USDA Agricultural Marketing Service (AMS) Dairy Programs

National Econometric Model Documentation

For Model Calibrated To
USDA Agricultural Baseline Projections to 2016

April 2007

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Dairy Programs

Introduction

Dairy Programs' Office of the Chief Economist maintains a dynamic econometric model of the U.S. dairy industry to support its economic analysis and forecasting responsibilities. The model is comprehensive, including the supply of milk, the allocation of butterfat and nonfat solids to fluid milk and the major manufactured dairy products, and consumer demand for milk and dairy products. The model's supply and demand equations are estimated using data from years 1980 through 2005. The model includes variables for the Federal Milk Marketing Order (FMMO) system, Milk Price Support Program (MPSP), and Milk Income Loss Contract (MILC) program. It is specified to generate long-term supply, demand, and price projections that are consistent with USDA's official baseline projections.[1] The model is estimated and simulated with SAS statistical software (SAS Institute, Inc., SAS/ETS User's Guide, Version 9.1).

The model simultaneously forecasts milk production, fluid milk and manufactured dairy product consumption, dairy manufacturing allocation, dairy product prices, and farm milk prices sequentially along the designated time path of 2006 through 2016. Butterfat and nonfat solids are allocated through the use of conversion factors consistent with farm milk and dairy products. Prices for dairy products, fluid milk, and farm milk are solved within the model to achieve equilibrium conditions for supply and demand.

Analytical Framework

Dairy Product Composition – Butterfat and Nonfat Solids

The requirements of fluid and manufactured dairy products for nonfat solids and butterfat are estimated with reported historical data. These milk and component uses are classified on a basis consistent with the FMMO system as follows:

Class I—fluid uses
Class II—soft manufactured products (frozen products and other Class II)
Class III—cheese and dry whey
Class IV—butter, nonfat dry milk (NFDM), whole dry milk, and canned milk.[2]

Fluid use data are obtained from the USDA Economic Research Service. Butterfat and nonfat solids content for fluid milk are determined from FMMO and California data. Modeled manufactured products include American cheese, other-than-American cheese (other cheese), butter, canned milk, whole dry milk, NFDM, total frozen products, and other Class II products. Data for manufactured products as reported by the National

[1] Dairy baseline forecasts are developed by an Interagency Commodity Estimates Committee at USDA. Intercept terms for the model are modified for each projection year as needed to calibrate the model to approximate baseline forecasts. For information on USDA's official baseline, see http://www.usda.gov/oce/commodity/ag_baseline.htm, U.S. Department of Agriculture, Office of the Chief Economist, World Agricultural Outlook Board, OCE-2007-1.

[2] The term "canned milk" in this documentation refers to evaporated or sweetened condensed milk in consumer-type packages.

Agricultural Statistics Service (NASS) is used for all modeled dairy products with the exception of other Class II. Other Class II is treated as a composite solids-equivalent product, historically calculated as the residual butterfat and nonfat solids after meeting all other model product requirements.

The nonfat solids and butterfat pounds required for each product are established by multiplying the production of hard manufactured products and the demands for fluid, frozen, and other Class II products by the appropriate conversion factors in Table 1. Frozen products and other Class II products are treated as aggregates. The factors for the aggregate frozen product are recent year weighted averages across all frozen products. The other Class II solids requirements were established in the historical data by the residual butterfat and nonfat solids left when accounting for all solids in Class I, III, IV, and total frozen products. The proportions of the solids in "other Class II" for the forecast period are held at recent averages.

Milk Supply

The model estimates milk production via milk per cow and number of cows (Table 2). The number of cows is estimated as a function of the milk-feed price ratio, the ratio of the boning and utility cow slaughter price to the all milk price, and trend variables. The year-over-year change in milk production per cow is estimated as a function of the previous year's all-milk price, and current-year feed costs. Prices are deflated by the Consumer Price Index (CPI) for all products as reported by the Bureau of Labor Statistics, U.S. Department of Labor (BLS).[3] Each equation includes dummies to adjust for unusual circumstances over the historical period. The average MILC payment per hundredweight (cwt.) is computed by dividing total MILC payments by U.S. milk production. For years when the MILC program is active, the average MILC payment per cwt. is added to the all-milk price.

Demand for Fluid Milk and Dairy Products

Per capita demands for fluid milk and manufactured dairy products are estimated as functions of product prices, per capita income, and other factors (Table 3). Dairy product prices are deflated by the CPI for all products, the CPI for food, or in the case of butter, the CPI for fats and oils. Per capita disposable income is deflated by the CPI for all products. Total consumption for each specific product or product aggregate is specified as per capita demand times the projected population for each year. Fluid milk demand responds to the CPI for fresh whole milk, per capita disposable income, and trend. The CPI for fresh whole milk is estimated as a function of the CPI for all products and the Class I price at 3.25 percent butterfat test, using the average Class I differential plus the estimated over- order Class I premium (Table 4). The average retail price for fresh

[3] Data for all CPIs are from BLS.

Table 1: Dairy Product Conversion Factors (percentages)

Products	Butterfat and nonfat solids required per product unit	
	Butterfat	Nonfat Solids
Producer milk	3.67	8.75
Butter	80.40	1.00
American cheese [1]	36.80	85.10
Other cheese [2]	28.70	85.80
Nonfat dry milk	0.80	96.20
Canned milk	7.90	18.50
Dry whey	1.10	95.00
Dry whole milk	26.50	71.00
Fluid milk	2.05	8.92
Ice cream-regular	12.00	10.00
Ice cream-lowfat	6.00	11.00
Ice Cream-nonfat	2.00	14.00
Sherbet	2.00	2.00
Frozen yogurt	1.70	9.00
Other frozen products	6.00	7.70
Total frozen products [3]	9.10	9.90
Other Class II [4]	46.00	54.00

[1] Based on Van Slyke Formula for cheddar Cheese, reflects solids required for production, not the actual percentage in final product.

[2] Weighted average of other cheeses, reflects solids required for production, not the actual percentage in final product.

[3] Derived a weighted average frozen product category. Ice Cream products are assumed to weigh 4.5 lbs. per gallon, other frozen products are assumed to weigh 6 lbs. per gallon.

[4] Other Class II composite solids equivalent product.

fortified whole milk in gallons as reported by BLS is estimated in the model as a function of the CPI for whole milk. For frozen products, demand responds to the average retail price of ice-cream as reported by the BLS. The retail price of ice-cream is estimated as a function of the Class II price at test and its own lag. The demand for other Class II products responds to the CPI for other dairy products. The six hard manufactured product demand equations are specified at the wholesale level. Wholesale prices for cheese, butter and NFDM, and dry whey represent estimates of the annual average NASS product prices used in the FMMO price formulas. Adjustments for leap year are included in the forecast period.

Table 2. Milk Supply

Dependent variable	Parameter	Estimate	t-Value	Pr > |t|	Price elasticities	R-Square
log (number of cows)	Intercept	0.666	0.73	0.4753		
	log (All-milk price / Feed value) [1]	0.029	1.46	0.1638	0.029	
	log (Trend: year minus 1979)	-0.013	-1.50	0.1540		
	lag (log (Number of cows))	0.929	9.61	<.0001		
	log (Boning and utility cow slaughter price / all milk price)	-0.013	-1.04	0.3148	-0.013	
	Dummy for 1984: Milk Diversion Program	-0.021	-2.11	0.0510		
	Dummy for 1986: Milk Production Termination Program	-0.020	-1.59	0.1316		
	Dummy for 1987: Milk Production Termination Program	-0.043	-3.47	0.0032		
	Dummy for 1998	-0.013	-1.32	0.2064		0.9715
Year-over-year change in milk per cow [2]	Intercept	333	2.29	0.0327		
	lag (All-milk price / CPI all) [1]	6,393	2.44	0.0236	0.039	
	Feed value / CPI all	-19,203	-2.63	0.0157	-0.041	
	Dummy for 1984: Milk Diversion Program	-297	-1.67	0.1098		0.9952

[1] For years when the Milk Income Loss Contract (MILC) program is in operation, the average MILC payment (total MILC payments/milk production) is added to the all milk price.

[2] Price elasticities are computed for milk per cow, not the year-over-year change in milk per cow, at the means of the explanatory variables.

Manufacturing Allocation

Manufacturing allocation is estimated directly from historical data for American and other cheeses, dry whey, dry whole milk, and canned milk (Table 5). American and other cheese production responses vary as functions of the gross returns of milk in each cheese relative to milk in butter and NFDM powder. Cheese production also responds to the previous year's marketing conditions: domestic commercial disappearance, imports, and net government removals. Dry whey production responds to its own price, cheese production, estimated milk solids used in whey protein concentrate production, and trend variables. Dry whole milk production responds to its own price, the previous year's dry whole milk production, and dry whole milk exported under the Dairy Export Incentive Program (DEIP). Production of canned milk lacks significant price responsiveness and is modeled as a function of trend and as a substitute for dry whole milk.

Table 3. Per Capita Demand and Related Equations

Dependent Variable	Parameter	Estimate	t-Value	Pr > |t|	Price and Income Elasticities [1]	R-Square
U.S. fluid milk	Intercept	232.016	10.74	<.0001		
	CPI fresh whole milk / CPI all	-0.349	-3.57	0.0017	-0.154	
	Per capita disposable income / CPI all	3.702	2.24	0.0356	0.238	
	Trend: year minus 1979	-2.893	-9.20	<.0001		0.9775
Butter	Intercept	-0.740	-0.70	0.4905		
	log (Butter price / CPI fats and oils)	-0.125	-1.38	0.1852	-0.031	
	log (Per capita disposable income / CPI all)	0.956	2.10	0.0505	0.233	
	lag (log (butter per capita))	2.102	3.66	0.0018		
	Dummy for 1989-1992	-0.265	-2.95	0.0085		
	Dummy for 1999	0.315	2.71	0.0143		
	Dummy for 2004	0.151	1.19	0.2479		0.9069
log (American cheese) [2]	Intercept	2.679	5.47	<.0001		
	log (Cheddar cheese price / CPI food)	-0.124	-1.34	0.1955	-0.124	
	(Per capita disposable income / CPI all) * Dummy for years after 1996	0.026	4.36	0.0003	0.389	
	log (Trend: year minus 1979) *Dummy for years before 1997	0.111	3.75	0.0012		0.9384
Other cheese	Intercept	-17.126	-1.92	0.0690		
	log (Mozzarella wholesale price / CPI for food)	-4.295	-1.57	0.1311	-0.295	
	log (Per capita income / CPI all)	10.594	2.86	0.0093	0.729	
	log (Trend: year minus 1979)	1.970	2.71	0.0131		0.9757
log (NFDM)	Intercept	4.081	8.55	<.0001		
	log (NFDM price / CPI food)	-0.753	-6.68	<.0001	-0.753	
	Dummy for years 1994-1997	0.391	5.97	<.0001		0.7757
log (Dry whey) [3]	Intercept	2.065	4.95	0.0003		
	log (Dry whey price / CPI food)	-0.164	-1.07	0.3066	-0.164	
	Trend: year minus 1979	-0.035	-8.01	<.0001		
	Dummy for year 1994	0.145	1.66	0.1222		
	Dummy for year 1998	0.186	2.01	0.0680		0.8312
log (Canned milk)	Intercept	4.157	2.71	0.0127		
	log (Evaporated milk price / CPI food)	-0.990	-2.05	0.0527	-0.990	
	Trend: year minus 1979	-0.044	-4.19	0.0004		0.7962

(Table 3 continued on next page.)

Table 3. Per Capita Demand and Related Equations Continued

Dependent Variable	Parameter	Estimate	t-Value	Pr > |t|	Price and Income Elasticities	R-Square
log (Dry whole milk)	Intercept	-0.959	-7.77	<.0001		
	log (Dry whole milk price / CPI all)	-1.168	-2.75	0.0119	-1.168	
	Dummy for years before 1991	0.380	2.33	0.0299		
	Dummy for years after 2000	-1.150	-10.21	<.0001		0.7543
log (Frozen products)	Intercept	5.037	15.49	<.0001		
	log (Retail price of ice cream / CPI all)	-0.471	-8.59	<.0001	-0.471	
	log (Per capita income / CPI all)	0.007	4.75	0.0001	0.007	
	Trend: year minus 1979	-0.010	-4.73	0.0001		
	Dummy for years after 2003	-0.094	-6.50	<.0001		0.8754
log (Other Class II solids)	Intercept	2.392	4.81	<.0001		
	CPI other dairy products / CPI all	-0.018	-5.88	<.0001	-1.110	
	Per capita disposable income / CPI all	0.098	2.03	0.0549	1.336	
	Trend: year minus 1979	-0.037	-3.87	0.0009		0.8142

[1] For equations where elasticities are not constant, they are computed at the means of the explanatory variables.

[2] The income elasticity for American cheese is calculated for the years 1997 through 2005.

[3] The equation for dry whey demand uses data from 1989 through 2005.

Table 4. Retail prices

Dependent Variable	Parameter	Estimate	t-Value	Pr > |t|	Price and Income Elasticities [1]	R-Square
Retail ice cream price	Intercept	-0.016	-0.26	0.7967		
	Class II price at test	0.022	5.35	<.0001	0.145	
	lag (Retail ice cream price)	0.882	30.85	<.0001	0.860	0.9793
log (CPI fresh whole milk)	Intercept	-0.188	-0.70	0.4914		
	Log (Class I price at 3.25 percent including average Class I differential and over-order payment)	0.531	4.38	0.0002	0.531	
	log (CPI all)	0.729	19.27	<.0001	0.729	0.9727
log (Retail price, fresh whole milk, fortified, per gallon)	Intercept	-2.534	-6.46	0.0002		
	log (CPI fresh whole milk)	0.704	9.10	<.0001	0.704	0.9156

[1] For equations where elasticities are not constant, they are computed at the means of the explanatory variables.

[2] The equation for the retail price, fresh whole milk, fortified, uses data from 1996 through 2005.

Table 5. Manufacturing Allocation Equations

Dependent variable	Parameter	Estimate [1]	t-Value	Pr > |t|	R-Square
log (Production, American cheese)	Intercept	0.374	0.59	0.5621	
	log (Gross value American cheese / Gross value butter-NFDM)	0.151	0.77	0.4484	
	lag (log (Domestic commercial disappearance of American cheese + net government removals of American cheese - imports of American cheese))	0.955	12.01	<.0001	
	Dummy for years 1980-1983	0.050	1.74	0.0984	
	Dummy for year 1999	0.075	1.80	0.0884	
	Dummy for year 2000	0.053	0.95	0.3523	0.9322
log (Production, other cheese)	Intercept	0.296	2.34	0.0290	
	log (Gross value other cheese / Gross value butter-NFDM)	0.067	0.83	0.4136	
	lag (log (Domestic commercial disappearance of other cheese - imports of other cheese))	0.969	53.24	<.0001	0.9960
log (Production, dry whey)	Intercept	-7.637	-1.70	0.1054	
	log (Wholesale price whey / CPI food)	0.169	2.15	0.0446	
	log (Production of American cheese + Production of other cheese)	1.761	3.24	0.0043	
	Estimated solids used in whey protein concentrate production * Dummy for years after 1992	-0.001	-3.65	0.0017	
	Trend	-0.026	-1.34	0.1976	
	Dummy for years after 2003	-0.190	-3.39	0.0031	
	Dummy for year 2001	-0.169	-2.67	0.0153	0.8479
log (Production, dry whole milk)	Intercept	1.029	2.29	0.0328	
	log (Wholesale price dry whole milk / CPI food)	0.651	3.01	0.0069	
	log (lag (Production of dry whole milk)	0.785	8.20	<.0001	
	Dry whole milk exported under DEIP	0.005	2.18	0.0417	
	Dummy for year 2001	-0.906	-5.25	<.0001	0.7025
log (Production, canned milk)	Intercept	7.129	44.97	<.0001	
	log (Production of dry whole milk)	-0.069	-2.44	0.0234	
	log (Trend: year minus 1979)	-0.183	-8.55	<.0001	0.8279

[1] Since equations are in double-log form with respect to price, coefficients can be interpreted as elasticities.

Butterfat allocation and nonfat solids allocation are estimated for specified dairy products as well as for fluid milk using conversions factors in Table 1. These amounts are subtracted from butterfat and nonfat solids estimates for milk marketed to estimate residual butterfat and nonfat solids available for butter and NFDM production.[4] Conversion factors from Table 1 are used to determine production quantities from the residual butterfat and nonfat solids.

To accurately account for butterfat and nonfat solids content, it is necessary to make some adjustments to avoid duplication. Historical data used to account for duplication are taken for the most part from *Dairy Products, Utilization and Production Trends* by the American Dairy Product Institute. For the forecast period, the proportion of NFDM used in cheese to total cheese production is estimated as a function of the butter/cheese price ratio and trend (Table 6). Condensed skim milk used in cheese is estimated as an inverse function of NFDM used in cheese and trend. Other types of duplication, such as nonfat solids used for fluid milk fortification, are accounted for as constant percentages of the applicable dairy product quantities produced.

Table 6. Duplication Adjustment Equations

Dependent variable	Parameter	Estimate	t-Value	Pr > |t|	R-Square
Nonfat dry milk used in cheese / total cheese production	Intercept	0.024	2.37	0.0298	
	Wholeseale butter price / wholesale cheese price	-0.018	-1.92	0.0722	
	lag (Nonfat dry milk used in cheese / total cheese production)	0.765	5.83	<.0001	0.6225
Condensed skim milk used in cheese	Intercept	-15.103	-0.41	0.6834	
	Nonfat dry milk used in cheese	-0.120	-2.29	0.0347	
	log (Trend: year minus 1979)	34.585	2.27	0.0365	0.2694

These duplication equations use data from 1985 through 2005.

Stocks

Year-end stocks are estimated for American cheese, other cheese, butter, and NFDM.[5] Estimating ending stock values is complicated by their volatility. For this reason

[4] NASS makes a distinction between NFDM and skim milk powders. NFDM is skim milk that has been dried with no alterations made to its content other than possible vitamin fortification. Skim milk powders include protein standardized milk powders and blends. Production of skim milk powders for export purposes have become an important factor in recent years. For years prior to 2005, skim milk powders were not included in NASS surveys. Skim milk powders are included in the *Dairy Products 2005 Annual Summary*. In the model, NFDM production includes skim milk powder for 2005, and NFDM production projections include skim milk powder.

[5] For fluid milk and dairy products other than American cheese, other cheese, butter, and NFDM, a simplifying assumption is made that the products are consumed in the same time period as produced.

Table 7. Annual Average Stock Equations

Dependent variable	Parameter	Estimate	t-Value	Pr > |t|	R-Square
log (Butter stocks)	Intercept	1.369	2.08	0.0492	
	log (Wholesale butter price / CPI all)	-0.346	-1.21	0.2403	
	log (lag (Butter ending stocks))	0.736	4.04	0.0006	0.5787
log (American cheese)	Intercept	1.400	2.74	0.0120	
	log (Wholesale cheese price / CPI all)	-0.249	-3.04	0.0060	
	log (lag (American cheese ending stocks))	0.773	8.88	<.0001	0.8743
log (Other cheese)	Intercept	-1.301	-1.76	0.0920	
	log (Wholesale mozzarella price / CPI all)	-0.708	-3.12	0.0050	
	log (lag (Other cheese ending stocks))	0.650	6.00	<.0001	0.8942
log (NFDM)	Intercept	3.248	4.59	0.0002	
	log (Wholesale NFDM price / CPI all)	-0.301	-1.37	0.1853	
	log (lag (NFDM ending stocks)	0.255	1.52	0.1434	
	Dummy for 2000	0.520	2.14	0.0447	0.5758
log (Whey)	Intercept	1.606	4.30	0.0003	
	log (Wholesale whey price / CPI food)	-0.759	-7.92	<.0001	
	log (lag (Average whey stocks))	0.125	1.20	0.2443	0.7333

a two-step process is used. First, average stock values are estimated (Table 7). For each year, this value is the simple average of the monthly ending stocks. For each equation, the average stock value has a negative relationship with the product price and a positive relationship with its own lag. Second, year-end stocks are estimated from average stocks, reflecting the typical seasonal relationship that exists between average stocks and year-end stocks (Table 8). For American cheese and NFDM, lags of ending stocks are also used as explanatory variables.

Milk Price Support Program Equations

Net government removals are defined as support price purchases plus DEIP removals minus unrestricted sales of government stocks. For each product (NFDM, cheese, and butter) net government removals are estimated as a negative log-linear function of the wholesale price minus the support price, with dummies and trends included to obtain adequate fit to historical data (Table 9). Use of the log-linear form acknowledges that government removals increase at an increasing rate as the value of the average wholesale price minus the support price gets smaller.

Table 8. Annual Ending Stock Equations

Dependent variable	Parameter	Estimate	t-Value	Pr > |t|	R-Square
log (Butter)	Intercept	0.671	1.37	0.1830	
	log (Average butter stocks)	0.716	5.94	<.0001	0.5710
log (American cheese)	Intercept	-1.445	-2.36	0.0275	
	log (Average American cheese stocks)	1.276	10.58	<.0001	
	lag (American cheese ending stocks)	-0.001	-2.18	0.0405	0.9553
log (Other cheese)	Intercept	-0.206	-0.67	0.5078	
	log (Average other cheese stocks)	1.026	16.42	<.0001	0.9616
log (NFDM)	Intercept	-0.634	-1.10	0.2840	
	log (Average NFDM stocks)	1.172	8.26	<.0001	
	lag (NFDM ending stocks)	-0.003	-1.87	0.0747	0.7416
log (Whey)	Intercept	1.955	3.31	0.0032	
	log (Average whey stocks)	0.467	2.81	0.0101	
	Dummy for year 1986	-0.266	-2.00	0.0578	0.3449

Import and Export Equations

Butter imports and commercial NFDM exports are projected by the model (Table 10). In observing the history of imports and exports of the various products included in the model, butter imports and commercial NFDM exports appear to be the most price responsive. Imports and exports for other dairy products are exogenous in the model. For projected scenarios, a simplifying assumption is made that imports and exports of other dairy products remain at baseline levels.

Butter imports are controlled to some extent by a tariff rate quota (TRQ) that allows limited imports at lower in-quota tariff rates and unlimited imports at higher over-quota tariff rates. Butter imports have usually exceeded the TRQ since it has been in place. The model assumes that the quota is filled each year, and thus only over-quota imports are estimated. Since data concerning in-quota imports is readily available from the Foreign Agriculture Service since 1997, the equation is estimated using 1997 through 2005 data. Over-quota butter imports are estimated as a log-linear function of the difference between the domestic butter price and the FOB Northern Europe butter price. As the value of the domestic price minus the FOB Northern Europe price increases, imports increase at an increasing rate.

Commercial NFDM exports are estimated as a log-linear function of the difference between the domestic NFDM price and the FOB Oceania skim milk powder price. As

Table 9. Net Government Removals Equations [1]

Dependent variable	Parameter	Estimate	t-Value	Pr > |t|	R-Square
log (net NFDM removals)	Intercept	6.742	125.11	<.0001	
	Wholesale NFDM price				
	- NFDM support price	-0.292	-6.92	<.0001	
	Dummy for 1980	-0.438	-2.14	0.0436	
	Dummy for 2002	0.464	2.86	0.0091	0.8746
log (net butter removals) [2]	Intercept	5.350	55.91	<.0001	
	Wholesale butter price				
	- butter support price	-0.096	-5.76	<.0001	
	Trend * Dummy for years before 1994	0.080	6.01	<.0001	0.9373
log (net cheese removals) [3]	Intercept	4.192	3.07	0.0054	
	Wholesale cheese price				
	- cheese support price	-0.141	-4.69	0.0001	
	Dummy for years before 1989	2.155	1.58	0.1278	0.9248

[1] Net government removals equals support price purchases plus Dairy Export Incentive Program (DEIP) removals minus unrestricted sales.

[2] The equation for net butter removals applies to observations for which the wholesale butter price exceeds the support price by more than 15 cents. For projected scenarios, if the wholesale price minus the support price is projected to be more than 15 cents, net government removals remain at baseline levels.

[3] The equation for net cheese removals applies to observations for which the wholesale cheese price exceeds the support price by more than 10 cents. For projected scenarios, if the wholesale price minus the support price is projected to be more than 10 cents, net government removals remain at baseline levels.

Table 10. Import and Export Equations

Dependent variable	Parameter	Estimate	t-Value	Pr > |t|	R-Square
log (butter imports over tariff rate quota) [1]	Intercept	-1.417	-0.79	0.4552	
	Wholesale butter price				
	- FOB Northern Europe butter price	4.992	2.73	0.0291	0.7721
log (Commercial NFDM exports)	Intercept	3.750	6.58	0.0001	
	Wholesale NFDM price				
	- FOB Oceania skim milk powder price	-6.114	-2.82	0.0200	
	Dummy for years after 2004	2.066	1.53	0.1607	0.6607

[1] In-quota butter imports are assumed to be filled over the projection period.

the value of the domestic price minus the FOB Northern Europe price gets smaller, exports increase at an increasing rate.[6]

Milk Income Loss Contract Program Equations

The USDA Farm Service Agency (FSA) makes MILC payments on a monthly basis when the Boston Class I milk price falls below $16.94 per cwt. FSA issues payments up to a maximum of 2.4 million pounds of milk produced and marketed by each operation per fiscal year. For any month in which the Boston milk price exceeds $16.94 per cwt., FSA makes no MILC payments for that month. Production for each operation during that month does not count toward the 2.4 million pound limit (cap). For the period from December 2001 through September 2005 the payment rate was 45 percent of the difference between the Boston Class I price and $16.94 per cwt. For Oct. 1, 2005, through Aug. 31, 2007, the payment rate is 34 percent of the difference. For September 2007, the payment rate is zero. The program expires at the end of the fiscal year ending September 30, 2007.

Data concerning milk cows and milk production grouped by dairy farm size is readily available from NASS since 1993. This data is used to estimate distributional information for milk production and operations had the MILC program been in effect continuously since 1993 (Table 11).[7] The percent of total milk production for operations producing less than 2.4 million pounds has declined since 1993. According to the estimates, the number of dairy farms exceeding the cap increased through 1997 but has remained fairly flat since then. For the forecast period, model equations assume that these trends will continue (Table 12).

The model projects an annual Boston Class I price consistent with the USDA baseline. Since MILC payments are made monthly, it is necessary to make an assumption about the distribution of monthly values for the Boston Class I price given an annual average.[8] For this purpose, it is assumed that the distribution monthly deviations from the average annual Boston Class I price in the projection period will have the same pattern as the

[6] While NASS makes a distinction between skim milk powders and NFDM with respect to production data, export data do not. Milk powders not exceeding 1.5 percent butterfat are all included in the same category of *Schedule B - Statistical Classification of Exports from the United States*.

[7] The methods used for estimating the distributional information for production and operations are taken from an unpublished manuscript by J. Michael Price, Richard P. Stillman, and Ralph Seeley, *The Food and Agricultural Policy Simulator: Implementation of the Milk Income Loss Contract Program*, USDA Economic Research Service, January 3, 2003. Other aspects of the model with respect to the MILC program build upon their work as well.

[8] If the annual average Boston Class I price were assumed to be constant throughout the year, MILC payments could be understated or overstated. For example, if the average Boston Class I price for a particular year was projected to be $16.94, and the price was assumed to be constant throughout the year, no MILC payments would be projected. Given the volatility of prices in recent years, this is not a reasonable assumption.

distribution for the period from January 2000 through December 2005.[9] The histogram in Figure 1 displays the distribution of Boston Class I prices from January 2000 through December 2005. The histogram uses 10 bins. The midpoint of the range for the lowest bin is $2.92 less than the average Boston Class I price over the period. The midpoint of each successive bin is $0.95 higher, with the highest bin having a midpoint that is $5.67 higher than the average Boston Class I price. Each bin has a proportional weight given the frequency of monthly occurrences over the five-year period.[10] When the annual Boston Class I price increases or decreases, the model assumes that the monthly distribution of Boston Class I prices increases or decreases by the same amount. However, for the projection period, the values of the lower bins of the distribution are floored at $13.15, the Boston Class I value corresponding to the $9.90 support price for manufactured milk.

The model assumes that an operator with less than 2.4 million pounds of production in a year (small operator), can be expected to receive MILC payments any time that the program is in effect and the Boston Class I price is less than $16.94. MILC payments for small operators are projected as follows:

Payments for small operations in a projection year (mil. $) =

$$\sum_{i=1}^{10} \max\{0, \max[0.01\ r\ (16.94 - (p + b_i))\ \gamma\ q\ w_i), 0.01\ r\ (16.94 - 13.15\ q\ w_i]\}$$

where:

r = 0.45 for December 2001 through September 2005
and 0.34 for October 2005 through August 2007
p = the annual average Boston Class I price
b_i = the price deviation from the annual average for the i^{th} bin
γ = the proportion of milk produced by small operators
q = total milk production
w_i = the weight associated with the i^{th} bin

[9] There are two reasons for using this time period: (1) The support price for milk has been set at $9.90 during this time period. Since the USDA baseline assumes that the support price will remain the same throughout the projection period, the volatility in prices should be similar. (2) If data from before 2000 were used, there could be some discontinuity due to Federal order reform.

[10] The method used to project the distribution of prices is similar to a method developed by Dale Leuck of USDA Farm Service Agency.

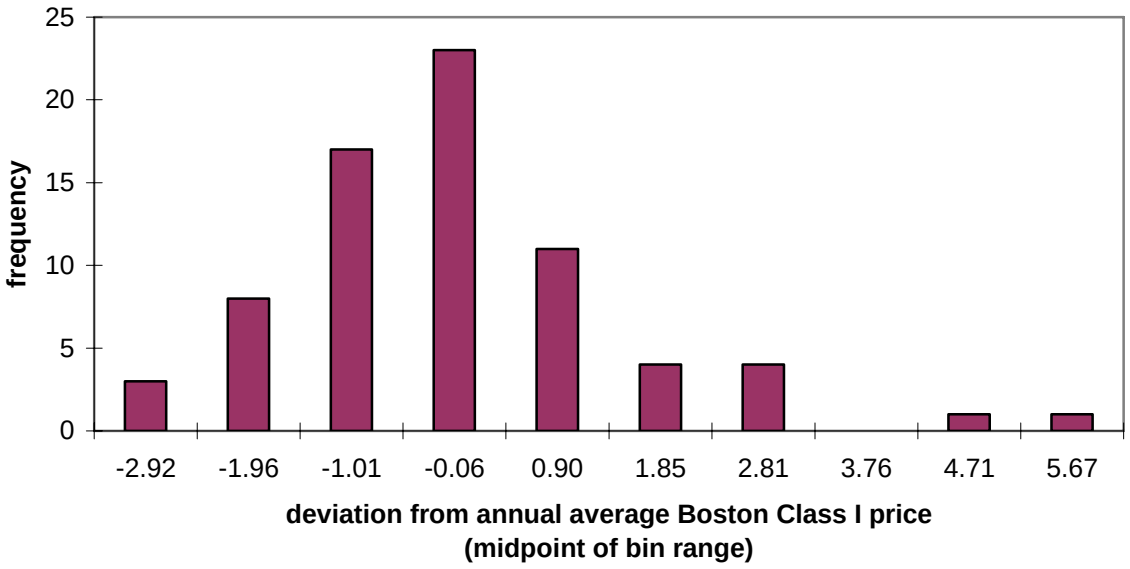
Table 11. Estimated Distributional Information for Milk Production and Operations Had the MILC Program Been in Effect Continuously Since 1993

Calendar year	Milk production	Milk production of operations producing less than 2.4 million pounds	Percent of total production for operations producing less than 2.4 mil. pounds	Number of operations producing at least 2.4 mil. Pounds	MILC-eligible production for operations producing at least 2.4 mil. pounds	Total MILC-eligible production	Percent of total production eligible for MILC payments
	mil. pounds	*mil. pounds*	*%*	*#*	*mil. pounds*	*mil. pounds*	*%*
1993	150,636	88,789	58.9	9,557	22,937	111,726	74.2
1994	153,602	84,187	54.8	10,042	24,100	108,287	70.5
1995	155,292	82,652	53.2	10,775	25,861	108,512	69.9
1996	154,006	77,083	50.1	11,164	26,793	103,876	67.4
1997	156,091	74,185	47.5	11,612	27,869	102,054	65.4
1998	157,441	73,767	46.9	10,718	25,723	99,490	63.2
1999	162,711	70,910	43.6	11,045	26,508	97,418	59.9
2000	167,658	66,830	39.9	11,474	27,538	94,367	56.3
2001	165,332	62,246	37.6	10,853	26,048	88,294	53.4
2002	169,758	58,675	34.6	10,917	26,200	84,875	50.0
2003	170,394	56,111	32.9	10,857	26,057	82,168	48.2
2004	170,806	53,493	31.3	10,725	25,740	79,233	46.4
2005	176,989	52,686	29.8	10,815	25,956	78,642	44.4

Table 12. Model Equations for MILC Program Distributional Information

Dependent variable	Parameter	Estimate	t-Value	Pr > |t|	R-Square
log (Percent of total milk production for operations producing less than 2.4 mil. pounds)	Intercept	4.089	358.45	<.0001	
	Trend: year minus 1993	-0.058	-35.95	<.0001	0.9916
Number of operations with milk production of at least 2.4 million pounds	Intercept	5909.991	3.32	0.0089	
	Lag (number of operations with milk production of at least 2.4 million pounds)	0.452	2.77	0.0219	
	(Trend: year minus 1993) * dummy before 1998	140.457	2.15	0.0600	0.5393

Figure 1. Distribution of Monthly Deviations in Boston Class I Price From Annual Average (January 2000 through December 2005)



To achieve a cutoff at the end of August 2007, payments for small producers are first estimated as though the program were effective for the entire calendar year; this estimate is then multiplied by 8/12. In this analysis, estimated payments are projected for the time period when they accrue. Payments may actually be made to producers for a few months following the month when they accrue.

The average operator with at least 2.4 million pounds of production in a year (large operator), can be expected to receive payments for about three months of the year on average. Since producers are allowed to select the months for which they will be receiving MILC payments, an assumption is made that they will choose the months when prices are typically the lowest. For the period from January 2000 through December 2004, payments were typically 93 percent lower than average during the months of February through April. The equation for payments for large operators reflects the 2.4 million pound limit per operation and payments based on Boston Class I prices that are 93 percent of the annual average.

Payments for large operations in a projection year (mil. $) =

$$\sum_{i=1}^{10} \max\{0, \max[0.01\ r\ (16.94 - 0.93(p + b_i))\ \ 2.4\ n\ w_i), \\ 0.01\ r\ (16.94 - 13.15)\ \ 2.4\ n\ w_i]\}$$

where:

r = 0.45 for December 2001 through September 2005
and 0.34 for October 2005 through August 2007
p = the annual average Boston Class I price
b_i = the price deviation from the annual average for the i^{th} bin
n = number of operations producing at least 2.4 million pounds
w_i = the weight associated with the i^{th} bin

The MILC program has an effect on production response because payments are tied to current marketings. There are insufficient data available to estimate the production response of small producers versus large producers. For this reason, the model production response is based on total MILC payments divided by milk production. This amount per cwt. is added to the all-milk price in the equations for the number of milk cows and the yield per cow.

Farm and Handler Milk Prices

Fluid milk processors regulated by FMMOs generally pay the Federal order Class I price plus a market-generated over-order payment. Federal order class prices are calculated from the Federal order price formulas using the estimated dairy product prices.[11] Class I over-order payment historical estimates are based on annual averages of announced cooperative Class I prices in selected cities. Class I over-order payments in the model are estimated as a function of the ratio of U.S. Class I to Class III and IV uses, and total cheese production (Table 13). This allows Class I over-order payments to vary as supply and demand conditions change. The Federal order Class I price plus the over-order payment applies to U.S. fluid milk in the model.

The equation for the U.S. all-milk price received by producers for farm milk is a function of Federal order minimum prices and market forces as reflected by dairy product prices and quantities. The equation has two terms other than the intercept. The first is a U.S. "blend" price calculated using Federal order class prices and U.S. quantities of butterfat and skim milk. Since the majority of U.S. milk is subject to Federal order pricing, prices for milk outside of Federal order regulation are similar due to competitive factors. The second term consists of a proxy for dairy processor revenue divided by U.S. milk marketings. The proxy makes use of data available for prices and quantities of major dairy products; comprehensive proprietary dairy processor revenue data are unavailable. Thus, the estimated U.S. all-milk price incorporates the Federal order minimum prices that prevail for the majority of the milk, dairy product prices, Class I over-order payments, fluid milk quantities, and dairy product quantities.

[11] See http://www.ams.usda.gov/dyfmos/mib/cls_prod_cmp_pr.htm for Federal Milk Order Price Information.

Table 13. Class I Over Order Payments, All Milk Price Equations

Computations not requiring econometric estimation

Wtd. avg. US fat price using FO min. prices

$$\frac{\sum_{j=I}^{IV} \left((\text{Fat per US Class Use})_j * (\text{Federal Order Class Fat Price})_j \right)}{\sum_{j=I}^{IV} (\text{Fat per US Class Use})_j}$$

Wtd. avg. US Skim price using FO min. prices

$$\frac{\sum_{j=I}^{IV} \left((\text{Skim Milk per US Class Use})_j * (\text{Federal Order Class Skim Milk Price})_j \right)}{\sum_{j=I}^{IV} (\text{Skim Milk per US Class Use})_j}$$

Wtd. avg. US "blend" price using FO min. prices

(((1 - US all-milk fat test) / 100) * Wtd. avg. US Skim price using FO min. prices)
+ US all-milk fat test * Wtd. avg. US fat price using FO min. prices

Proxy for dairy processor revenue

Class I price at test plus over order premiums * U. S. fluid use
+ Domestic comm. disappearance other cheese * mozzarella wholesale price
+ Domestic comm. disappearance American cheese * cheddar cheese wholesale price
+ Domestic comm. disappearance butter * butter wholesale price
+ Domestic comm. disappearance NFDM * NFDM wholesale price
+ Net government removals butter * butter support price
+ Net government removals cheese * cheese support price
+ Net government removals NFDM * NFDM support price

Econometric Estimations

Dependent variable	Parameter	Estimate	t-Value	Pr > |t|	R-Square
log (Class I over order payments)	Intercept	-17.958	-4.50	0.0002	
	log (US Class I use / (US Class III use + US Class IV use)	2.452	3.00	0.0066	
	log (Total cheese production)	2.106	4.32	0.0003	
	Dummy for years after 1999	0.527	4.71	0.0001	0.8610
log (All milk price)	Intercept	-1.763	-2.52	0.0192	
	log (Wtd. avg. U.S. "blend" price using Federal order class prices)	0.685	9.90	<.0001	
	log (Proxy for dairy processor revenue / Total of U.S. marketing of milk)	0.218	3.12	0.0048	0.9482