with young children has statistically significant negative effects on demand for 1%, 2%, and no-fat milk, but has statistically insignificant effects on other dairy products.

Ethnicity also affects a few of the non-milk dairy products (particularly some of the cheeses and ice cream). For most dairy products, we cannot reject (at the 5% significance level) the hypothesis that the coefficient on the age of the male household head is positive. The

[10] A complete set of empirical results is available from the authors upon request.

exceptions are ice cream and yogurt, where the demand decreases with the age of a male head of household, and cream, butter, and cooking yogurt where the effect is not statistically significant. Home ownership has statistically significant effects on 1% milk, cream, and processed cheese.

Collectively, the demographic variables are statistically quite important. For example, a χ^2 test that the coefficients for all of the ethnicity share variables in all of the demand equations are collectively zero is $\chi^2(56) = 410.41$ with a *p*-value of 0.00000. An analogous test on the employment variables is $\chi^2(112) = 557.67$ (0.00000), and on all of the children variables is $\chi^2(98) = 432.10$ (0.00000).

Similar patterns hold for other demographic variables: They are statistically significant in some but not all equations and 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.

Elasticities

As the prices of dairy products change due to a fat tax, consumers alter the mix of dairy products that they demand. Table 5 shows the own- and cross-price elasticities for various categories of dairy products calculated at the mean of the variables (from Table 2). Each cell shows the price elasticity for a change in the product listed at the top of the column.

All of the own-price elasticities are negative, statistically significant, and inelastic. This is consistent with the previous literature. The magnitudes of our point estimates are similar. The own-price elasticities of demand for the four types of fresh milk (1%, 2%, no-fat, and whole) range from –0.622 for no-fat milk to -0.882 for 1% milk. The other dairy products are generally even less elastic, down to cream cheese, which has an elasticity of -0.185. There are roughly equal numbers of positive and negative cross-price elasticities of demand, but all of these elasticities are very close to zero—mostly below 0.05 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% level of significance.

Even though many of the demographic variables are statistically significant, the own-price elasticities of demand do not vary much across demographic groups. 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 appears to happen here.

Table 6 reports the income elasticities evaluated at the mean. All of the income elasticities are negative and nine (including all of the milk products) are statistically different from zero at the 5% significance level. The income elasticities also 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.

Effect of Taxes on Consumption

Many possible taxes have been applied or proposed (Table 1). However, if the intent is to discourage fat consumption, a tax on the percentage of fat (analogous to a carbon tax used to control pollution) seems appropriate. Table 7 shows the proportion of fat in each of our categories.

A tax on the percentage of fat would have unequal effects on prices. If a product is competitively supplied with a horizontal supply curve, the tax will have a proportional effect on the final retail price. Given these assumptions and the price elasticities in Table 5 we can calculate the quantity effects of a 10% fat tax on the consumption of dairy products.[11] Given that the elasticities do not vary substantially across groups, we report only average effects in Table 8.

Because the price elasticities are relatively inelastic, the tax has relatively small effects on total quantity. A similar point is made in Kuchler et al. with respect to an ad valorem tax on snack foods. However, it is still possible that the tax can have a more substantial effect on fat consumption. The second column of Table 8 shows the estimated percentage change in the quantity of the good demanded for each category, while the third column shows the change in fat grams per household per week. Given that the average family has 2.82 members, the average person consumes 7.4 fewer grams of fat per week—or slightly over 1 gram per day—due to the tax. The U.S. Department of Agriculture 2005 Dietary Guidelines Advisory Committee Report recommends 24 grams of healthy fat per day on a 2,000-calorie diet, and the average consumption was 75 grams daily from 1994-1996. Thus, the reduction in fat is a relatively small effect.[12]

Short-Run Welfare and Tax Effects

Many people would be even better off if they cut back their fat consumption without the tax: A growing proportion of the population is obese and suffers from diet-related health conditions. According to most proponents, the main justification for a fat tax would be to

[11] We also simulated the effects for other tax percentages. The change in quantity is proportional to the change in the tax.

[12] A gram of fat contains about 9 calories. It takes a reduction of about 100 calories a day for the average person to lose one pound of body weight in a month.

increase the health of these 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.

However, in the short-run, consumers will view themselves as being worse off, as they have to pay more for the dairy goods that they consume. Table 9 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. Thus, the first row of the first column shows the mean for all variables. We report the equivalent variation as the annual change in wealth, -$22.11, that a consumer is willing to accept instead of experiencing a 10% fat tax evaluated at the mean of the explanatory variables. Poorer families (average income of $10,000) suffer a greater loss, $25.69, and those with higher incomes ($30,000) face a lesser loss, $20.75. Black families suffer a relatively small loss, $20.88, which may be due to their relatively high level of lactose intolerance. The table shows the equivalent variations for a number of groups. They range between -$19.40 and -$26.25.

The welfare effects of a 10% tax applied to the fat in dairy products are large. Given that the average household would be willing to accept an income reduction of $22 instead of facing the tax and there are 111 million U.S. households, the total national welfare effect of a 10% tax on fat in dairy products would be $2.5 billion annually.

If we believe that tax equity is defined by progressive tax systems where people with higher incomes pay a larger percentage of their incomes in the form of taxes, then a uniformly low price elasticity, such as which we observe, makes the fat tax inequitable. A 10% tax on the fat in dairy products is very regressive in terms of the *regulatory burden*: the annual equivalent variation associated with the tax divided by a household's annual income. In Figure 1, we show how the regulatory burden for the average family declines rapidly with income. The burden is

0.35% at an income of $7,500. It falls to 0.26% at $10,000, 0.12% at $20,000, 0.07% at $30,000, 0.016% at $70,000. The burden is slightly negative –0.01 at $200,000 (not shown in the figure.) The regulatory burden curves associated with different ethnicities do not vary much from the average household. The curves for white, black, and Asian families lie slightly below and that for Hispanic families lies slightly above the average curve.

One obvious benefit to the government is that it would raise substantial tax revenues. The second column of Table 10 shows the annual tax burden on a typical household is slightly less than $22. However, when that amount is multiplied by 111 million households, the government raises more than $2.4 billion.[13]

Summary and Conclusions

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 are relatively inelastic and vary little across demographic groups. As a consequence, a 10% tax on fat content has relatively little effect on the quantity of dairy products consumed of any group. More importantly, our simulations suggest that such a tax has only a 1.4% reduction in average fat consumption. To have a substantial effect, the tax rate would have to be extremely high.

Although an inelastic demand elasticity makes the tax unsuitable for affecting behavior, it makes it an efficient means of raising tax revenue. However, this tax is very regressive.

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[13] Some may contend that the welfare computations should consider externalities associated with obesity and unhealthy diets; diet related health care costs are large and are partially borne by others without unhealthy diets. However, research of similar externalities for cigarette smoking suggests that positive and negative externalities cancel each other out, justifying little, if any, tax (Strnad, 2004).

Clearly in the short run, a 10% 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. Indeed, the elderly and the poor suffer greater welfare losses—reinforcing the regressive nature of this tax.

Thus, to justify a fat tax, one needs to look for offsetting long-run health increases, which result in long-run increases in welfare due to longer lives (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 "sin taxes"—possibly very large—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 will bear the burden of the tax as well as poor health.

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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% 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% 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 Variables

	Mean (standard deviation)
Household (HH) Size	2.82 (0.18)
Income	471.76 (84.69)
Own house	0.83
Race/Ethnicity	
Black	0.054
Hispanic	0.045
Asian	0.014
Male Household Head	
Age	54.20 (2.08)
Years of Education	12.90 (0.49)
Technical Education	0.11
Unemployed	0.030
Employed Part Time	0.037
Employed Full Time	0.65
Nonprofessional Occupation	0.36
Female Household Head	
Age	53.55 (2.12)
Unemployed	0.23
Years of Education	13.37 (0.40)
Technical Education	0.068
Employed Part Time	0.17
Employed Full Time	0.37
Nonprofessional Occupation	0.43
Children	
Have children present in HH	0.35
Share of HH with children with Children Ages 0-5.9	0.31
Share of HH with children with Children Ages 6-11.9	0.52
Share of HH with children with Children Ages 12-18	0.56
Average Number of Children 0-5.9	0.13 (0.04)
Average Number of Children 6-11.9	0.25 (0.05)
Average Number of Children 12-18	0.31 (0.06)
	Mean (standard deviation)

Table 3
Equation Summary Statistics

	Dependent Variable		*Regression Equation*	
	Mean	*S.E.*	^{2}	R^2
1% Milk	1.671	.303	.038	.59
2% Milk	1.684	.266	.015	.78
Nonfat Milk	1.579	.274	.015	.80
Whole Milk	1.545	.335	.025	.78
Cream	1.016	.204	.019	.56
Coffee	1.100	.174	.017	.44
Natural Cheese	1.963	.356	.044	.65
Processed Cheese	1.884	.272	.028	.62
Shredded Cheese	1.996	.259	.036	.47
Cream Cheese	1.178	.204	.023	.46
Butter	1.711	.445	.111	.44
Ice Cream	2.662	.465	.100	.54
Cooking Yogurt	.958	.243	.046	.22
Other Yogurt	1.534	.213	.020	.57

Notes: “Cooking yogurt” is plain and vanilla yogurt. “Other yogurt” is yogurt of all other flavors.

Table 4
Coefficients on Selected Demographic Variables

	White	*Black*	*Hispanic*	*Asian*	*Male Age*	*Own House*	*Young Children*
1% Milk	**-345.84**	**-498.84**	**-215.14**	**-288.51**	**5.76**	**-44.36**	**-96.45**
2% Milk	**165.74**	29.93	**295.10**	**159.79**	**2.72**	14.14	**-57.25**
Nonfat Milk	24.63	-72.91	82.79	-76.88	**3.24**	-5.10	**-42.47**
Whole Milk	-23.23	**-125.43**	73.97	-11.68	**1.40**	-4.15	-8.96
Cream	-20.00	-12.44	-1.03	-19.48	-.06	**11.73**	-1.74
Coffee Creamer	-8.33	-5.57	7.70	**-69.20**	**.71**	-6.23	-4.57
Natural Cheese	-12.75	**-20.15**	-9.76	**-22.94**	**.25**	-.23	-.61
Processed Cheese	**-26.80**	**-27.23**	**-23.43**	**-28.10**	**.22**	**-4.15**	2.81
Shredded Cheese	3.65	-2.83	5.19	2.66	**.24**	-1.10	2.85
Cream Cheese	-14.74	-15.24	-12.70	-19.74	**.28**	3.24	-1.91
Butter	-24.83	-16.11	-37.23	-10.45	-.19	1.11	-5.79
Ice Cream	**-108.48**	**-169.27**	-71.53	**-137.57**	**-2.43**	7.40	-15.99
Cooking Yogurt	-16.87	-43.21	-2.34	-59.23	-.34	-11.09	-9.17
Yogurt	-31.32	**-54.36**	-24.78	-20.59	**-.41**	4.48	6.93

Notes: Male Age is the average. The other variables are proportions. The coefficient is boldfaced if we can reject the null hypothesis that it is zero at the 0.05 significance level.

Table 5

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

	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*
1% Milk	**-0.882** (0.026)	**0.091** (0.014)	**0.122** (0.014)	**0.135** (0.015)	0.014 (0.015)	0.001 (0.013)	**0.073** (0.021)	**0.045** (0.017)	-0.012 (0.014)	-0.023 (0.016)	-0.009 (0.012)	**-0.055** (0.026)	**-0.083** (0.028)	-0.027 (0.016)
2% Milk	**0.089** (0.014)	**-0.788** (0.027)	**0.078** (0.022)	**0.097** (0.023)	-0.016 (0.018)	**-0.066** (0.019)	**0.095** (0.032)	0.007 (0.027)	0.012 (0.009)	-0.014 (0.015)	0.012 (0.009)	-0.027 (0.024)	0.019 (0.026)	-0.020 (0.017)
Milk No-Fat	**0.128** (0.015)	**0.083** (0.023)	**-0.622** (0.034)	0.010 (0.026)	0.030 (0.021)	**0.059** (0.022)	-0.037 (0.029)	**-0.089** (0.032)	-0.003 (0.014)	0.008 (0.020)	**-0.032** (0.010)	0.005 (0.024)	**0.121** (0.028)	0.019 (0.019)
Milk Whole	**0.146** (0.016)	**0.107** (0.025)	0.011 (0.026)	**-0.742** (0.041)	-0.028 (0.021)	**-0.054** (0.021)	**-0.177** (0.035)	-0.019 (0.032)	-0.021 (0.015)	0.021 (0.017)	0.010 (0.012)	-0.010 (0.030)	-0.025 (0.031)	0.010 (0.022)
Fresh Cream	0.022 (0.024)	-0.026 (0.030)	0.047 (0.032)	-0.044 (0.032)	**-0.421** (0.052)	0.033 (0.035)	**0.108** (0.053)	**0.196** (0.048)	0.039 (0.037)	0.015 (0.051)	0.004 (0.023)	0.066 (0.052)	**-0.123** (0.056)	0.037 (0.035)
Coffee Additives	0.001 (0.020)	**-0.102** (0.029)	**0.085** (0.031)	**-0.077** (0.030)	0.031 (0.032)	**-0.477** (0.049)	-0.006 (0.044)	-0.006 (0.046)	-0.034 (0.031)	**-0.098** (0.033)	-0.009 (0.017)	**0.126** (0.048)	-0.021 (0.057)	**0.102** (0.032)
Natural Cheese	**0.061** (0.018)	**0.081** (0.027)	-0.029 (0.023)	**-0.139** (0.028)	**0.056** (0.028)	-0.003 (0.025)	**-0.721** (0.050)	**0.208** (0.036)	0.015 (0.015)	**-0.109** (0.028)	0.022 (0.013)	**0.126** (0.042)	-0.021 (0.036)	**0.057** (0.024)
Processed Cheese	**0.038** (0.015)	0.006 (0.025)	**-0.075** (0.027)	-0.016 (0.026)	**0.105** (0.026)	**-0.003** (0.027)	**0.216** (0.037)	**-0.773** (0.053)	0.006 (0.022)	**-0.084** (0.020)	-0.006 (0.013)	**0.161** (0.036)	0.066 (0.036)	-0.010 (0.026)
Shredded Cheese	-0.012 (0.012)	0.010 (0.007)	-0.003 (0.011)	-0.017 (0.012)	0.020 (0.019)	-0.019 (0.017)	0.014 (0.015)	0.006 (0.021)	**-0.253** (0.082)	-0.034 (0.020)	-0.001 (0.013)	-0.008 (0.025)	0.026 (0.016)	0.005 (0.014)
Cream Cheese	-0.034 (0.023)	-0.020 (0.021)	0.010 (0.026)	0.027 (0.023)	0.013 (0.044)	**-0.092** (0.031)	**-0.183** (0.047)	**-0.134** (0.032)	-0.059 (0.033)	**-0.185** (0.0003)	-0.007 (0.017)	0.080 (0.082)	**-0.158** (0.047)	0.024 (0.034)
Butter	-0.008 (0.012)	0.013 (0.009)	**-0.028** (0.009)	0.009 (0.011)	0.003 (0.014)	-0.005 (0.011)	0.026 (0.014)	-0.005 (0.014)	-0.000 (0.015)	-0.004 (0.012)	**-0.410** (0.023)	**0.187** (0.023)	**0.034** (0.016)	-0.012 (0.012)
Ice Cream	**-0.035** (0.016)	-0.016 (0.015)	0.004 (0.014)	-0.006 (0.018)	0.025 (0.020)	**0.053** (0.020)	**0.093** (0.031)	**0.115** (0.025)	-0.005 (0.019)	0.036 (0.036)	**0.120** (0.015)	**-0.803** (0.049)	**0.097** (0.030)	**0.059** (0.020)
Yogurt Cooking	**-0.145** (0.049)	0.0340 (0.046)	**0.201** (0.045)	-0.040 (0.050)	**-0.130** (0.059)	-0.023 (0.065)	-0.042 (0.075)	0.132 (0.071)	0.0556 (0.034)	**-0.193** (0.058)	**0.060** (0.029)	**0.270** (0.082)	**-0.683** (0.155)	0.095 (0.057)
Yogurt Flavored	-0.031 (0.018)	-0.022 (0.019)	0.0196 (0.019)	0.009 (0.009)	0.024 (0.023)	**0.073** (0.023)	**0.072** (0.030)	-0.012 (0.032)	0.007 (0.018)	0.019 (0.026)	-0.014 (0.013)	**0.102** (0.035)	0.059 (0.036)	**-0.773** (0.034)

Table 6

Income Elasticities for Dairy Products

	Income Elasticity	*Standard Error*
1% Milk	**-0.511**	0.071
2% Milk	**-0.162**	0.054
Milk No-Fat	**-0.168**	0.052
Milk Whole	**-0.333**	0.066
Fresh Cream	**-0.228**	0.102
Coffee Additives	-0.090	0.090
Natural Cheese	**-0.242**	0.075
Processed Cheese	-0.056	0.063
Shredded Cheese	-0.141	0.073
Cream Cheese	-0.065	0.110
Butter	**-0.523**	0.138
Ice Cream	**-0.294**	0.075
Yogurt Cooking	**-0.445**	0.183
Yogurt Flavored	-0.113	0.068

Note: The elasticity is bold if we cannot reject the null hypothesis that it is zero at the 0.05 level.

Table 7

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
Whole Milk	1 cup	8	3.51
Non-fat Milk	1 cup	0	0
Coffee Creamers	1 tablespoon	2	14.05
Fresh Cream	1 tablespoon	4.5	31.61
Processed Cheese	0.7 ounces	4.5	23.68
Natural Cheese	1 ounce	9	31.61
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
Plain Yogurt	6 ounces	1.5	0.88
Flavored Yogurt	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 8

Effect of a 10% Fat Tax on Dairy Product Categories

Dairy Product	*Percentage Quantity Change*	*Change in Fat Grams per Household per Week*
Milk 1%	0.12	0.05
Milk 2%	0.11	0.09
Whole Milk	-0.91	-1.10
Non-fat Milk	-0.32	0
Fresh Cream	-0.24	-0.33
Coffee Creamer	-1.07	-1.29
Natural Cheese	-1.71	-2.05
Processed Cheese	-1.01	-0.50
Shredded Cheese	-0.84	-0.88
Cream Cheese	-1.82	-4.13
Butter	-2.92	-11.7
Ice Cream	1.18	0.93
Plain Yogurt	-0.18	-0.01
Flavored Yogurt	0.36	0.03
Total		-20.88

Table 9

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

			Only Child's Age Bracket		
Demographic Group	*Mean*	*No Children*	*0-5.9*	*6-11.9*	*12-18*
Mean	-22.11	-23.06	-26.25	-19.40	-20.03
White	-21.94	-24.68	-25.86	-18.84	-19.47
Black	-20.88	-23.62	-24.63	-17.78	-18.41
Asian	-21.53	-24.27	-25.28	-18.42	-19.06
Hispanic	-22.91	-25.65	-26.67	-19.81	-20.44
Income=$10,000	-25.69	-26.65	-29.84	-22.98	-23.62
Income=$30,000	-20.75	-21.71	-24.91	-18.05	-18.68
10 Years of Education	-17.58	-20.31	-21.33	-14.47	-15.11
16 Years or Education	-25.55	-28.29	-29.30	-22.44	-23.08
HH Heads 25 Years Old	-10.41	-13.15	-14.16	-7.31	-7.94
HH Heads 35 Years Old	-15.60	-18.34	-19.35	-12.50	-13.13
HH Heads 60 Years Old	-24.25	-26.98	-28.00	-21.14	-21.78
No Children	-23.06				
Young Family[a]	-21.99				
Childless Couple[b]	-24.27				

[a] The young family's household heads are 25 years old, they have a real income of $10,000, 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 35 years old, they have a real income of $30,000, both are working professionals, and they own their dwelling.

Table 10
Annual Tax Revenue ($) Raised from a 10% Fat Tax on Dairy Products

	Annual Tax Revenue from an Average Household ($)	Annual National Tax Revenue ($ million)
1% Milk	0.0988	11.0
2% Milk	0.1924	21.4
Nonfat Milk	0.0000	0
Whole Milk	0.2808	31.2
Cream	1.7004	188.7
Coffee Creamer	0.8008	88.9
Natural Cheese	3.1876	353.8
Processed Cheese	2.3296	258.6
Shredded Cheese	3.2968	365.9
Cream Cheese	2.1216	235.5
Butter	6.8068	755.6
Ice Cream	0.9932	110.2
Cooking Yogurt	0.0416	4.6
Yogurt	0.0728	8.1
Total Tax Revenue from all Products	21.9232	2,433.5

Figure 1
Percent of the Regulation Burden on Income for Various Income Levels