

USDA Agricultural Marketing Service (AMS) Dairy Programs

Econometric Baseline Model Documentation

For Model Calibrated To
USDA Agricultural Baseline Projections to 2014

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Dairy Programs

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Introduction

Dairy Programs' Office of the Chief Economist has developed 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 fiscal years 1979-80 through 2002-03. The model includes Federal Milk Marketing Order prices as well as Milk Price Support Program variables and 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 (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 2003-04 through 2013-14. 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 Federal order as follows:

- Class I - fluid uses
- Class II - soft manufactured products (frozen products and other Class II)
- Class III - cheese, dry whey, and canned milk²
- Class IV - butter, nonfat dry milk, and whole dry milk

¹ Dairy baseline forecasts are developed by an Interagency Commodity Estimates Committee at USDA. Intercept terms for the model are modified for each forecast year as needed to calibrate the model to approximate baseline forecasts. For information on USDA's official baseline, see [USDA Agricultural Baseline Projections to 2014](#) U.S. Department of Agriculture, Office of the Chief Economist, World Agricultural Outlook Board, OCE-2005-1.

² Since December 1, 2004, evaporated milk in consumer-type packages or sweetened condensed milk in consumer-type packages has been reclassified as Class IV. Dairy Programs plans to adapt the model to this change in the near future.

Fluid use is obtained from Dairy Market Statistics published by AMS. Butterfat and nonfat solids content for fluid milk are determined from Federal order and California data. Manufactured products include American cheese, other-than-American cheese (other cheese), butter, canned milk, whole dry milk, nonfat dry milk, total frozen products, and other Class II products. Manufactured product production as reported by NASS is used for all dairy products with the exception of other Class II products. Other Class II is treated as a composite solids-equivalent product, historically calculated as the residual butterfat and nonfat solids after meeting all other 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 year 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 producer milk price, feed costs, and slaughter prices. Milk production per cow is estimated as a function of milk prices and feed costs. Producers adjust cow numbers based on changes in milk prices, feed prices, and cow slaughter prices. Milk marketings are estimated as milk production (milk cows times milk per cow), less farm use. Adjustments for leap year are included in the forecast period.

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, the prices or price indices for product substitutes (e.g., margarine for butter), and other factors, such as expenditures on food away from home and trend (Table 3). 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 average Class I price at the average test for fluid milk, using the average Class I differential plus the estimated over-order Class I premium. For frozen products, demand responds to the average retail price of ice-cream as reported by the Bureau of Labor Statistics. 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

Table 1: Dairy Product Conversion Factors

Products	Butterfat and nonfat solids required per product unit	
	Butterfat	Nonfat Solids
Producer Milk	3.685	8.720
Butter	80.40	1.00
American cheese ¹	36.80	85.10
Other Cheese ²	28.70	85.80
NDM	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	9.88
Other Class II ⁴	46.00	54.00

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

² Weighted average of other cheeses, reflects solids required for production not 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. Based on recent year's average.

nonfat dry milk, and dry whey represent estimates of the annual average NASS product prices used in the Federal Order price formulas. Wholesale retail margins are assumed to be constant. Adjustments for leap year are included in the forecast period.

Manufacturing Allocation

Manufacturing allocation is estimated directly from historical data for American and other cheeses, dry whey, dry whole milk, and canned milk (Table 4). American and other cheese production responses vary as functions of the gross returns of milk in each cheese relative to milk in butter and nonfat dry milk powder. Dry whey production responds to its own price and cheese production. Dry whole milk production responds to its own price and as a substitute for nonfat dry milk. 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 2. Milk Supply

Dependent variable	Parameter	Estimate	t-Value	Pr > t	R-Square
milk cows	Intercept	-53.763	-0.13	0.8978	
	all milk price ¹ / cpi all	75.476	3.55	0.0027	
	feed price / cpi all	-98.783	-2.37	0.0310	
	lag (milk cows)	0.969	17.43	<.0001	
	slaughter price / cpi all	-3.178	-0.95	0.3579	
	Dummy - Buyout Program	-579.599	-6.02	<.0001	
	Dummy 2002 and 2003	123.965	2.11	0.0508	0.9885
log (Milk per cow)	Intercept	0.123	0.92	0.368	
	lag (log (milk-feed price ratio))	0.029	1.95	0.0673	
	lag (log (Milk per cow))	0.986	70.56	<.0001	
	Dummy - Diversion Program	-0.023	-2.47	0.0236	
	Dummy 2001	-0.029	-3.12	0.0059	0.9968

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.

Butterfat 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 nonfat dry milk production. 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 nonfat dry milk used in cheese to total cheese production is estimated as a function of the butter/cheese price ratio and trend (Table 5). Condensed skim milk used in cheese is estimated as an inverse function of nonfat dry milk 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.

Stocks

Stocks are estimated for American cheese, other cheese, butter, and nonfat dry milk (Table 6). For other dairy products and fluid milk, a simplifying assumption is made that the products are consumed in the same time period as produced. Demand for stocks is negatively related to price for all equations except for other cheese. The stock change for other cheese is a function of its own lag, production of other cheese, imports, and domestic commercial disappearance. While American cheese ending stocks are estimated in terms of year-end stocks, stocks for the other dairy products are estimated in

Table 3. Demand Equations

Dependent Variable	Parameter	Estimate	t-Value	Pr > t	R-Square
U.S. fluid milk per capita ¹	Intercept	225.363	7.95	<.0001	
	(Class I price at fluid test + over order premium) / CPI all	-1.537	-1.78	0.0910	
	Per capita disposable income / CPI all	3.221	1.82	0.0850	
	Trend	-2.927	-8.70	<.0001	0.9694
log (Butter per capita)	Intercept	0.594	1.70	0.1045	
	log (Butter price / CPI margarine)	-0.065	-2.34	0.0304	
	log (Per capita disposable income / CPI all)	0.435	4.51	0.0002	
	Dummy 1988-1993 * trend	-0.011	-7.78	<.0001	0.8782
log (Amer. cheese per capita)	Intercept	7.365	6.90	<.0001	
	log (Cheddar cheese price / CPI all)	-0.081	-0.91	0.3748	
	log (Per capita disposable income / CPI all)	0.010	3.56	0.0024	
	log (Food expenditures away from home / total food expenditures)	2.481	3.78	0.0015	
	log (Trend)	-0.202	-2.69	0.0155	
	Dummy for 1988	-0.070	-2.13	0.0482	0.9502
log (Other cheese per capita)	Intercept	2.443	4.72	0.0002	
	log (Mozzarella price / CPI for meat)	-0.222	-2.31	0.0332	
	log (Per capita income / CPI all)	0.650	3.41	0.0031	
	log (Food expenditures away from home / total food expenditures)	1.983	4.43	0.0003	
	log (Trend)	0.066	1.27	0.2196	0.9916
log (NDM per capita)	Intercept	2.848	4.38	0.0003	
	log (NDM price / CPI all)	-0.396	-2.56	0.0188	
	Govt removals / total NDM production	-0.618	-4.26	0.0004	0.5431
log (Dry whey per capita)	Intercept	0.382	2.21	0.0394	
	log (Dry whey price / CPI food)	-0.092	-1.90	0.0723	
	log (lag (Dry whey per capita))	0.937	10.58	<.0001	
	Trend	-0.004	-2.46	0.0237	0.7792
log (Canned milk per capita)	Intercept	1.476	1.07	0.2997	
	log (Evaporated milk price / CPI food)	-0.925	-2.32	0.0319	
	Trend	-0.023	-2.35	0.0297	
	log (Food expenditures away from home / total food expenditures)	-2.732	-3.39	0.0031	0.8935
log (Dry whole milk per capita)	Intercept	3.079	6.09	<.0001	
	log (Dry whole milk price / CPI all)	-2.354	-3.62	0.0020	
	Dummy 1990	0.702	3.38	0.0034	
	log (Canned milk per capita)	-2.869	-6.59	<.0001	
	Trend	-0.164	-6.90	<.0001	0.6807

Table 3 continued on next page.

Demand Equations Continued

Dependent Variable	Parameter	Estimate	t-Value	Pr > t	R-Square
log (Frozen products per capita)	Intercept	1.906	6.53	<.0001	0.8569
	log (Retail price of ice cream / CPI all)	-0.478	-9.55	<.0001	
	log (Per capita income / CPI all)	0.699	5.53	<.0001	
	Trend	-0.011	-5.42	<.0001	
log (Other Class II solids per capita) 2	Intercept	2.471	5.55	<.0001	0.8597
	CPI other dairy products / CPI all	-0.014	-7.38	<.0001	
	Per capita disposable income / CPI all	0.107	2.52	0.0209	
	Trend	-0.044	-5.28	<.0001	

¹ For fluid milk demand per capita, at means of independent variables, real price elasticity of demand = -0.08, and real income elasticity of demand = 0.20.

² For Other Class II solids per capita, at means of independent variables, real price elasticity of demand = -1.22, and real income elasticity of demand = 1.42.

terms of year-over-year changes in year-end stocks to obtain equations with better fit and forecast characteristics.

Farm and Handler Milk Prices

Fluid milk processors regulated by Federal orders 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.³ Class I over-order payment data are based on annual averages of announced cooperative Class I prices in selected cities, and are estimated in the model as a function of fluid milk per capita and cheese production. This allows Class I over-order payments to vary as supply and demand conditions change. When fluid milk per capita or cheese production rises, competition for the milk supply raises the over order payment. The Federal order Class I price plus the over-order payment applies to U.S. fluid milk in the model.

The U.S. all-milk price received by producers for farm milk is estimated in two steps. First, a U.S. “blend” price is calculated using Federal order class prices and U.S. quantities of butterfat and skim milk. The U.S. all-milk price is then estimated from the U.S. “blend” price and the gross revenue generated by commercial sales of fluid milk and commercial and price-support sales of American cheese, other cheese, butter, and nonfat dry milk (Table 7). Thus, the estimated U.S. all-milk price incorporates the Federal order minimum prices that prevail for the majority of the milk, and the market forces that are reflected by dairy product prices and quantities and Class I over-order payments.

³ See http://www.ams.usda.gov/dyfmos/mib/cls_prod_cmp_pr.htm.

Table 4. Manufacturing Allocation

Dependent variable	Parameter	Estimate	t-Value	Pr > t	R-Square
log (Production, American cheese)	Intercept	0.646	1.05	0.3085	
	log (Gross value American cheese / Gross value butter)	0.075	0.39	0.6986	
	lag (log (Domestic commercial disappearance of American cheese + net government removals of American cheese - imports of American cheese))	0.923	11.91	<.0001	
	Dummy for year 2000	0.057	1.24	0.2289	0.9108
log (Production, other cheese)	Intercept	0.332	3.1	0.0056	
	log (Gross value other cheese / Gross value butter)	0.069	0.99	0.3343	
	lag (log (Domestic commercial disappearance of other cheese - imports of other cheese))	0.965	62.81	<.0001	0.9964
log (Production, canned milk)	Intercept	7.115	39.32	<.0001	
	Production of dry whole milk	-0.066	-1.9	0.0725	
	Trend	-0.182	-8.58	<.0001	0.7891
Production, dry whey	Intercept	-4521.180	-5.1	<.0001	
	Wholesale price whey / CPI food	527.803	0.81	0.4294	
	log (Production of American cheese + Production of other cheese)	627.179	6.61	<.0001	
	Trend * Dummy for years prior to 1993	12.757	3.34	0.0037	
	Dummy for year 2001	-139.589	-1.81	0.0865	0.7619
log (Production, dry whole milk)	Intercept	4.176	6	<.0001	
	Wholesale price dry whole milk / CPI food	0.573	2.05	0.0544	
	lag (Production of dry whole milk - imports of dry whole milk)	0.006	3.12	0.0057	
	Production of nonfat dry milk	-0.001	-1.63	0.1192	0.5137

Table 5. Duplication adjustment

Dependent variable	Parameter	Estimate	t-Value	Pr > t	R-Square
Nonfat dry milk used in cheese / total cheese production	Intercept	0.028	2.29	0.0361	0.6102
	Butter price / cheese price	-0.030	-2.80	0.0129	
	Trend	0.001	3.68	0.0020	
Condensed skim milk used in cheese	Intercept	-82.721	-2.94	0.0095	0.6156
	Nonfat dry milk used in cheese	-0.140	-2.85	0.0116	
	Trend	62.027	4.82	0.0002	

Table 6. Stocks

Dependent variable	Parameter	Estimate	t-Value	Pr > t	R-Square
Change in butter stocks	Intercept	19.267	2.97	0.0083	0.6546
	Change in butter price	-0.116	-0.76	0.4593	
	Government removals of butter	-0.066	-2.86	0.0105	
	lag (change in butter stocks)	-0.323	-2.28	0.035	
	Dummy 2002	80.028	4.3	0.0004	
American cheese ending stocks	Intercept	16.317	0.36	0.7247	0.5686
	Change in cheese price	-1.315	-2.44	0.0251	
	Domestic commercial disappearance, American cheese	0.056	3.07	0.0066	
	Dummy 1988	-85.986	-2.24	0.0377	
	lag (American cheese ending stocks)	-0.447	-3.43	0.003	
Change in other cheese stocks	Intercept	20.798	3.14	0.0051	0.7769
	Production of other cheese + imports of other cheese - domestic commercial disappearance, other cheese	0.424	8.15	<.0001	
	lag (Other cheese ending stocks)	-0.424	-5.6	<.0001	
	NDM price	-1.395	-1.96	0.0645	
Change in NDM stocks	Intercept	120.449	1.88	0.0762	0.1677
	Trend	1.109	0.98	0.34	
	Lag (change in NDM stocks)	-0.536	-3.04	0.0067	
	NDM price	-1.395	-1.96	0.0645	

Table 7. Class I Over Order Payments All Milk Price

Dependent variable	Parameter	Estimate	t-Value	Pr > t	R-Square
Class I over order payments	Intercept	-4.1350	-1.92	0.0686	
	Total cheese production	0.0002	3.29	0.0035	
	Fluid milk per capita	0.0158	1.97	0.0624	0.7310
Wtd. avg. US fat price using FO min. prices	$\frac{\sum_{j=1}^{IV} ((\text{Fat per US Class Use})_j * (\text{Federal Order Class Fat Price})_j)}{\sum_{j=1}^{IV} (\text{Fat per US Class Use})_j}$	identity: no parameters estimated			
Wtd. avg. US Skim price using FO min. prices	$\frac{\sum_{j=1}^{IV} ((\text{Skim Milk per US Class Use})_j * (\text{Federal Order Class Skim Milk Price})_j)}{\sum_{j=1}^{IV} (\text{Skim Milk per US Class Use})_j}$	identity: no parameters estimated			
Wtd. avg. US "blend" price using FO min. prices	$(((1 - \text{US all-milk fat test}) / 100) * \text{Wtd. avg. US Skim price using FO min. prices}) + \text{US all-milk fat test} * \text{Wtd. avg. US fat price using FO min. prices}$	identity: no parameters estimated			
log (All milk price)	Intercept	-0.530	-1.13	0.2697	
	log (Wtd. avg. U.S. "blend" price using Federal order class prices)	0.720	12.19	<.0001	
	log (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 NDM * NDM wholesale price				
+ Net government removals butter * butter support price					
+ Net government removals cheese * cheese support price					
+ Net government removals NDM * NDM support price)	0.106	2.37	0.0276	0.9238	