School of Economic Sciences

Working Paper Series

WP 2009-03

MILK MARKETING ORDER WINNERS AND LOSERS

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February 2009

Washington State University
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Abstract

Determining the impacts on consumers of government policies affecting 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.

Jel codes: Q1, D12, E21

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Milk Marketing Order Winners and Losers

1. Introduction

The U.S. dairy industry has been subjected to more government intervention and regulation than almost any other domestic industry. There are three major areas of this market intervention: 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 over the past two decades, price supports have become essentially irrelevant to market outcomes in the dairy industry and trade policy has been renegotiated in the Uruguay Round of the General Agreement on Trades and Tariffs (Cox, Coleman, Chavas, and Zhu 2005). On the other hand, the Federal Agriculture Improvement and Reform Act of 1996 mandated reforms to the FMMO program. These reforms include changing the way that minimum prices paid to farmers are determined and reducing the number of FMMOs through consolidation from 42 to no less than 10 and more than 14 by January 2000. The period 1997–1999 was a significant transition period for these reforms, and so far the effects of these reforms on the consumers of dairy products have not yet been analyzed thoroughly.

To better understand the distributional effects on consumers due to the FMMO program during this period, this paper investigates an econometric model of the retail demand for 14 dairy products. The model analyzes weekly city–level purchases of dairy products matched with demographic characteristics of the purchasing households in 22 cities across the U.S. during the transition period 1997–1999 of the FMMO program. 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 disaggregation of products included 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 price 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 the extant literature.

Second, 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.

Third, 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 the own–price elasticity and positive unity for the 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.

Fourth, the functional form for the dependent and independent variables, i.e., linear in quantities, prices, and income, rather than budget shares as dependent variables with the natural logarithms of prices and income on the right–hand side of the demand equations 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 the evolution of domestic Federal policy in the dairy industry is presented next. 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.

2. A Brief History of Federal Domestic Dairy Policy

The origins of Federal dairy policy can be traced to the Agricultural Adjustment Acts of 1933 and 1935 as part of the New Deal in the Great Depression. Permanent authorization for the dairy price support program is the Agricultural Act of 1949, which is the last permanent farm bill. The FMMO program is authorized by the Agricultural Marketing Agreement Act of 1937. With high support prices relative to world prices up until the mid to late 1990's, import quotas have been used to prevent imports of dairy products from overwhelming the price support program. This section reviews the history and evolution of domestic policy in the U.S. dairy industry.

The Dairy Price Support Program

The Agricultural Act of 1949 specifies that farm milk prices are to be supported at between 75 and 90 percent 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 1910–14. 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 through government purchases of butter, cheese, and nonfat dry milk from the processors of these products by the Commodity Credit Corporation (CCC). The purchase prices for these products are pre–announced and determined by formulas that include a manufacturing "*make margin*" intended to cover the cost of a processing plant of average efficiency to convert milk into these products and 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.

Before 1977, support prices were set once a year and were effective throughout the marketing year. But 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, 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 government 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 reduced further 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 this date, fluctuating slightly 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 program, the price support program had little to no impact on farm, wholesale, or retail prices for milk and dairy products. However, although the 1949 Agricultural Act has been suspended by omnibus farm bill amendments since 1972, it remains the last piece of permanent farm legislation. In the event that an expiring farm bill is not extended or replaced by a new one, Federal policies in the dairy industry will revert to the 1949 regulations, with the attendant disrupting impacts on both demand and supply that would result from a more than fourfold increase in the farm price for manufacturing grade milk. Nevertheless, given the evolution of the dairy price support program, we can safely ignore it in our analysis of the distributional impacts on consumers of the FMMO program.

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 to farmers at least the minimum price for four classes of milk defined by the Federal government.[1] Class I is the milk used for fluid beverage products.[2] 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 to provide market stability. In reality, these marketing orders allow the Federal government, acting for milk producers, to price discriminate.

FMMOs set minimum prices that must be paid by processors to dairy farmers or their

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[1] Berck and Perloff (1985) present a theory of how marketing order prices are set and how they affect milk prices.

[2] 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 reduce the variability in the availability of Grade A milk. Today nearly all milk produced in the U. S. meets the Grade A standards, so this rationale is outdated.

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 $\frac{2}{3}$ of the milk marketed in a given demand area or $\frac{2}{3}$ of the number of producers that market milk in that area have elected to come under a Federal order.

Only Grade A milk is regulated under FMMOs. Over 85 percent of all milk currently produced in the United States is Grade A. FMMOs regulate over 80 percent 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 U.S. 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 are classified pricing according to use and the pooling of revenue from the sale of milk to obtain a single blend price to be paid to dairy farmers. Milk used for fluid products is Class I. Milk used for soft manufactured products (ice cream, cottage cheese, and yogurt) is Class II. Milk used for hard manufactured products (butter, cheese, nonfat dry milk, and canned milk) is Class III.[3]

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[3] In 22 of the 34 FMMOs in operation during 1997–1999, a fourth class, Class III–A, for nonfat dry milk also was in effect. The minimum price for Class III–A milk was based on a formula that used the Chicago Mercantile Exchange (CME) price for nonfat dry milk minus a *make margin* intended to reflect the cost of production at an average efficiency processing plant, with the difference multiplied by a *yield factor* that is

FMMOs set minimum prices based on specified relationships to the price of Grade B milk in Minnesota and Wisconsin, where more than a third of the Grade B milk in the U.S. is produced. The average price paid for Grade B milk obtained from a monthly survey of 100 processing plants in Wisconsin and 62 plants in Minnesota that produce butter, cheese, and nonfat dry milk is used to calculate the Minnesota–Wisconsin price, or the Base Month Price (BMP). These plants purchase approximately 80 percent of the Grade B milk sold in these two states.

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.[4] 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.[5] The BFP is calculated by adjusting the previous month's BMP to 3.5% butterfat content using a dairy product price formula. The formula uses information contained in reports by the National Agricultural Statistics

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intended to represent the average yield in pounds of nonfat milk solids from a hundred pounds of milk. This class became Class IV in all FMMOs on January 1, 2000, as part of the final order for the milk marketing order reforms. Both butter and nonfat dry milk are included in the new Class IV. We do not include nonfat dry milk in our analysis and our sample period is 1997–1999. Hence, we focus only on Classes I, II, and III.

[4] 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 during 1997–1999.

[5] From the early 1960s until June 1, 1995, the Minnesota–Wisconsin price was the BPF for all milk marketing orders (ERS, USDA, 1996). Federal milk order reform replaced the BFP with a dairy products components based formula beginning on November 1, 1999.

Service (NASS) on CME and National Cheese Exchange (NCE) prices for grade AA or A butter (CME), 40–pound blocks of Cheddar cheese (CME or NCE), nonfat dry milk (CME), and dried whey (CME), yield factors for each of these products, and a weighted average of American cheese and nonfat dry milk production in Minnesota and Wisconsin. The NASS central market exchange prices are published weekly by the USDA Agricultural Marketing Service in *Dairy Market News*. During the period 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.

The formulas for calculating the component values of farm milk in the production of butter and cheese are as follows:[6]

$$\begin{aligned} \textit{Cheese Value} &= \textit{Cheese Yield Factor} \times \textit{NASS Cheese Price} \\ &\quad + \textit{Whey Cream Butter Yield Factor} \times \textit{NASS Butter Price}; \\ \textit{Butter Value} &= \textit{Butter Yield Factor} \times \textit{NASS Butter Price} \\ &\quad + \textit{Nonfat Dry Milk Yield Factor} \times \textit{NASS NFDM Price} \\ &\quad + \textit{Dry Buttermilk Yield Factor} \times \textit{NASS Buttermilk Powder Price.} \end{aligned} \tag{1}$$

These formulas are used to update the previous month's BMP obtained from the NASS survey of Minnesota and Wisconsin processing plants to the current month's BFP. This is then used as the basic policy price for all minimum prices for all classes of milk in the

[6] The formula for the nonfat dry milk value of farm milk is the same as that for butter.

FMMOs. However, while they differ from month–to–month, on average over a marketing year the BMP and BFP are quite similar.

During the period 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, farm–level FMMO blend price of \$14.04/cwt, in comparison to an average dairy support price of \$10.05/cwt.

3. The Economic Model

We assume that city–level weekly average purchases of dairy products can be modeled with 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

$$\boldsymbol{q} = \boldsymbol{\alpha} + \boldsymbol{A}\boldsymbol{s} + \boldsymbol{B}\boldsymbol{p} + \boldsymbol{\gamma}\left(m - \boldsymbol{\alpha}'\boldsymbol{p} - \boldsymbol{p}'\boldsymbol{A}\boldsymbol{s} - \tfrac{1}{2}\boldsymbol{p}'\boldsymbol{B}\boldsymbol{p}\right), \tag{2}$$

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.[7]

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 (2), the equivalent variation for such a price change is

$$ev = \left(m - \boldsymbol{\alpha}'\boldsymbol{p}_1 - \boldsymbol{p}_1'\boldsymbol{A}\boldsymbol{s} - ½\boldsymbol{p}_1'\boldsymbol{B}\boldsymbol{p}_1\right)e^{\boldsymbol{\gamma}'(\boldsymbol{p}_0 - \boldsymbol{p}_1)} - \left(m - \boldsymbol{\alpha}'\boldsymbol{p}_0 - \boldsymbol{p}_0'\boldsymbol{A}\boldsymbol{s} - ½\boldsymbol{p}_0'\boldsymbol{B}\boldsymbol{p}_0\right). \qquad (3)$$

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

$$\frac{\partial ev}{\partial s_k} = \sum_{j=1}^{n} a_{jk}\left[p_{j0} - p_{j1}e^{\boldsymbol{\gamma}'(\boldsymbol{p}_0 - \boldsymbol{p}_1)}\right]. \qquad (4)$$

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[7] This model can be thought of either as an incomplete demand system (LaFrance and Hanemann 1989) or as a complete system in which the demand for the n+1st good, x, has a different functional form than the demands for $\boldsymbol{q}$, i.e., $x = (1 - \boldsymbol{\gamma}'\boldsymbol{p})(m - \boldsymbol{\alpha}'\boldsymbol{p} - \boldsymbol{p}'\boldsymbol{A}\boldsymbol{s}) - (1 - ½\boldsymbol{\gamma}'\boldsymbol{p})\boldsymbol{p}'\boldsymbol{B}\boldsymbol{p}$. In either case, it does not produce a separable subset of demand equations for dairy products.

This depends on the coefficients on the variables s_k in the demands 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.

4. 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 facing consumers. 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. We also include several weekly city–level demographic variables to avoid the problem with scanner data due to omitted variables bias: ethnicity; home ownership; employment status; occupation; ages and numbers of children in the household; education and ages 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 January 1, 1997 through December 30, 1999 for 23 U.S. cities.[8] The city populations range from 50,000 to 10 million. Each re-

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[8] Atlanta, Boston, Cedar Rapids (IA), Chicago, Denver, Detroit, Eau Claire (WI), Grand Junction (CO),

gion of the country is represented with 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 14 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

$$p_{jt} = \sum_{i_j=1}^{n_j} \left(p_{i_j t} \overline{q}_{i_j} \Big/ \Sigma_{k_j=1}^{n_j} \overline{q}_{k_j} \right),\ j = 1,\ldots,14\,, \tag{5}$$

where n_j is the number of unique UPC codes for that dairy product, $\overline{q}_{i_j}$, $i_j = 1,\ldots,n_j$, is the average quantity purchased per household per week in the given city of the dairy product

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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).

with UPC code i_j,[9] 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.[10]

We match each household's price and quantity data with household–level weekly measures of several demographic variables. The first is the household's annual income bracket. There are eight income brackets with midpoints from $7,500 to $200,000.[11] We constructed an estimate of the city–level average weekly household income by taking the

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

[10] If the general ad valorem retail sales tax rate in the state is τ, then the after–tax nonfood CPI is $(1+\tau)$CPI. Retail sales tax rates are taken from the Council of State Governments (1997–1999) and the regional nonfood CPI's are from the Bureau of Labor Statistics (1997–1999), with 1982 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.

[11] 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.

sum of the products of the proportion of households in each income bracket times the midpoint of that income bracket, using the number of households that purchased a given dairy product as a fraction of the number households that purchased at least one dairy product in that city during that week as weights. We deflated the city–level average household income with that city's after–tax nonfood CPI. We divided these measures of deflated average annual household income by 52 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, so that the demographic variables vary week–to–week and city–by–city as averages of dairy–product purchasing households' demographic characteristics. These demographic variables include ethnic group, home ownership, employment status, occupation, whether the household has children under 18, has young children (ages 0–5.9), has medium aged children (ages 6–11.9), or has 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 model. Not shown in the table, but included in the empirical model, are city–level fixed effects.

5. 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 the race, home ownership, and income variables with the wholesale milk price and 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.[12]

In equation (2), each structural parameter enters each demand equation through the income term, $m - \boldsymbol{\alpha}'\boldsymbol{p} - \boldsymbol{p}'\boldsymbol{A}\boldsymbol{s} - \frac{1}{2}\boldsymbol{p}'\boldsymbol{B}\boldsymbol{p}$. 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, we need a set of instrumental variables for each demand equation that includes a constant, city–level fixed effects dummies, demographic variables including average weekly

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

household income, predicted prices, own– and cross–product second–order interactions between predicted prices, and interactions between predicted prices and the city dummies and the demographic variables. Thus, we need 856 instruments for the 819 structural parameters with a total of 3588 cross–section/time–series observations per demand equation and 14 demand equations, for 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 models error variances and goodness of fit measures. As can be seen from this table, this 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 series of tables.[13] Many coefficients on the demographic variables are statistically different from zero at a 5% significance level in some, but generally not 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 quantities demanded variable by variable, we turn to their effects on the price elasticities of demand and the distribution of the welfare effects due to marketing

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[13] A complete list of empirical results is available from the authors on request.

orders.

As the prices of dairy products change, households that consume dairy products alter the mix of dairy products that they demand. Table 3 shows the own– and cross–price elasticities for dairy products calculated at the mean of all of the variables (from table 1). 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. The 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.[14] The demands for other dairy products are less elastic, and the demand for butter is the least elastic, with an estimated own–price elasticity of demand of –0.295. 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.

[14] Again, recall that mixing two half gallons of nonfat and 2% milk produces a gallon of 1% milk, so that this variety, in particular, has a ready substitute available in the market. Hence, one would expect it to have an elastic demand curve.

Table 4 reports the income elasticities, also evaluated at the sample means of the data. All of the income elasticities are negative, and eight are statistically different from zero at the 5% significance level. The estimated income elasticities fall generally in the range of other estimated income elasticities for dairy products[15].

6. 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 government 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 31 Federal marketing orders and 4 state orders, of which only the Virginia and California orders completely replace the Federal orders.

Other studies have examined the effects on consumers of eliminating or changing milk marketing orders, although none of them have looked at the 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 also would decrease 20% (LaFrance 1991, 1993). Some estimate that eliminating the New England Dairy Compact, which acted

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[15] 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 (2004). In a recent study of U.S. food demand over the 20th 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.

much like a marketing order, would result in a 4% – 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 the consumers with the lowest incomes are the 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, 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 (2) to analyze the differential welfare effects of this contrapositive policy question. We simulate the weekly equivalent variation per household – 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), –18% for fluid milk and +11% for manufacturing milk, with the farm–to–retail price elasticities of LaFrance (1993) – 1.0 for Fluid milk 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 an average of 16% and increase farm–level manufacturing milk prices an average 2.5%. Combining these estimates with the farm–to–retail price elasticities taken from LaFrance (1993) implies prices 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 (yogurt, cottage cheese, and cream cheese) prices increase 0.6%, butter prices decrease 7.6%, cheese prices decrease between 0.1% (Italian cheese) to 0.5% (American processed cheese), frozen dairy product prices (ice cream and frozen yogurt) prices decrease 2.2%, and other manufactured dairy product (nonfat dry milk, canned and condensed milk, dry whole milk, and dry whey) prices increase 1.9%.

Although the predictions are nearly identical for the impacts of eliminating FMMOs on the retail prices of fluid milk, they 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.[16] Table 5 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 the above three combined sources in the literature.

Table 5 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, quantities purchased of fresh milk products rise and those for processed dairy products fall. In all simulations, the quantity purchased of 1%, 2%, non–fat, and whole milk increase substantially. In the scenarios where some or all processed prices rise, the corresponding quantities purchased of these products fall by comparatively modest amounts.

Given the estimated changes in the quantities purchased 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 6 presents the simulated welfare effects across several demographic groups by holding all but one demographic variable fixed at

[16] Other simulation experiments showed that smaller or larger cuts in the retail prices of milk fluid 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.

the sample means and changing one characteristic at a time. The first column of this table presents the obvious result that if the retail prices of processed dairy products do not 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 (yuppies) losing. The third column shows that if prices of processed dairy products 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, and in most cases by 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 of table 6 shows the equivalent variation for a family with average demographic characteristics. Given that the price of fresh milk falls 20%, such 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 of table 6 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 proportion of the sample 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 variations for a White family (the second row) is $1.50. Nonwhite families always benefit less than White families in all of the simulations.

The above result 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 prevalence of lactose intolerance are relatively low for whites: 5% for Caucasians of northern European and Scandinavian descent (although 70% for North American Jews), 45% for African American children and 79% for African American adults, 55% for Mexican American males, to 90% for Asian Americans, and 98% for Southeast Asians (Nutrigenomics 2005).

Table 6 also shows how welfare changes as we vary one variable at a time for income, education, 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 older children between 12 and 18 years of age benefit more than others from eliminating marketing orders.

Perhaps the most striking experiments are those in the last two rows of table 6, 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 a higher income of $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 for non–white families.[17] The equivalent variation of removing the marketing order is positive at low incomes – consumers benefit from removing it – so

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

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, 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 a third for the Nonwhite family as for a white one. Perhaps this difference has to do with higher rates of lactose intolerance among Nonwhites.

7. 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 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 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 childless yuppies 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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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 hh	0.350	0.058
Average number of young children ages 0–5.9	0.133	0.041
Average number of middle children ages 6–11.9	0.249	0.050
Average number of older children ages 12–18	0.307	0.064
Share of hh with children with young children	0.309	0.059
Share of hh with children with middle children	0.524	0.039
Share of hh with children with older children	0.562	0.060

Table 2. equation Summary Statistics

Dairy Product	Average Quantity Purchased		Regression Equation	
	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	2.2551	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.

Table 3. Price Elasticities of Demand for Dairy Products of Households that Consume Dairy Products Calculated at the Mean of the Explanatory Variables

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
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
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
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
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
Fresh Cream	–0.063	–0.084*	0.139*	–0.056	–0.407*	0.022	0.101	0.274*	0.118*	0.173*	0.004	–0.016	–0.139	0.035
Coffee 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*
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
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
Shredded Cheese	–0.038	0.020	0.006	–0.038	0.060*	–0.031	0.039	–0.008	–0.404*	–0.082*	0.022	0.036	0.068	0.044
Cream Cheese	0.014	–0.019	–0.018	0.006	0.149*	–0.076*	–0.026	–0.194*	–0.138*	–0.515*	0.064*	0.128*	–0.225*	–0.012
Butter	0.093	0.033*	–0.056*	0.001	0.003	–0.009	0.019	–0.019	0.029	0.045*	–0.295*	0.136*	0.047	–0.038*
Ice Cream	0.010	–0.062*	–0.013	0.013	–0.006	0.058*	0.077	0.196*	0.028	0.057*	0.087*	–0.741*	0.187*	0.090*
Yogurt Cooking	–0.196*	0.079	0.348*	–0.111	–0.147	0.023	–0.071	0.113	0.142*	–0.276*	0.084	0.520*	–0.911*	–0.070
Yogurt Flavored	0.011	–0.035	–0.001	0.029	0.023	0.103*	0.066	–0.034	0.057	–0.009	–0.044*	0.154*	–0.044	–0.808*

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

Table 4. Income Elasticities for Households that Consume Dairy Products

Dairy Product	Income Elasticity	Standard Error
1% Milk	–0.558	0.468
2% Milk	–0.221*	0.058
Nonfat Milk	–0.239*	0.059
Whole Milk	–0.484*	0.075
Fresh Cream	–0.205*	0.098
Coffee Additives	–0.071	0.087
Natural Cheese	–0.209*	0.077
Processed Cheese	–0.040	0.066
Shredded Cheese	–0.115	0.068
Cream Cheese	–0.109	0.091
Butter	–0.676*	0.127
Ice Cream	–0.406*	0.082
Yogurt Cooking	–0.327	0.182
Yogurt Flavored	–0.151*	0.071

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

Table 5. Percent Change in Quantity Given Fresh Milk and Processed Product Prices Change by Various Percentages (at the Means of the Explanatory Variables).

Dairy Product	Percent Change		Percent Change		Percent Change	
	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
Yogurt Cooking	0	–2.4	+5	–5.3	1.25	–4.2
Yogurt Flavored	0	–0.1	+5	–2.7	1.25	–1.0

Table 6. Equivalent Variation ($/week) for Demographic Group of Households that Consume Dairy Products 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
Non–white	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 non–professional 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.

Figure 1. Federal Milk Marketing Order Minimum Prices, 1997-1999.

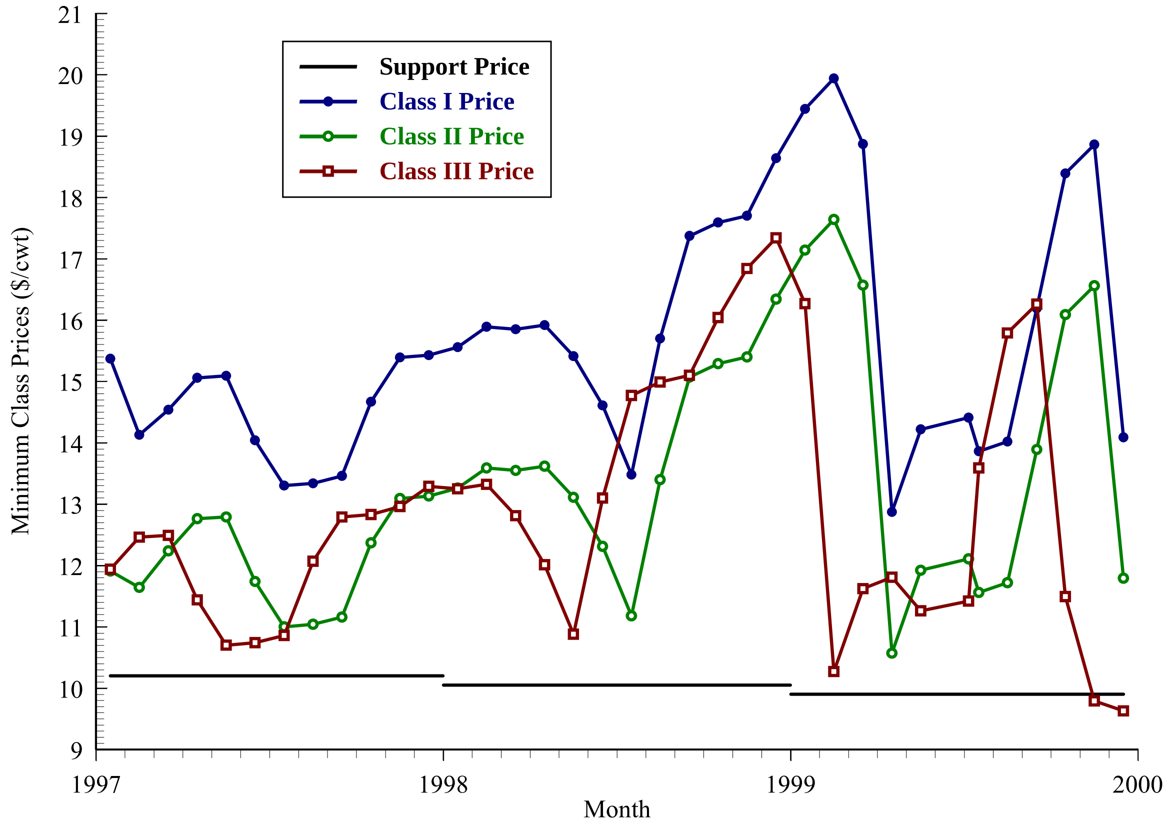

Figure 2. Distribution of Regulatory Burden for Federal Milk Marketing Orders.