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Milk Marketing Order Winners and Losers

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Abstract *Determining the impacts on consumers of governmental policies that affect the demand for food products requires a theoretically consistent micro-level demand model. We estimate a system of demands for weekly city-level dairy product purchases by nonlinear three-stage least squares to account for joint determination between quantities and prices. We analyze the distributional effects of federal milk marketing orders, and find results that vary substantially across demographic groups. Families with young children suffer, while wealthier, childless couples benefit. We also find that households with lower incomes bear a greater regulatory burden due to marketing orders than those with higher income levels.*

Key words: consumer welfare, dairy product demand, distribution, federal milk marketing orders.

JEL Codes: D12, E21, H22, Q18.

Introduction

The U.S. dairy industry has been subjected to more governmental intervention and regulation than almost any other domestic industry. This intervention is divided into three major areas: the dairy price support program; import quotas on dairy products; and federal milk marketing orders (FMMOs). For several decades, these three policy instruments were closely connected and operated jointly to establish farm, wholesale, and retail prices for milk and manufactured products. But by the mid-1980s, price supports had become essentially irrelevant to market outcomes in the dairy industry, and trade policy was renegotiated in the 1986 General Agreement on Trades and Tariffs (GATT) Uruguay Round (Cox, Coleman, Chavas, and Zhu 1999). On the other hand, the Federal Agriculture Improvement and Reform Act of 1996 mandated reforms to the FMMO program. These reforms included changing the way that minimum prices paid to farmers were determined and consolidating the number of FMMOs from 42 to between ten and fourteen by January 2000. The period of 1997–1999 was a significant transition period, and thus far these reforms' effects on dairy product consumers have not been thoroughly analyzed.

To better understand the FMMOs' distributional effects on consumers during this period, this paper applies an econometric model of the retail demand for fourteen dairy products. The model analyzes weekly city–level purchases of dairy products matched with demographic characteristics of the purchasing households in twenty-two cities across the United States during the program's transition period of 1997–1999. The model is flexible with respect to estimated price and income effects, and satisfies the conditions that are necessary and sufficient for the existence of a rational, representative consumer in each city.

There are four important gains that can be expected from the approach taken in this paper. First, a higher level of product disaggregation in the empirical model increases the degree of substitution across goods. For example, whole milk, 2%, 1%, and nonfat beverage milk should be close substitutes. Indeed, if the price of 2% milk is higher than the average of the prices of whole and nonfat milk, then mixing two half gallons of each of the latter types would give approximately 1.9% milk at a lower cost than a gallon of 2% milk. A similar argument applies to the price of 1% milk relative to the average of the prices of 2% and nonfat milk. Thus, we expect *ex ante* that the estimated own-price elasticities of demand will increase in the empirical model, and this is precisely what we find relative to existing literature.

The second gain is that nonlinear three-stage least squares estimation methods are used to account for simultaneous determination of prices and quantities. This also should increase the point estimates for the own–price elasticities of demand, and improve the bias, consistency, and precision of those estimates.

The third gain of the paper is that the model chosen for the empirical analysis is associated with a null hypothesis of zero for each price and income elasticity, which is the appropriate null in a valid statistical analysis. This contrasts to a null hypothesis of negative unity for own-price elasticity and positive unity for income elasticity in the Almost Ideal Demand System. Thus, we expect the inferences drawn from the model specification employed in this paper to be less biased and inconsistent.

The paper's fourth gain is the functional form for the dependent and independent variables, which are linear in quantities, prices, and income. This contrasts to the standard use of budget shares as dependent variables and natural logarithms of prices and income on the right-hand side of the demand equations. The functional form used in this paper generates a demand model with a much larger region of economic regularity (LaFrance, Beatty, and Pope 2005). Thus, *ex ante*, the empirical model can be expected to be more useful for welfare and other economic analyses than alternative functional forms.

To set the stage for this analysis, a brief history of domestic federal policy in the dairy industry is presented. This is followed by a description of the model and its properties, a description of the data and its use in the empirical model, the estimation techniques and results, a simulation analysis of the welfare effects of FMMOs during this period, and our summary and conclusions.

History of Federal Domestic Dairy Policy

The Dairy Price Support Program

The origins of federal dairy policy trace back to the Agricultural Adjustment Acts of 1933 and 1935, which were part of the New Deal. The Agricultural Act of 1949, which made the program permanent, specifies that farm milk prices are to be supported at between 75–90% of parity and authorizes the Secretary of Agriculture to determine the specific price support level within this range. Parity is defined by the index of prices paid by farmers for commodities and services, interest, taxes, and wages relative to the base period 1910–1914. For example, this index reached 2,244 in January 2008, and the parity price equivalent for manufacturing grade milk was $40.40 per hundred pounds (cwt) of farm milk (NASS, USDA, *Agricultural Prices* January 2008), while the parity price for all milk was $43.76/cwt in January 2008 and $47.10/cwt in April 2008 (NASS, USDA, *Agricultural Prices* April 2008).

Farm milk prices are supported indirectly by the Commodity Credit Corporation (CCC) through governmental purchases of butter, cheese, and nonfat dry milk from the processors of these products. The purchase prices for these products are pre-announced and determined by formulas that include a manufacturing "make margin" intended to cover an averagely efficient processing plant's cost of converting milk into these products, as well as an estimated "yield factor" for each product that converts a cwt of milk into a pound of butter, cheese, or nonfat dry milk. The objective of these administratively determined CCC purchase prices is to achieve a farm-level price received for manufacturing milk at least equal to the support price.

Prior to 1977, support prices were set once a year and were effective throughout the marketing year. The Food and Agriculture Act of 1977 required midyear adjustments in the support price, and added the prices of land and fixed inputs to the calculations for support prices, thereby dramatically increasing milk support prices twice a year during this period of rapid commodity price inflation. As a result, large surpluses of dairy products developed (LaFrance and de Gorter 1985), and the Agriculture and Food Act of 1981 broke away from parity pricing altogether, setting the manufacturing milk support price nominally at $13.10/cwt. As a result of continuing surpluses, the 1983 Dairy and Tobacco Adjustment Act lowered the support price again to $12.60/cwt and allowed for additional reductions if net governmental removals of manufactured dairy products remained high.

These reductions in the nominal support price for farm milk continued throughout the 1980s. The Food Security Act of 1985 set the support price at $11.60/cwt for the 1986 calendar year, $11.35 for January–September 1987, and $11.10/cwt through the end of 1989. On January 1, 1990, the support price was further reduced to $10.10/cwt because CCC purchases of manufactured dairy products were projected to exceed 5 billion pounds in terms of farm milk equivalent weight. The support price for manufacturing milk has been quite steady since then, fluctuating between $10.35 and $9.90/cwt, and current legislation continues the support price at the latter level through 2012.

Since 1990, the farm milk support price has been set low enough that it seldom affects the market prices received for manufacturing grade milk.

Thus, during the transition period of 1997–1999 for the FMMO, the price support program had little to no impact on farm, wholesale, or retail prices for milk and dairy products.

Federal Milk Marketing Orders

FMMOs divide the country into geographic regions. First handlers of milk (manufacturers or processors) in each region are required to pay farmers at least the minimum price for four classes of milk defined by the Federal government. Class I is the milk used for fluid beverage products.[1] Class II milk is used to produce soft dairy products such as ice cream, cottage cheese, and yogurt. Class III milk goes into hard dairy products such as butter and cheese. Class III–A milk is used to manufacture nonfat dry milk. The original objectives of milk marketing orders focused on equalizing the market power of buyers and sellers and providing market stability. In reality, these marketing orders allow the federal government, acting for milk producers, to price discriminate. Berck and Perloff (1985) present a theory of how marketing order prices are set and how they affect milk prices.

FMMOs set minimum prices that processors must pay dairy farmers or their cooperatives for Grade A milk. Grade A milk meets the sanitary requirements to be legally sold as a fluid product. Markets where FMMOs are in place are those where the producers of two-thirds of the milk marketed in a given demand area, or two-thirds of the number of producers that market milk in that area, have elected to be governed by a federal order.

Only Grade A milk is regulated under FMMOs. Over 85% of all milk currently produced in the United States is Grade A, and FMMOs regulate over 80% of the Grade A milk produced in the United States. The USDA (1984) estimates that virtually all Grade B milk (milk that can only be used to make manufactured dairy products) produced in the United States would qualify as Grade A if a market existed for the additional fluid grade milk. State milk marketing orders that mimic the FMMO program control virtually all remaining Grade A milk produced in the country.

Two major provisions of FMMOs require classified pricing and the pooling of revenue from the sale of milk to obtain a single blend price to be paid to dairy farmers. FMMOs set minimum prices based on specified relationships to the price of Grade B milk in Minnesota and Wisconsin, where more than one-third of the Grade B milk in the United States is produced. The price of Grade B milk is presumed to be a competitive price because manufacturing grade milk is not directly regulated by federal or state milk marketing orders.[2] The Basic Formula Price (BFP) was used to determine the minimum prices for all classes of milk in all FMMOs until the end of October, 1999. The BFP is calculated by adjusting the previous month's Basic Milk Price (BMP) to 3.5% butterfat content using a dairy product price formula. This formula uses information contained in reports by the National Agricultural Statistics Service (NASS) on the Chicago Mercantile Exchange (CME) and National Cheese Exchange (NCE) prices

[1]*Only Grade A milk may be used for the Class I market. When milk marketing orders were introduced in the 1930s, one of the justifications was to control Grade A milk's fluctuating availability. Today nearly all milk produced in the United States meets the Grade A standard, so this rationale is outdated.*

[2]*However, as discussed above, the federal dairy price support program provided a floor on the price of Grade B milk from 1949 until 1990, though this was not a binding price floor from 1997–1999.*

for grade AA or A butter (CME), 40–pound blocks of Cheddar cheese (CME or NCE), nonfat dry milk (CME), and dried whey (CME), as well as yield factors for each of these products, and a weighted average of American cheese and nonfat dry milk production in Minnesota and Wisconsin. During the period of 1997–1999, the yield factors used in the FMMO calculations are: butter, 4.27 lbs./cwt; Cheddar cheese, 9.87 lbs./ cwt; dry buttermilk, 0.42 lbs./cwt; nonfat dry milk, 8.07 lbs./cwt; and whey cream butter, 0.238 lbs./cwt.

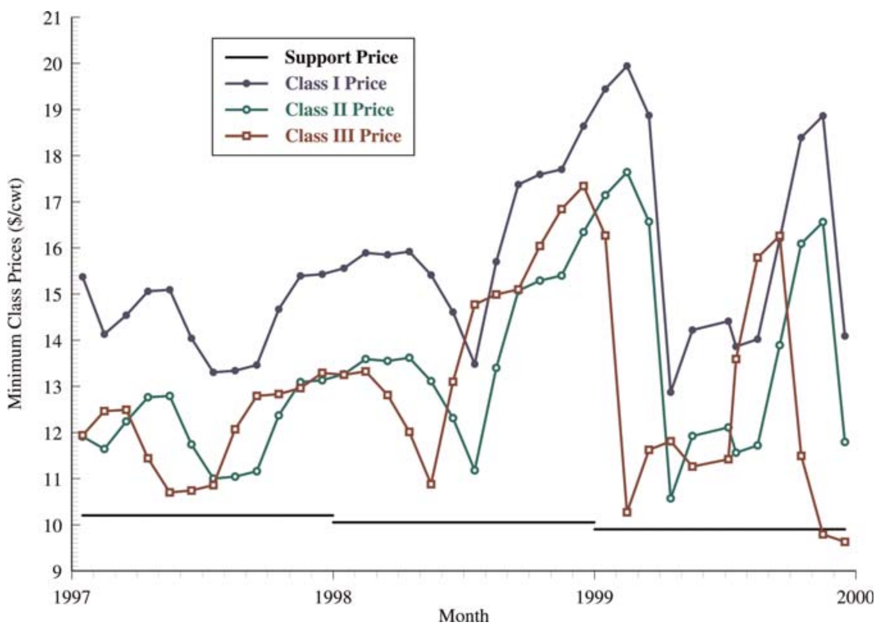
From 1997–1999, the minimum Class III price in all FMMOs was equal to the BFP, the minimum Class II price was the BFP from two months previous, plus a $0.30/cwt differential, and the average minimum Class I price was the BFP plus a $2.60/cwt differential. The time paths of these minimum class prices over the entire sample period are presented in figure 1. These price policies produced an average farm–level price of Class I milk equal to $15.58/cwt; Class II milk of $13.04; Class III milk of $12.91; and a farm–level FMMO blend price of $14.04/cwt, in comparison to an average dairy support price of $10.05/cwt.

The Economic Model

We assume that city-level weekly average purchases of dairy products can be modeled by using a representative consumer. We use a generalized Almost Ideal Demand System that is linear and quadratic in prices and linear in income (LQ–IDS), is flexible with respect to price and income effects, and satisfies the conditions that are necessary and sufficient for the existence of a rational, representative consumer (LaFrance 2004). The demand equations for the LQ–IDS can be written in matrix form as

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

Figure 1 Federal Milk Marketing Order Minimum Prices, 1997–1999



where $\boldsymbol{q}$ is the vector of quantities demanded, $\boldsymbol{\alpha}$ and $\boldsymbol{\gamma}$ are vectors of parameters, $\boldsymbol{A}$ is a matrix of parameters, $\boldsymbol{B} = \boldsymbol{B}'$ 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 are normalized by a positive–valued, increasing, concave, and linearly homogeneous function of the prices of all other goods.

To identify and predict the impacts of dairy product prices on consumer welfare, we need to compare the utility level at the initial prices to the utility level at the final prices. Suppose that dairy product prices 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 utility level at the final price vector, $\boldsymbol{p}_1$. For the demand model in Equation (1), the equivalent variation for such a price change is

$$\begin{aligned} ev = {} & (m - \boldsymbol{\alpha}'\boldsymbol{p}_1 - \boldsymbol{p}_1'\boldsymbol{As} - 1/2\boldsymbol{p}_1'\boldsymbol{Bp}_1)e^{\boldsymbol{\gamma}'(\boldsymbol{p}_0 - \boldsymbol{p}_1)} \\ & - (m - \boldsymbol{\alpha}'\boldsymbol{p}_0 - \boldsymbol{p}_0'\boldsymbol{As} - 1/2\boldsymbol{p}_0'\boldsymbol{Bp}_0). \end{aligned} \tag{2}$$

For this model, the compensating variation is proportional to the equivalent variation, $cv = ev \times e^{\boldsymbol{\gamma}'(\boldsymbol{p}_1 - \boldsymbol{p}_0)}$. Hence, we focus only on the equivalent variation.

To better understand the distributional effects of FMMOs, note that 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

$$\frac{\partial ev}{\partial s_k} = \sum_{j=1}^{n} a_{jk}\left[p_{j0} - p_{j1}e^{\boldsymbol{\gamma}'(\boldsymbol{p}_0 - \boldsymbol{p}_1)}\right]. \tag{3}$$

This depends on the coefficients on the variables s_k in the demand for dairy products, the size of the relative prices changes, and the vector of income coefficients. Therefore, we expect *a priori* that the welfare effects of marketing orders for dairy products vary systematically across consumer characteristics. This is precisely what we find in the empirical work reported below.

Data and Variable Definitions

Consumer prices and quantities are obtained from individual scanner data. These prices are adjusted for the effects of retail sales taxes by calculating real, after–tax prices that consumers face. We use robust, nonlinear three–stage least squares estimation to account for the joint determination of city–level quantities and prices. We carefully select instruments to obtain a best estimator in this class. To avoid the problem with scanner data due to omitted variables bias, we also include several weekly city–level demographic variables: ethnicity; home ownership; employment status; occupation; age and number of children in the household; education and age of household heads; and income.

The quantity data are city–level weekly average household purchases of fourteen dairy products calculated from weekly Information Resources Incorporated's (IRI) Infoscan™ scanner data for the three–year period of

January 1, 1997 through December 30, 1999 for twenty-three U.S. cities.[3] The cities' populations range from 50,000 to 10 million. Each region of the country is represented by several cities. IRI records both 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 group the UPC code data into fourteen products: 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 dependent variable in the demand system is the average quantity purchased per household in each city in each week for each of the fourteen dairy products.

The consumer prices of dairy products are city–level weekly average prices. Given a generic city, the j^{th} product category and the t^{th} week define the city's average price for product j in week t by

$$p_{jt} = \sum\nolimits_{i_j=1}^{n_j} \left(p_{i_j t}\bar{q}_{i_j} / \Sigma_{k_j=1}^{n_j} \bar{q}_{k_j} \right), \ j = 1, \ldots, 14, \tag{4}$$

where n_j is the number of unique UPC codes for that dairy product, $\bar{q}_{i_j}, i_j = 1, \ldots, n_j$, is the average quantity purchased per household per week in the given city of the dairy product with UPC code i_j,[4] and $p_{i_j}t$ is the retail price of that good in week t. To reflect the effects of sales taxes and inflation, we adjusted the reported prices in two ways. We first multiplied each price by one plus the state–level retail sales tax on food items to account for the effects of sales taxes on the final retail prices paid by consumers. We then deflated by the regional consumer price index for all items except food for all urban consumers, not seasonally-adjusted (the nonfood CPI). The nonfood CPI was multiplied by one plus the general retail sales tax rate in the state where the city is located.[5]

We match each household's price and quantity data with household–level weekly measures of several demographic variables. The first measure is the household's annual income bracket. There are eight income brackets with midpoints from $7,500 to $200,000.[6] We constructed an estimate of the city–level average weekly household income as a weighted average of the midpoints of these income brackets. The weights were defined by the fractions of all households that purchased dairy products in that city and week

[3]*Included cities are: 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).*

[4]*The average quantity weights are calculated over all 156 weeks in the sample period.*

[5]*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 (1997–1999) and the regional nonfood CPI's are from the Bureau of Labor Statistics (1997–1999), with 1982 used as the base year. We linearly interpolated monthly nonfood CPI data to obtain weekly series. We matched each IRI city to one of four CPI regions: Northeast, South, Midwest, and West.*

[6]*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.*

whose incomes were reported in the respective brackets. We deflated the city–level average household income with that city's after–tax nonfood CPI. We then divided these measures of deflated average annual household income by fifty-two to estimate the deflated average weekly income per household for each city and week in our sample.

We constructed weekly city–level aggregate measures of several other demographic variables in a manner similar to the calculations for weekly average household income. If a household purchased any dairy product in a given week, then we included that household's demographic characteristics to calculate the city–level aggregates, meaning that the demographic variables vary week–to–week and city–by–city, representing the average demographic characteristics of dairy–product purchasing households. These demographic variables include: ethnic group; home ownership; employment status; occupation; whether the household has children under eighteen, young children (ages 0–5.9), medium-aged children (ages 6–11.9), or older children (ages 12–17.9); the number of young, medium, and older children in the household; number of individuals in each household; years of education of male and female heads of household; and ages of the heads of household. Table 1 presents summary statistics for weekly household income and the other demographic variables included in the regression model. Also included in the regression model are city-level fixed effects.

Model Estimates

We estimate the demand system by nonlinear three-stage least squares (NL3SLS) to account for joint determination between quantities and prices (Deaton 1988). The instruments used 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 grocery stores in the city; squared household income; squared wholesale milk price; squared HHI; and interactions between race; home ownership; and income with the wholesale milk price and with the HHI. These instruments produced coefficients of multiple determination, ranging from 0.691 to 0.956 for the deflated average prices, indicating a reasonably strong instrument set.[7]

In Equation (1), each structural parameter enters each demand equation through the income term, $m - \boldsymbol{\alpha}'\boldsymbol{p} - \boldsymbol{p}'\boldsymbol{A}\boldsymbol{s} - 1/2\mathbf{p}'\boldsymbol{B}\boldsymbol{p}$. In this expression, 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, a set of instrumental variables are needed for each demand equation, including 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

[7] *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.*

Table 1 Summary Statistics of the Households that Purchase Dairy Products

Variable	Mean	Standard error
Household size	2.816	0.176
Weekly income	471.839	84.690
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
Share 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 household	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 household with children with young children	0.309	0.059
Share of household with children with middle children	0.524	0.039
Share of household with children with older children	0.562	0.060

dummies and demographic variables. Thus, we require 856 instruments for the 819 structural parameters, with a total of 3,588 cross–section/time–series observations per demand equation and fourteen demand equations. This makes a total of 50,162 observations.

We used white's robust heteroskedasticity consistent covariance matrix estimator in the NL3SLS system estimates to calculate robust, asymptotically consistent standard errors. Table 2 presents summary statistics for each of the fourteen dependent variables and the model's error variances and goodness of fit measures. As can be seen from this table, the demand model fits the available data reasonably well.

Because we estimated the LQ–IDS demand model for the fourteen dairy products using a large number of demographic variables, it is impractical to report all of the coefficient estimates in a table, or a series of tables.[8] Many coefficients on the demographic variables are statistically different from zero at a 5% significance level in some, but generally not

[8]*A complete list of empirical results is available from the authors upon request.*

Table 2 Model Summary Statistics

	Average quantity purchased		Regression equation	
Dairy Product	**Mean (ounces)**	**Standard error**	**Error variance**	R^2
1% milk	151.409	77.692	3553.0	.41
2% milk	137.592	24.049	107.7	.81
Nonfat milk	127.630	25.798	101.8	.85
Whole milk	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
Cooking yogurt	22.060	5.937	25.9	.26
Other yogurt	33.882	4.480	9.7	.52

Notes: "Cooking yogurt" is defined as plain and vanilla yogurt. "Other yogurt" is yogurt of all other flavors.

all, equations. However, the demographic variables are, collectively, strongly statistically significant. Rather than try to describe the effects of all of the demographic variables on demanded quantities variable-by-variable, we turn to their effects on the price elasticities of demand and the distribution of welfare effects due to marketing orders.

As the prices of dairy products change, households that consume dairy products alter the mix that they demand. Table 3 shows own–price, cross–price, and income elasticities for dairy products calculated at the mean of all variables. In each row, each cell shows the price elasticity for the product due to a change in the price listed at the top of the corresponding column. All of the own–price elasticities are negative, statistically significant, and with one exception – 1% milk – are inelastic. The magnitudes of the point estimates for the own–price elasticities are comparable to those reported in the previous literature, although for the reasons discussed in the introduction, are larger in absolute value. Own–price elasticities of demand for the four types of fresh milk (1%, 2%, non–fat, and whole) range from −0.628 for nonfat milk, to −2.05 for 1% milk. Demands for other dairy products are less elastic, and the demand for butter is the least elastic, with an estimated −0.295 own–price elasticity of demand. There are roughly equal numbers of positive and negative cross–price elasticities of demand. All of these are close to zero – generally below 0.15 in absolute value – and none are larger than 0.3 in absolute value. Most cross–price elasticities of demand are not statistically different from zero at a 5% significance level. All of the income elasticities are negative, and eight are statistically different from zero at the 5% significance level.

The estimated income elasticities generally fall in the range of other estimated income elasticities for dairy products. See Heien and Roheim Wessells (1990), Park, Holcomb, Raper and Capp (1996), Huang and Lin (2000), Gould, Cox and Perali (1990) and Bergtold, Akobudu and Petersen

Table 3 Price and Income Elasticities of Demand for Dairy Products Calculated at the Means of the Data

Dairy product	1% milk	2% milk	Nonfat milk	Whole milk	Fresh cream	Coffee additive	Natural cheese	Process cheese	Shredded cheese	Cream cheese	Butter	Ice cream	Yogurt cooking	Yogurt flavored	Income
1% milk	−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	−0.558
2% milk	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	−0.221*
Nonfat milk	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	−0.239*
Whole milk	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	−0.484*
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	−0.205*
Coffee additive	−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*	−0.071
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	−0.209*
Process 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	−0.040
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	−0.115
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	−0.109
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*	−0.676*
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*	−0.406*
Cooking yogurt	−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	−0.327
Flavored yogurt	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*	−0.151*

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

(2004). In a recent study of U.S. food demand in the twentieth century, LaFrance (2008) finds that the income elasticities of demand for many food items have decreased over time and that those for all five dairy products studied—milk, butter, cheese, ice cream and frozen yogurt, and other dairy products—turned negative in the mid–1990s. Thus, our negative income elasticities differ from much of the earlier literature, but are consistent with LaFrance (2008).

Distribution of the Consumer Welfare Effects of Eliminating FMMOs

One important use of a carefully estimated demand system is the ability to conduct useful welfare analysis of governmental policies. We apply the results of estimating the model above to investigate the distributional effects on consumers from FMMOs. During the 1990s, milk production was affected by thirty-one federal marketing orders and four state orders, of which only the Virginia and California orders completely replace federal orders.

Other studies have examined the effects on consumers of eliminating or changing milk marketing orders, although none of them have examined distributional effects across demographic and income groups. LaFrance and de Gorter (1985) find that raw milk prices would fall nearly 20% in the absence of marketing orders. A retail pass–through of 100% implies that retail prices would also decrease 20% (LaFrance 1991, 1993). Some estimate that eliminating the New England Dairy Compact, which acted much like a marketing order, would result in a 4% to 70% decrease in fresh milk prices (Cotterill 2003).

LaFrance and de Gorter (1985) and Dardis and Bedore (1990) estimated that consumer surplus losses due to marketing orders averaged nearly $700 million dollars annually in constant 1967 dollars (approximately $3.6 billion per year in constant 2000 dollars) during the 1970s and the mid–1980s. Dardis and Bedore (1990) pointed out that consumers with the lowest incomes are those hardest hit by this type of price discrimination policy. Heien (1977), Ippolito and Masson (1978) and Masson and Eisenstat (1980) find social costs involving milk marketing orders of $175 million, $25 million and $70 million per year, respectively, also in constant 1967 dollars.

As discussed in Section 3 above, we expect a priori that the welfare effects of price changes will vary substantially across demographic characteristics. If marketing orders for dairy products were eliminated, consumers in some demographic groups may gain while others may lose. We use the empirical estimates of the demand model in (1) to analyze the differential welfare effects of this contrapositive policy question. We simulate the weekly equivalent variation per household, that is, the change in weekly income that a household would be willing to accept in lieu of experiencing the price changes associated with eliminating the marketing order. Households benefit from the policy change if the equivalent variation is positive, and suffer a loss when the equivalent variation is negative.

To analyze the economic and distributional effects of FMMOs, we examine three cases taken from the literature. For FFMO policies in effect prior to the marketing order reforms of the FAIR Act, combining the farm–level results of LaFrance and de Gorter (1985), which are −18% for fluid milk and +11% for manufacturing milk, with the farm–to–retail price elasticities of LaFrance (1993) −1.0 for fluid milk, 0.33 for butter, 0.16 for cheese, 0.00 for ice cream and frozen yogurt, and 0.14 for other dairy products—one predicts that on average, fluid milk prices decrease 18%, butter prices increase 3%, cheese prices increase 2%, frozen dairy product prices remain unchanged, and all other dairy product prices increase 1%. More recently, Kawaguchi, Suzuki, and Kaiser (2001) predict that moving from FMMOs to competition would decrease farm–level fluid milk prices by an average of 16% and increase farm–level manufacturing milk prices an average of 2.5%. Combining these estimates with the farm–to–retail price elasticities taken from LaFrance (1993) implies price changes of −16% for fluid milk, +1% for butter, +0.4% for cheese, 0% for frozen dairy products, and +0.35% for all other dairy products. Cox and Chavas (2001) simulate regional retail price changes from eliminating the FMMOs and moving to a competitive market in their scenario 2. This simulation predicts that average fluid milk prices decrease 15%, soft dairy product prices (yogurt, cottage cheese, and cream cheese) increase 0.6%, butter prices decrease 7.6%, cheese prices decrease between 0.1% (Italian cheese) and 0.5% (American processed cheese), frozen dairy product prices (ice cream and frozen yogurt) decrease 2.2%, and other manufactured dairy product prices (nonfat dry milk, canned and condensed milk, dry whole milk, and dry whey) increase 1.9%.

Although the predictions are nearly identical for the impacts of eliminating FMMOs on the retail prices of fluid milk, the predictions do differ in terms of the size and sign of the retail price effects for manufactured products. In an effort to bracket the consumer welfare effects, we simulate three cases, with retail fluid milk prices falling by 20% in each case.[9] Table 4 displays the results on the average quantities demanded for each of these cases. The first column simulates no change in the retail prices of any manufacturing dairy products, the second column simulates a 5% increase in the retail prices of all manufactured dairy products, and the third column uses the average increase or decrease in each manufactured dairy product taken from Cox and Chavas (2001), Kawaguchi, Suzuki, and Kaiser (2001), LaFrance and de Gorter (1985), and LaFrance (1993).

Table 4 shows the simulated average quantities purchased (evaluated at the mean of the explanatory variables) for each of the scenarios. As expected, if fluid milk prices decrease and manufactured dairy product prices increase, purchased quantities of fresh milk products rise and those of processed dairy products fall. In all simulations, the purchased quantities of 1%, 2%, nonfat, and whole milk increase substantially. In the scenarios where some or all processed prices rise, the corresponding purchased quantities of these products fall by comparatively modest amounts.

Given the estimated changes in the purchased quantities of fresh fluid milk and processed dairy products in the scenarios when all dairy prices change, we expect some dairy consumers to benefit and others to lose. Table 5 presents the simulated welfare effects across several demographic groups by holding all but one demographic variable fixed at the sample means and changing one characteristic at a time. The first column of this table presents an obvious result, that if the retail prices of processed dairy products do not

[9] *Other simulation experiments showed that smaller or larger cuts in the retail prices of milk beverage products have proportional effects. For example, a 10% cut in fluid milk prices has almost exactly half as large an* ev *effect as a 20% decrease.*

Table 4 Percent Change in Quantity Given Fresh Milk and Processed Product Prices Change by Various Percentages (at Explanatory Variable Means)

	Percent change		Percent change		Percent change	
Dairy product	**Price**	**Quantity**	**Price**	**Quantity**	**Price**	**Quantity**
1% milk	−20	32.9	−20	32.7	−15.5	25.0
2 % milk	−20	12.2	−20	12.9	−15.5	9.5
Nonfat milk	−20	8.8	−20	9.6	−15.5	7.4
Whole milk	−20	9.2	−20	6.8	−15.5	6.8
Fresh cream	0	1.3	+5	2.1	1.25	0.8
Coffee additives	0	2.2	+5	0.6	1.25	1.1
Natural cheese	0	0.6	+5	−0.9	0.5	0.2
Processed cheese	0	1.1	+5	−0.3	0.5	0.5
Shredded cheese	0	1.0	+5	−0.3	0.5	0.5
Cream cheese	0	0.3	+5	−3.8	0.5	−1.1
Butter	0	−1.4	+5	−1.8	−3.0	−0.3
Ice cream	0	1.0	+5	1.2	−1.0	1.9
Cooking yogurt	0	−2.4	+5	−5.3	1.25	−4.2
Flavored yogurt	0	−0.1	+5	−2.7	1.25	−1.0

change, then all consumers benefit from a drop in fresh milk prices. Moving down the rows in this column reveals that, as one would expect, these economic gains vary considerably across different types of households. The second column shows that if the prices of all manufactured dairy products increase by 5%, then the economic gains to each demographic group decrease, with wealthy households and childless couples losing. The third column shows that if processed dairy product prices change by the average predictions gleaned from the literature, then all but the wealthiest of consumers would gain from eliminating the federal milk marketing order program. In most cases these gains are considerably more than is predicted for the simulation in which retail prices for manufactured products do not change as a result of moving from FMMOs to a free market for dairy products.

The first row in table 5 shows the equivalent variation for a family with average demographic characteristics. Given that the price of fresh milk falls 20%, a typical household's weekly equivalent variation is $1.44 if the prices of processed goods do not change, 63¢ if they rise by 5%, and $2.94 if they change by the average prediction in the literature. The second row in table 5 shows the equivalent variation for a white household. The third row shows the equivalent variation for a comparable nonwhite family, which is simulated by setting the variable for white equal to zero and the variables for black, Asian, and Hispanic equal to the sample's proportion of each of these nonwhite groups, divided by the fraction of all households that are not white. For example, the simulated equivalent variation for a nonwhite family (the third row) is 96¢/week for a 0% price change in processed goods. The corresponding equivalent variation for a white family (the second row) is $1.50. Nonwhite families benefit less than white families in all of the simulations.

That the welfare effects of changes in dairy product prices vary with the race of the household may be due to varying incidences of lactose intolerance. In the United States, the occurrence of lactose intolerance is, at 5%, relatively low for Caucasians of northern European and Scandinavian

Table 5 Equivalent Variation ($/week) for Different Demographic Groups Given Fresh Milk and Processed Product Prices Change by Various Percentages

Demographic Group	Milk prices decrease 20% Processed product prices no change	Milk prices decrease 20% Processed product prices increase 5%	Milk, processed product prices change the average of the literature
Mean	1.44	0.63	2.94
White	1.50	0.68	2.96
Nonwhite	0.96	0.23	2.10
Income = $10,000	1.73	0.80	3.84
Income = $30,000	1.33	0.56	2.63
Income = $50,000	0.94	0.33	1.41
Income = $70,000	0.54	0.09	0.20
Income = $90,000	0.15	−0.14	−0.92
Education = 10 Years	1.19	0.47	1.95
Education = 16 Years	1.41	0.53	3.62
Young Child (0–5.9)	1.68	0.76	3.88
Middle Child (6–11.9)	0.84	0.17	1.65
Older Child (12–18)	2.00	1.13	2.57
No Children	1.69	0.84	2.83
Family with 3 Children[a]	1.25	0.70	5.77
Childless Couple[b]	0.22	−0.37	3.34

[a] *Heads of household are 35 years old, they have a real income of $20,000, the wife is not employed, the husband works in a nonprofessional occupation, they have three children under 6 years of age, and they rent their dwelling.*
[b] *Heads of household are 30 years old, they have a real income of $60,000, both are working professionals, and they own their dwelling.*

descent (although it spikes to 70% for North American Jews). Lactose intolerance is much higher for other ethnicities: 45% for African American children and 79% for African American adults, 55% for Mexican American males, and 90% for Asian Americans (98% for those from Southeast Asia) (Nutrigenomics 2005).

Table 5 also shows how welfare changes as we vary one variable at a time for income, education, the presence of children, and whether the household has a child in each age group. In all of the simulations, lower income families benefit more than wealthier families from eliminating FMMOs. Similarly, more educated families fare better than less educated ones. Families with children under six years of age or with children between twelve and eighteen years of age benefit more than others from eliminating marketing orders.

Perhaps the most striking results are those in the last two rows of table 5, where we compare the equivalent variations of two types of families by varying several characteristics at once. In the next to last row, we examine a family with three small children. The parents are 35 years old, they have a deflated income of $20,000, the wife is not employed, the husband works in a non-professional occupation, they have three children under the age of six, and they rent their dwelling. In contrast, in the last row is a childless couple: they are 30 years old, have an income greater than $60,000, are working professionals, and own their dwelling. The family with three children gains more from eliminating FMMOs than virtually any other group, presumably because their children consume relatively large amounts of fresh milk. In contrast, the childless, wealthier couple only benefits if the increase in processed dairy product prices is less than 5%. Moreover, even if there is no increase in the retail prices for manufactured dairy products, the benefit to the young family with three children is 82% greater than that for the childless couple. In general, if the 20% drop in the fresh milk price is offset by a 0% or 5% increase in the processed products prices, nearly all consumer groups benefit, with the exception of the wealthiest members of the population.

Finally, our simulations show that FMMO regulations are highly regressive. We define the *regulatory burden* of the FMMO program as a household's annual equivalent variation from removing the marketing order divided by its annual income. We look at the regulatory burden associated with a 20% decrease in fluid milk prices and a 5% increase in manufacturing prices. Figure 2 compares the regulatory burden as a function of income for white and nonwhite families.[10]

The equivalent variation of removing the marketing order is positive at low incomes—consumers benefit from removing it—so there is a regulatory burden (loss) from imposing marketing orders for milk. For white families, the burden falls from 0.61% at an income of $7,500, to 0.44% at $10,000, 0.19% at $20,000, 0.11% at $30,000, 0.04% at $50,000, and 0.01% at $75,000. At higher incomes, the burden is slightly negative, ranging from −0.002% at $85,000 to −0.04 at $200,000.

The curve for nonwhite families lies strictly below that for white families, although both curves fall with income. At $7,500, the regulatory burden of a nonwhite family is about half that of a white family. At the average real income, $25,000, the regulatory burden is about one-third for the nonwhite family as for a white one. Perhaps this difference has to do with higher rates of lactose intolerance among nonwhites.

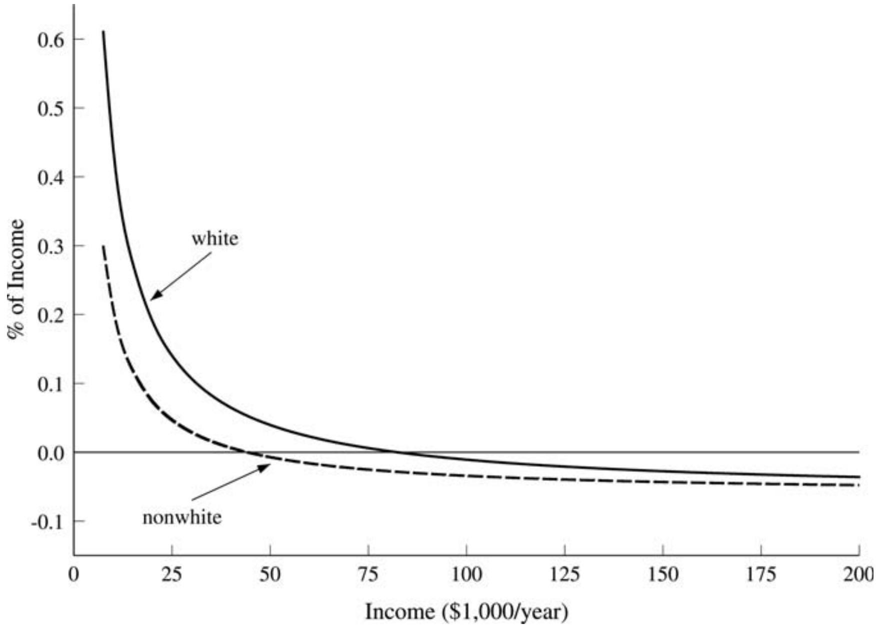
Conclusions

We presented and estimated a dairy demand system for households that consume dairy products using an exactly aggregable, theoretically consistent demand model, scanner data, and matching household-level demographic variables. We estimated this model using nonlinear three-stage least squares to account for the possibility of measurement errors and simultaneous equations bias, and calculated robust standard errors to account for heteroskedasticity of an unknown form. We then used the empirical results of this model to simulate the welfare effects of eliminating federal milk marketing orders for various demographic groups.

There are substantial differences across demographic groups in welfare effects from eliminating market orders. Virtually all major groups of

[10]*Simulations for the other two scenarios have the same regressive structure.*

Figure 2 Distribution of Regulatory Burden for Federal Milk Marketing Orders



consumers benefit from eliminating milk marketing orders, except for the wealthiest members of the population. Poorer families with young children gain more from eliminating this policy–induced price discrimination than do richer families with no children or older children. That is, as predicted, orphans and young families with small children suffer from milk marketing orders while wealthy childless families benefit. Finally, marketing orders are a highly regressive policy tool. Households with lower income levels pay a larger percentage of their incomes as a result of the milk marketing order regulations than do those with higher income levels.

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