The Milk Inventory Management Study:
Economic Modeling for Dairy Policy Analysis *

by

Don P. Blayney¹


Long-term milk supply-demand "balance" has generally been elusive. Commodity Credit Corporation (CCC) purchases of dairy products during the debate prior to the signing of the 1990 Farm Bill (Food, Agriculture, Conservation, and Trade Act of 1990) were relatively low in comparison to purchases in the early 1980's. Much of the dairy policy debate focused on what the policy response to future (anticipated) surplus milk production situations should be.

Both the House and Senate versions of the Farm Bill, and ultimately the final version, included a mandate that the United States Department of Agriculture (USDA) study alternative inventory management programs for reducing surplus milk production and submit its recommendation(s) to Congress. The original deadline for submitting the report and recommendations was August 1, 1991 but rapidly falling milk prices in late 1990 and early 1991 and the resulting political responses led to an earlier deadline--June 15, 1991.

The general requirements of the Congressional mandate and the results of the USDA study are widely known. A 21 member team representing 7 USDA agencies undertook the study. Nearly forty (40) different program options were analyzed and twelve (12) were reported in the final study sent to the Congress:

- 4 target price/deficiency payment plans,
- 3 Class IV programs,
- 3 two-tier pricing plans, and
- 2 milk marketing diversion programs.

The 12 options represented "composite" programs that incorporated the unique features of the individual proposed programs submitted for study (6)².

**Economic Modeling for Analysis of Milk Inventory Management Programs**

From a modeling perspective, two important questions had to be answered for analyzing the milk inventory management programs as mandated: (1) what programs were to be evaluated and what are their unique features?, and (2) what criteria were to be used for evaluating each program?

Congress mandated that establishing an alternative class for surplus milk (called the Class IV program), and establishing a

² Numbers in parentheses indicate references listed at the end of the paper.
system of target prices and deficiency payments would be program alternatives included in the USDA study. The public was also to be solicited for proposals of which seventy-seven (77) were submitted by the February 6, 1991 deadline.

Proposals submitted by the public fell into five main categories: 1) Class IV plans, 2) target price/deficiency programs, 3) two-tier pricing plans, 4) paid milk diversion, and 5) demand-increasing programs. The Congress had also mandated what were considered unacceptable programs: 1) those including provisions for milk production termination similar to the dairy herd buy-out of 1986-87, and 2) those with a support price below $10.10 per hundredweight (cwt).

After receiving and analyzing the public proposals, four program types were selected for study: Class IV, target price/deficiency payment, two-tier pricing, and paid milk diversion. No particular proposed program was evaluated: instead, composite programs incorporating the unique features of specific alternatives were defined. The composites generally captured the spectrum of program variables, such as target prices or diversion program parameters, offered in the proposals.

The permanent authority for the milk price support program (Section 201 of the 1949 Agriculture Act) states that the objectives of the program are "to assure an adequate supply of pure and wholesome milk" and "to meet current needs, reflect changes in the cost of production, and assure a level of income adequate to maintain productive capacity sufficient to meet anticipated future needs."

The capability of a particular milk inventory management program or program type to meet such broad policy objectives would be difficult to determine. The Congress provided a slate of twelve (12) specific criteria to be used for program evaluation, the last being a general one for capturing unlisted issues deemed by the Secretary of Agriculture as appropriate. Three (3) criteria were added in this category resulting in a total of fourteen (14):

(A) The program's ability to limit Government purchases to 6 billion pounds (milk equivalent, total milk solids basis) in a calendar year;

(B) Speed and effectiveness of reducing excess milk production;

(C) Effectiveness in sustaining reduced production for at least 5 years with and without continuation of the program;

(D) The regional price, revenue, and supply impacts;

(E) Impacts on national producer income and Government expenditures;
(F) Impacts on the rural economy and maintaining family farms;

(G) Effects on the availability of wholesome dairy products for domestic and foreign nutrition and food assistance programs;

(H) Technological innovations;

(I) Effectiveness in reducing butterfat production and increasing milk's protein content;

(J) Effects of temporary increases or decreases (shocks) in milk production;

(K) Impacts on the U.S. livestock industry; and

(L) (1) Consistency with international obligations and it's impacts on international trade.

(2) Impacts on consumers, including levels of consumption and costs.


Constructing an economic model of the U.S. dairy industry that included all of the possible program variables, supply factors, demand factors, and variables or relationships that captured the essence of the 14 evaluation criteria would have been then, and would be now, a mammoth undertaking. It is difficult to believe that anyone could have anticipated the complexities of evaluating the alternative inventory management programs and had a comprehensive model ready and waiting to complete the task.

The Economic Research Service (ERS) was actively involved in the evaluation of the proposed milk inventory management programs based on the results of economic models. From the beginning of the study, it was clear that constructing a "new" model for the analysis was out of the question. The study represents an analytical approach more common than many would admit; a linkage of statistical models, ad hoc analysis, and the knowledge/expertise of dairy analysts throughout USDA. In the policy environment of Washington, D.C., an environment that often requires quick turn-around times, this approach is not uncommon.

There are four "models" included in the Milk Inventory Management Study: 1) a simulation model of aggregate U.S. milk supply and demand relationships, 2) a simulation model of the U.S. livestock and poultry sector, 3) a computable generalized equilibrium (CGE) model, and 4) an input-output model (IMPLAN). Only highlights of each model are presented here; references presenting greater detail are available in most cases (see reference and additional readings list).
Aggregate Dairy Industry Simulation Model

The simulation model of the aggregate U.S. dairy industry used in the milk inventory management study is a straightforward empirical tool. USDA dairy analysts regularly meet to develop baseline estimates for future levels of, among other variables, production, commercial use, milk prices, and government program costs. The baseline thus represents estimates of current policy effects on the dairy industry. The pros and cons of the baseline procedure itself are not our concern here.

A LOTUS spreadsheet was constructed in what might be described as an "accounting" framework to reconstruct baseline estimates of aggregate dairy industry variables. The spreadsheet was then modified to specifically account for program options, such as a reduction in production in order to receive deficiency payments or an assessment to cover program costs, and their effect on variables in the baseline model. The analysis that followed was thus based on changes from a baseline.

The model is static in the sense that each marketing year is modeled in "isolation", e.g. production in year t is not functionally related to production in year t+1. Some of the dynamics of the industry were approximated by the assumptions regarding the short- and long-term elasticities of supply and the introduction of bovine somatotropin (BST). Relationships between the milk support price, the price of manufacturing grade milk, and the all-milk price are USDA interagency estimates. Such a modeling framework may jar the sensitivities of purists, but the approach has gained a measure of acceptance among analysts and policy-makers within the USDA.

Livestock and Poultry Sector Model

The impact of milk inventory management programs on other livestock industries was one criterion listed by the Congress for evaluating such programs. In particular, cattlemen were concerned that the programs might result in dairy cow slaughter that would put pressure on the beef and meat markets leading to lower prices. Memories of the Dairy Termination Program were still relatively fresh, despite the proscription of herd buyout plans in the Farm Bill.

The annual livestock and poultry model developed by ERS (7) was used to evaluate the effects of selected milk inventory management program options on the beef, pork, broiler, and turkey industries. The endogenous components of the 50-equation model are: cattle, hog, broiler, and turkey inventories; the supply of these four animals as meat; and the farm, wholesale, and retail demand for the four meats. Macroeconomic variables in the model, such as total consumer expenditures and expenditures on non-meat
food items, and nonfood items, disposable income and inflation, and feed sector variables such as hay, corn, and soybean meal prices are determined exogenously.

Since milk inventory management program effects on the beef industry aroused the greatest concerns during the course of the USDA study, the structure of the beef portion of the ERS model is discussed in greater detail. The supply portion of the beef model contains 14 equations defining the inventories of beef cows, heifers, and steers; the calf crop; beef cow, heifer, and steer slaughter; and average dressed weight. An identity defines federally inspected production (slaughter x average dressed weight). Since supply and demand are estimated simultaneously, a common unit of measurement is defined for the two sides of the equation--retail weight per capita disappearance.

The retail (consumer) demand equation for beef and veal is part of an eight-equation inverse demand system specified following Huang (3). The dependent variable is the percentage change in the retail beef and veal consumer price index. The independent variables are the percentage changes in quantities of beef and veal, pork, broilers, turkeys, nonmeat food items, energy, nondurables less food and energy, and personal consumption expenditures less durables.

The wholesale and farm demands for beef are derived from the retail level. Six price equations are estimated: wholesale boxed beef, cow carcass, Omaha fed steer, Omaha fed heifer, Omaha utility cow, and Kansas City feeder steer. The model was estimated using three stage least squares (3SLS). The 3SLS technique accounts for contemporaneous correlation in the time series data for consumer prices and supplies over the period of fit, 1960-1988. Standard test statistics, such as mean square error and decomposition of Theil's U, were used to evaluate the model.

**Computable General Equilibrium (CGE) Model**

The model used for estimating economy-wide effects of changes in dairy policy associated with milk inventory management programs is an expanded version of the basic USDA/ERS computable general equilibrium (CGE) model (5). It includes 32 sectors: 8 agricultural, 8 agricultural processing, 3 energy, 10 other manufacturing, and 3 service, and explicitly treats some farm programs (2). Raw milk from dairy farms and processed dairy products are identified in the agricultural and food processing sectors.

A CGE model simulates the working of a market economy in which prices and quantities adjust to clear factor and product markets. Consumers and producers are assumed to be optimizers in the economy. Government is explicitly included in the model but not
as an optimizing economic agent and all transactions are captured in a circular flow of income.

Each industry in the model produces a composite commodity that can be transformed into either a commodity for export or one for domestic consumption. The output of each industry is modeled by a production function incorporating both primary and intermediate inputs. Sectoral input demands are derived from first order conditions for profit maximization.

The markets for the primary factors such as land, labor, and capital may be modeled in one of two modes. In a "shortrun" version of the model, capital is assumed fixed in each sector and the final equilibrium will have sectorally differentiated rental rates. In the "longrun" version, all factors are mobile and average factor returns adjust to clear markets with full employment.

Aggregate domestic demand has four components in the model: consumption, intermediate, government, and investment (including inventory accumulation). Household expenditure functions are derived under utility maximization. Each household pays income taxes to the government and saves a fixed proportion of after-tax income. Intermediate demands are given by fixed input-output coefficients. Aggregate real spending on goods and services by government is exogenous. Sectoral inventory demands are fixed proportions of domestic output. Fixed investment and demand for investment goods are distinguished in the model by sector of destination and sector of origin. A capital composition matrix translates the demand for investment goods by sector of destination to a sector of origin basis.

The CGE model includes the major macro balances: savings-investment, government deficit, and balance of trade. Aggregate investment is either set exogenously from a macro model or is "savings driven". Aggregate savings is the sum of enterprise-retained earnings plus a capital consumption allowance, household saving, government saving, and foreign saving. Government saving is the difference between government revenues and spending on goods and services and transfer payments.

In the balance of trade equation, the value of imports at world prices must equal the value of exports at world prices plus foreign savings, net remittances, and net foreign borrowing by the U.S. government. One of two equilibrating approaches may be specified: 1) real exchange rates adjust to achieve a predetermined balance of trade or 2) real exchange rates are fixed exogenously and foreign saving adjusts to reach equilibrium.

The CGE model solves for relative prices only. The numeraire price index chosen for the model is the GNP price deflator. Given the numeraire, the model solves for all relative factor returns and prices that clear the markets for factors and products. The model also solves for the equilibrium value of the real exchange rate, given exogenously set balances of trade.
There is a fair amount of detail in the agricultural sectors of the CGE model. Government programs are modeled individually rather than by incorporating them as ad valorem price wedges. Programs in the model include deficiency payments (for cotton, foodgrains, and feedcrops), export subsidies (for foodgrains, feedcrops, meat processing, grain milling (flour), and soybean milling), and import quotas (for dairy processing and sugar processing).

Input-Output Analysis

Input-output (I-O) analysis is one means of measuring the economic impacts of agricultural policy changes in a regional economy. The attempt to explicitly trace the direct, indirect, and induced economic effects and place them in an accounting system is one value of I-O modeling efforts. The U.S. Forest Service has developed the IMPLAN (IMpact analysis for PLANning) model. IMPLAN contains I-O accounting matrices for 528 industries for all 3,097 counties in the United States. IMPLAN permits the examination of input-output relationships for the industries at any level from a single county to the entire nation (1,4).

IMPLAN is a "non-survey" based I-O model comprised of two major parts: 1) the non-survey data base containing regional economic statistics, and 2) a data reduction procedure. The data base contains estimates of a region's final demand, final payments, total industry output, and total industry outlays. The data reduction procedure provides derivations of regional interindustry production and domestic trade (including interindustry trade) I-O accounts. These industry I-O accounts are distinguished from standard I-O models' results because both upstream and downstream linkages can be derived.

Five areas were selected for study using the IMPLAN model: the Northeast (Burlington, VT), the Southeast (Macon, GA), the Southwest (Hopkins County, TX), the Upper Midwest (Fond du Lac, WI), and the Pacific (Visalia-Hanford, CA). These areas represent varying dairy farm structure and varying importance of the dairy industry to the local economy.

Linking the Models

Each model provides empirical evidence for analyzing different types of questions. In the Milk Inventory Management Study, the four models were brought together for analytical purposes. An example is the best way to explain how the analytical process unfolded. The specific results of the study are not our concern, rather the approach for generating estimates of the economic
changes due to potential dairy policy changes on a diverse set economic units is the focus.

Baseline projections for cow numbers, milk production, commercial use, prices, farm receipts, retail value, and government costs for the period 1991/92 through 1996/97 were made. The same items were then estimated using the aggregate dairy industry simulation model modified to account for specific inventory management program options and compared with the baseline. Thus, inventory management program options were evaluated according to estimated changes from the current policy baseline.

Inventory management program-specific projections were then used as input to the other three models, i.e., an exogenous shock in a key model variable matching the change estimated by the aggregate dairy simulation model was introduced into each model. In this way, the three models provide estimates of the livestock sector, economy-wide (agricultural-nonagricultural sector), and rural area effects of the selected program option.

The estimates of beef industry impacts were generated by using the implied change in dairy cow slaughter due to implementation of an inventory management program. The change in the dairy cow inventory was used to determine dairy cow slaughter and calf-crop effects which are elements of the supply portion of the beef sector supply model. Since supply and demand are simultaneously estimated, the effects of the inventory management programs on beef consumers is also estimated.

The CGE model simulates the price and quantity adjustments that clear the markets for products and input factors in a market economy when an exogenous shock is introduced. The estimated changes in the farm milk price and the aggregate milk production under alternative inventory management programs were exogenous for the analysis with the CGE model. The model was used to provide analysis of short-run "what-if?" types of questions.

The I-O model was used to estimate income and employment effects in selected local rural economies based on the estimated changes in milk production and in cash receipts from milk (which included Government payments) due to inventory management programs. Local area changes can be separated into two components: 1) the effects on backward-linked industries due to milk production changes, and 2) effects on consumption by dairy farmers due to changes in cash receipts (inside and outside the local area).

Closing Comments

The "model" used for analyzing milk inventory management programs and options considered in the USDA study is clearly not a unified comprehensive model. It is a series of models, each one capable of standing alone and each designed to provide the empirical estimates of relationships for different sets of questions.
The aggregate dairy industry simulation is best suited for questions at the national level, for example the aggregate U.S. milk production and commercial use. The simulation model of livestock and poultry is also an aggregate national model. The CGE model provides a method for examining the linkages between the agricultural and nonagricultural sectors within the economy. Finally, the I-O model allows one to focus on impacts at the local level.

The link among the models is the approach for analyzing impacts—each model is "shocked" through key variables. The shock applied to each model is the same, that is, the change generated by the aggregate dairy industry simulation model is applied to each of the other models as was described. There is no simultaneity implied or in actuality by following this approach. There is no need to dwell on the strengths and weaknesses of each model, we recognize them and may argue their merits at great length.

Finally, I would like to offer some personal observations. We have gathered to consider what direction modeling (and in a more fundamental sense, research efforts) for dairy industry and policy analysis might take in the future. I would suggest that there are plenty of dairy industry and policy models available; we are going to hear about several of them today. Focusing on how we might link models, as was done in the milk inventory management study could be fruitful.

I do not believe that the opportunities for both improved versions of current and past models and possibly new models are in any way exhausted. Three specific examples come to mind:

1) Much of the current policy debate has arisen because of regional issues. Over and above the definition of "region", I believe that regional models are one area that we ought to make a higher priority.

2) Looming on the horizon is the recommended actions on the Federal Milk Marketing Orders. There are several spatial equilibrium models of the order system that may need to be reexamined.

3) Accounting for whole milk on the basis of fats and solids-not-fat or milk components in marketing models.

This is not likely to be the last time that we will be faced with questions concerning the modeling of the dairy industry and the policy that affects it. I look forward to the presentations of the other speakers and the discussion that will follow.
References


