EXHIBIT

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Testimony on the U.S. Spatial Value of Milk and Whey Practices in Cheese Plants

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Introduction

Judge Clifton and personnel of AMS Dairy Programs, I am appearing before you to offer testimony relevant to the promulgation hearing of a California Federal Milk Marketing Order (FMMO). I am an agricultural economist currently employed at the University of Wisconsin as the Director of Dairy Policy Analysis. For more than 30 years, my work has focused on the dairy industry at both the firm and sector levels. I have testified at several FMMO hearings over that time period.

My testimony today is not as a witness in support of, or opposition to any particular proposal, but rather to offer comments and research results that have bearing on the promulgation decision. Primarily, I would like to offer insights into the spatial value of milk in California and across the country and to summarize current research into whey processing practices of U.S. cheese plants.

The Spatial Value of Milk

The background for my testimony derives from numerous Federal Milk Marketing Orders issues that were the subject of discussion in the mid 1990s. The grade B milk supply had declined to the point that the old Minnesota-Wisconsin (MW) price survey was being questioned as a monthly price discovery method for FMMOs. The level of Class I differentials were also being challenged in many parts of the country. Members of Congress were discussing whether the U.S. dairy markets should be combined into a mandatory, single FMMO including existing state order regulation.

In response to these issues, the 1996 Farm Bill provided guidelines and directed the Secretary of Agriculture to complete modifications to FMMOs under a strict timeline. Dairy Programs of the Agricultural Marketing Service (AMS) contracted with the Cornell Program on Dairy Markets and Policy to conduct research into alternatives for price discovery and potential modifications of the Class I differentials. I was the Associate Director for Outreach with the Cornell Program on Dairy Markets & Policy at that time and helped to develop the U.S. Dairy Sector Simulator (USDSS). This spatially disaggregated model of the U.S. dairy industry provided insights into geographic price relationships that were used by AMS in developing their 1999 recommended decision for Class I differentials across the U.S.

The U.S. Dairy Sector Simulator

The USDSS is a highly detailed mathematical spatial optimization model, but at its core solves a fairly practical problem: how to get milk from dairy farms to plants to be processed into various dairy products and distribute those products to consumers in the most efficient way (lowest cost) possible. The model takes the total milk supply, plant locations and product mix, and consumer demand as it existed for an individual month. It indicates how to move that farm milk to plants via the existing road network and distributes the finished products to consumers also according to the road network.

The Milk Supply Data

Data needs for the USDSS are significant. These data include the amounts and composition of farm milk and dairy products consumed, disaggregated by regions in the U.S. and also accounting for imports and exports. To represent the U.S. milk supply, where possible we use county estimates of milk production and composition. California is a state where those values are available. Where those data are not available, we use state values and estimate county-level milk production from Agricultural Census and FMMO data. We aggregate the data from the 3112 counties in the contiguous 48 states into 231 milk supply regions to reduce the computational intensity of solving such a spatially disaggregated model[1].

Dairy Product Demand Data

The USDSS model is comprehensive: it includes all sources and uses of milk and dairy components in the U.S. The current structure includes 19 final and 18 intermediate product categories. Intermediate products are those like cream, condensed skim milk, nonfat dry milk, etc., which can be used in the further manufacture of other dairy products such as cheese or ice cream. The final products are consumer products such as fluid milk, yogurt, cheese, etc., which satisfy domestic consumption or export sales. All dairy products have different component requirements and some product component values differ by region. For instance, California's lower fat fluid milk is fortified with skim milk solids as per the state regulation.

A variety of data sources are used to determine per capita demand for dairy products. For example, the Economic Research Service (ERS) reports some calculations of dairy product demand and other values are determined from route dispositions of FMMOs. County-level demands are then calculated based on per capita demand and population and then aggregated to 424 demand locations.

Dairy Plants Data

As with the aggregation of milk supply and demand locations, dairy plants are represented at 628 locations. Although there are more plants than this in the U.S., we use a single location to represent a multiple processing entities if they are not actually geographically distant from one another. Plants are constrained to process only the products that are produced at any location (i.e., a fluid milk plant location cannot process cheese).

The USDSS tracks and accounts for multiple components in products. For example, a fluid milk plant that has excess butterfat can send cream to a churn, ice cream plant or other manufacturing facility with need of the cream. Of course, sending cream from a fluid plant also sends nonfat solids to the receiving plant requiring somewhat more raw milk than is necessary to meet only fluid needs.

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[1] Additional maps showing the supply regions and other data supporting this testimony can be found at http://DairyMarkets.org/CA

Imports, Exports and Stocks

USDSS uses three locations for port cities in the Atlantic, Pacific and Gulf coast regions. Imports and exported products exactly match those reported in the months modeled. Some dairy products are storable and accounted for in the model as stocks which can be increased or drawn upon as observed in the months modeled.

Transportation Costs

A road network of actual road mileage connects all of the supply, demand, plant and trade locations in the model. There are about 200,000 possible road routes connecting locations in the USDSS . States also have differing Gross Vehicle Weight limits, which restrict the size of loads shipping raw milk or finished products that can be transferred between some states. These limits are also represented within the model.

The cost to assemble raw milk to a plant, ship intermediate dairy ingredients from plant to plant, or to distribute finished dairy products are calculated for every road route. Fuel and energy costs differ across the country as do labor costs and are factored into our calculations. Transportation costs are an important driver of model outcomes and as for other information, are calculated for each month for which the model is used.

The Primal Solution

The model's purpose is to find the least-cost combination of assembling milk from farms to plants, processing dairy products and distributing them to meet domestic consumer and export demand while respecting a large number of constraints imposed. Constraints include such things as cheese or any other dairy product can't be made without ingredients that ultimately come from milk supplied by the farms represented in the model. Another constraint is that finished dairy products must contain the milk components and be provided in the amounts that consumers in the region demand. Finally, shipments can't exceed the road weight limits of any state.

There are two types of solutions that come from such a model: a "primal solution" and a "dual solution". The primal solution describes the physical flows of product through the dairy supply chain network. The dual solution represents the relative monetary values of milk and dairy products at each model location.

We have assembled data and determined solutions for the USDSS model for March and September 2014 (representative of flush and short months). An example of the primal output is shown in Figure 1. In this figure, the green lines represent milk assembly flows from farms to plants, which are represented by triangles. A triangle with no obvious green line simply represents a local milk supply. Orange squares represent demand locations and orange lines represent distribution of finished products from plants to demand locations. The yellow lines are cream shipments. The size of triangles, squares and the weight of lines gives an indication of relative volume shipped or processed.

Figure 2 shows the primal solution of cheese plants for March 2014. Cost minimizing solutions favor a more local milk supply and more distant distribution of finished products than is the case for fluid milk plants (Figure 1).

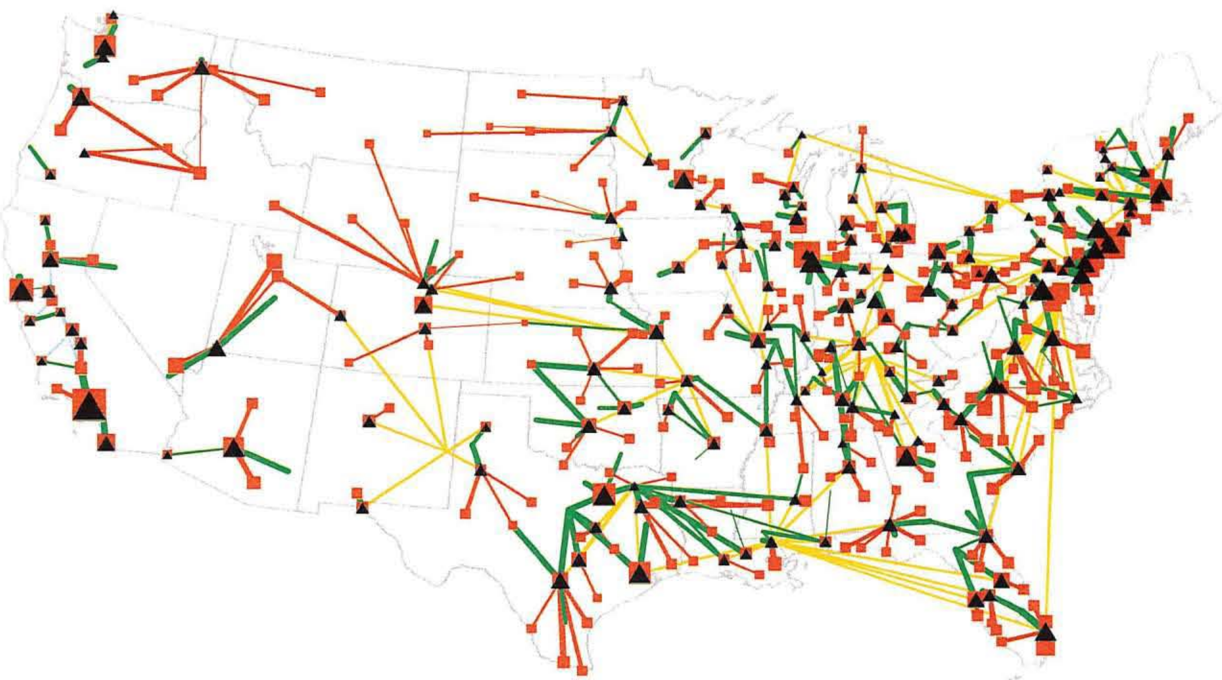

Figure 1. Least-Cost Fluid Milk Processing Locations and Flows,
USDSS Primal Solution, March 2014.

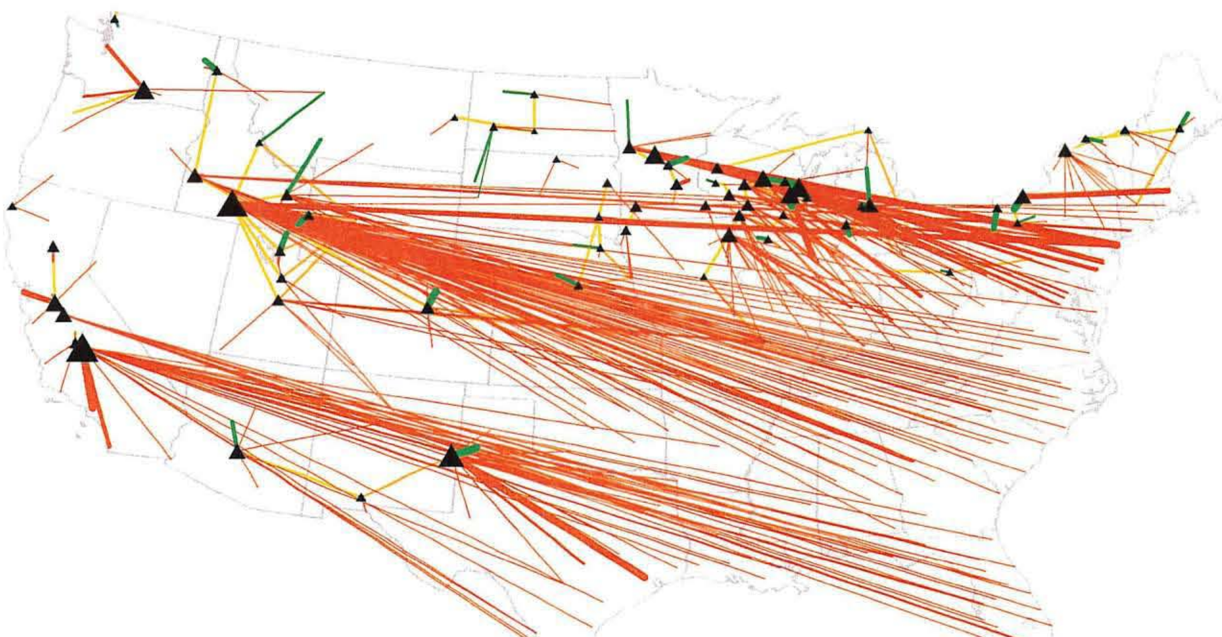

Figure 2. Least-Cost American Cheese Processing Locations and Flows,
USDSS Primal Solution, March 2014.

Primal solution flow maps can be constructed for any of the products in the model. Although we can constrain the model to capacitate plants, we do not have complete information about plant capacities. As such, we usually run the model with plant locations able to process as much product at the processing site as the model would choose to do.

Although it is difficult to evaluate the degree to which the USDSS model matches actual outcomes with available data, we can compare the model-generated volume of five dairy products to those produced in regions of the US based on the monthly *Dairy Products* report from the National Agricultural Statistics Service. The correlation between the model-generated regional production quantities and observed values is greater than 0.88 for all products evaluated in both months and as high at 0.99 for many products such as cheese. Moreover, the model results are not sensitive to changes of plus or minus 5% in demand values or estimated transportation costs. Both outcomes suggest a high degree of confidence in the sensibility of the model outcomes. In addition, the model has been used as the principal analytical tool for two studies that have been published in the well-known international journals *Food Policy and Environmental Science and Technology*[2], and so the USDSS has been subject to both industry and peer review.

Figures 1 and 2 demonstrate that it is economically efficient to have a great deal of cheese manufactured in areas of relative surplus milk production when compared to other products such as fluid milk.

The Dual Solution

The dual solution indicates the marginal value of an additional unit of milk at a farm supply or plant location. Conceptually, this can be thought of as follows. If you would ask fluid plant owners how much more they would be willing to pay for another hundredweight of milk, they would have to consider all of their options for other milk supplies and the cost of transporting that milk to their plant. And, they would have to consider the additional sales opportunities for the finished product and the cost of distribution to those locations. This value would never be more than the cost of transportation from the closest supply region and it will be minimal in some locations where there is plenty of milk or little nearby demand. **Thus, supply, demand and transportation costs become the important determinants for the relative spatial values of milk.**

The USDSS dual values for fluid milk are what AMS contracted with the Cornell Program on Dairy Markets and Policy to provide in response to the issues identified in the 1996 Farm Bill. Results from the USDSS have been extensively used by AMS Dairy Programs over the years as a resource in consideration of hearings discussing changes in Class I differentials.

[2] References: Nicholson, C.F., He, X., Gao, H. and M. Gómez. 2015. "Environmental and Economic Analysis of Regionalizing Fluid Milk Supply Chains in the Northeastern U.S." *Environmental Science and Technology*, in press, and Nicholson, C. F., M. I. Gómez and Oliver H. Gao. 2011. "The Costs of Increased Localization for a Multiple-Product Food Supply Chain: Dairy in the United States." *Food Policy*, 36:300-310.

In the original publication[3] documenting Class I differential estimates using 1995 data, it was noted that other dairy products also have spatial price relationships. *"Just as USDSS generates relative milk values at fluid processing locations utilized in the optimal solution, it also generates relative milk values at manufacturing locations."* Figure 7 of that document displayed a "price surface" map of model-generated cheese differentials in which *"Generally, these values increase from low valued areas in the Northwest to high-valued areas in the East and Southeast."* A copy of that map is shown in Figure 3.

The Class III price surface with the 1995 data showed a difference of about 30¢ per hundredweight of milk between central California and a location like Chicago in the Upper Midwest. I chose these two locations because they are both regions of surplus milk supply which manufacture significant quantities of cheese that are sold outside of their respective regions. Figure 2 demonstrates this and also shows that the flows are generally from west to east and slightly north to south. Another way to interpret that 30¢ difference back in 1995 is that a central California manufacturer of cheese could not afford to pay any more than 30¢ less for milk than a processor in the Upper Midwest and still be competitive with Midwest cheese plants —ceteris paribus.

It should be noted that the spatial prices shown in the map in Figure 3 have had a fixed value added to each location and should not be interpreted as the Class III price, or what would have been the Basic Formula Price, at that time. It is the difference in prices between locations that is of importance.

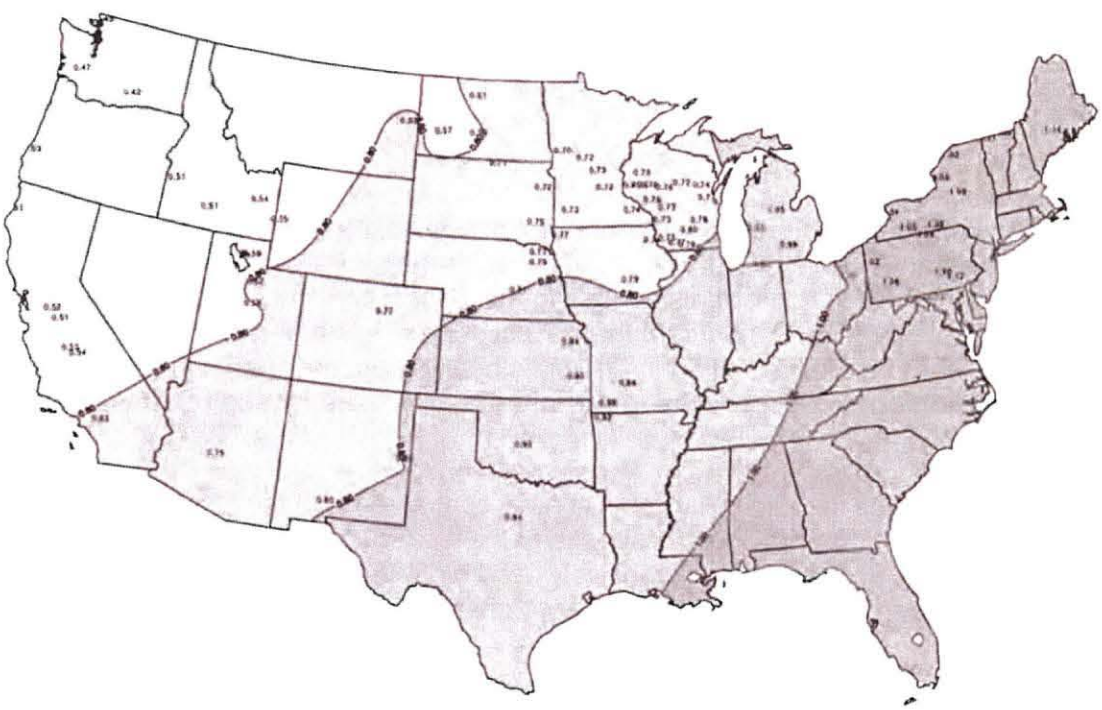

Figure 3. USDSS Model-Generated Cheese Differentials, May 1995.

[3] Pratt, James, Phillip Bishop, Eric Erba, Andrew Novakovic, and Mark Stephenson, *Normative Estimates of Class I Prices Across U.S. Milk Markets*, July 1998, R.B. 98-05, http://dairymarkets.org/PubPod/Reference/Library/Pratt,etal.07.1998.b.pdf

Since the initial analyses of 1995 data, the USDSS model has been updated to represent two months of the year in each of 2001, 2006, 2011 and now for 2014. Figure 4 shows the March 2014 solution for marginal cheese milk values. Again, it is the difference in prices across the surface that matters, not the absolute values shown. For simplicity in interpretation, the lowest marginal milk value area is shown as a $0.00 value.

The important item to note between Figures 3 and 4 is that the difference in marginal value between central California and Chicago is now about 70¢ per hundredweight of milk. A similar difference was observed in the analysis of data from September 2014. We have seen a steady progression from that 30¢ difference in 1995 to today's value over time. For instance, the 2006 model runs[4] showed about a 60¢ difference in the cheese milk price surface between the same locations.

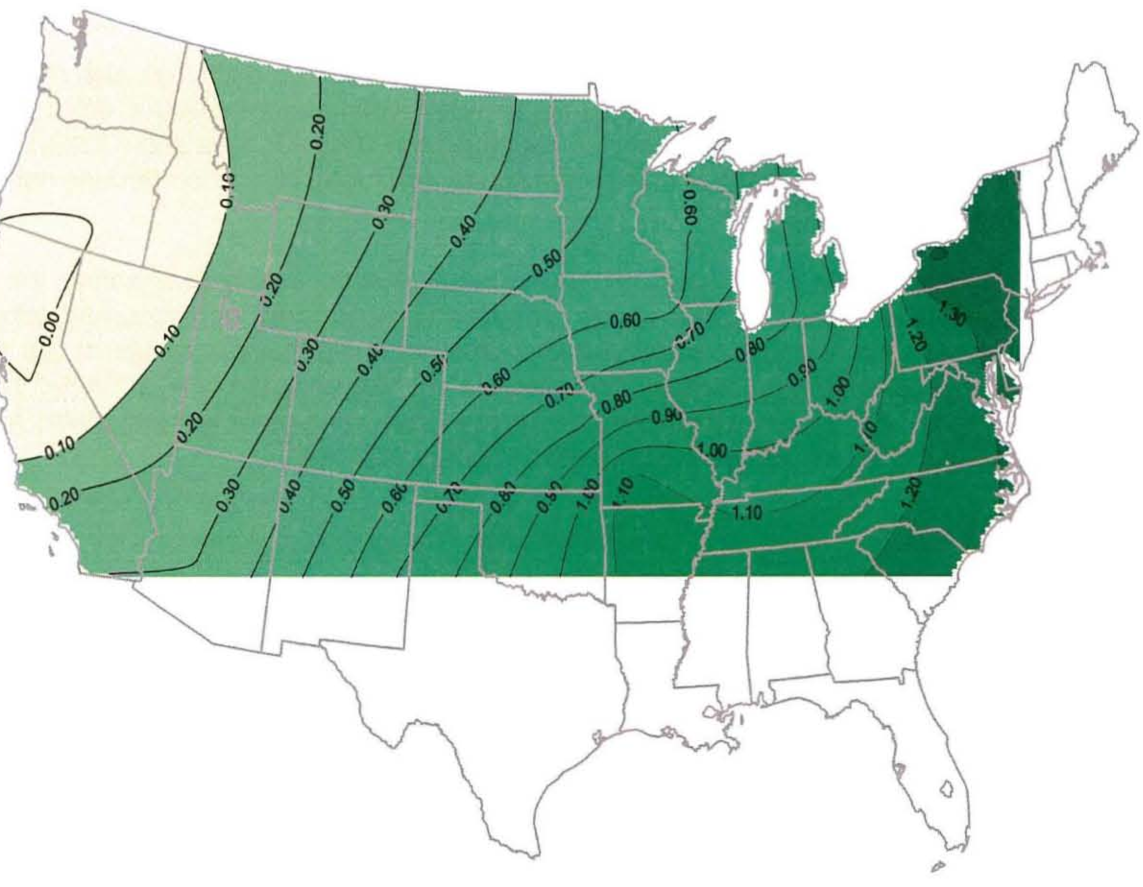

Figure 4. USDSS Model-Generated Cheese Difference in Marginal Value of Milk at Cheese Plants[5] from Low Value-Point, March 2014.

[4] Nicholson, Charles, *Sources of Differences in California Class 4b and Federal Milk Marketing Order Class III Prices During 2007 to 2012*, April 2012, Briefing Paper Series, http://dairymarkets.org/PubPod/Pubs/CA4bValue.pdf

[5] Values are shown for only those regions of the US where the model predicts cheese processing to be located.

The Evolution of Markets

Recall that supply, demand and transportation costs are the important determinants for the relative spatial values of milk. To help partition these changes in value over time, we ran the March 2014 data using the same transportation costs used in the 1995 model runs. This showed that about half of the difference in costs from 1995 to 2014 was due to higher transportation costs and half was due to changes in the relative spatial locations of milk supply and demand for dairy products.

In the 19 years from 1995 to 2014, California milk supplies had increased by about 67% and, more generally in the western states milk supplies had increased by more than 82%. Over this same time period, the California population had increased by 23% and the western states by 34%. Clearly, milk production has increased by much more than the local demand for milk and dairy products in this region diminishing the relative value of milk.

It is fair to recognize that per capita consumption of milk and dairy products has also risen over that 19-year time period. Taking into account the per capita demand for milk and dairy products, California was about 7.2 billion pounds of milk net surplus in 1995 and was about 18.7 billion pounds of milk net surplus in 2014. The western states are about 34.4 billion pounds net surplus as a region.

Figure 5 shows the change in the intensity of milk produced at the county level across the country for a recent decade. Changes in milk production have clearly been occurring within California as well as the rest of the country. It is important to note that milk values in California change not just because of what happens in California but also because of what happens outside of the state. Strong growth in milk production in Idaho and other western states has had an impact on California milk values as well their own internal growth.

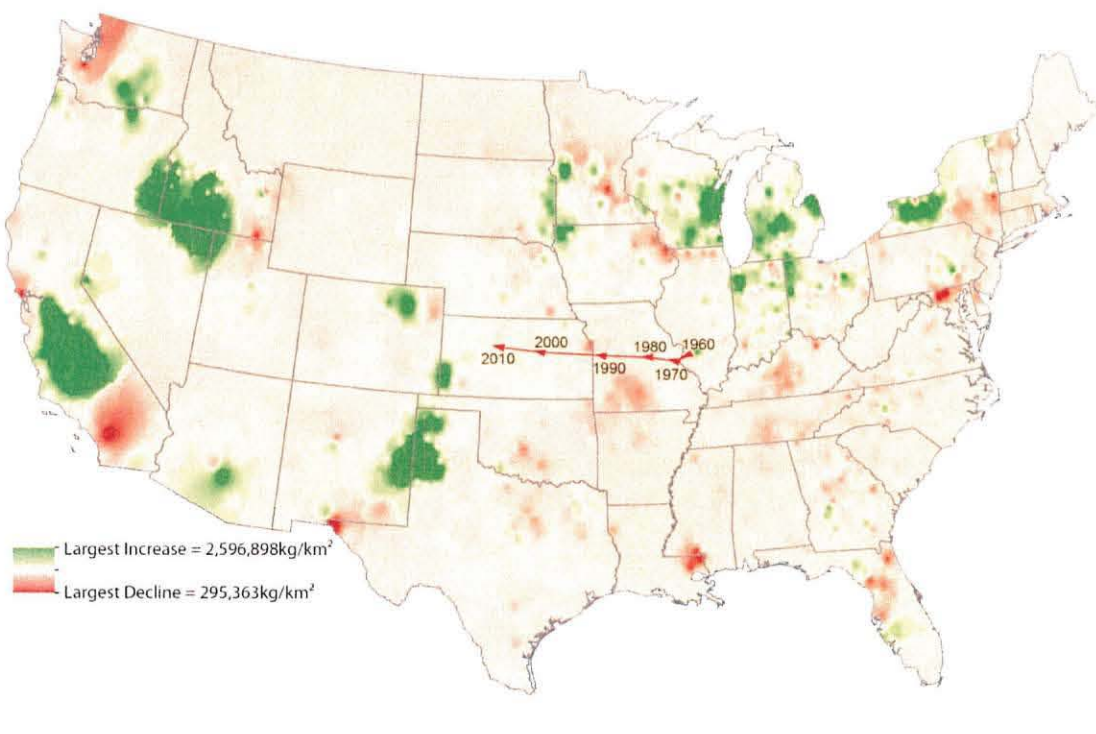

Figure 5 Change in Milk Production Intensity from 2001 to 2011.

The red line with arrows in the middle of Figure 5 shows the centroids of milk production by decade. A centroid is a geographically weighted average. This too demonstrates that milk production has been moving to the west for the last five decades, affecting the spatial value for milk. This weighted average calculation, or centroid, requires a substantial change in regional values to show a visible change in map coordinates.

Figure 5 also shows that the Southeast has been losing milk production with the exception of a few isolated pockets in Florida and Georgia. AMS Dairy Programs recognized this when it announced a tentative final decision in February, 2008 to raise Class I differentials in the Appalachian, Florida and Southeast Milk Orders. A fundamental conclusion from these analyses is that spatial milk values for milk cannot be considered static for long periods of time —and this has implications for minimum regulated milk prices.

Minimum Class Prices

The Federal Milk Marketing Order system has tried to mimic what an economist would call a "competitively determined price" with the tools of classified pricing and pooling. The spatial value of milk is recognized in Class I differential values, but for many years all other classes of milk have had identical regulated minimum values across the country at the same point in time.

Economists often draw a graph with supply and demand lines. The intersection of these lines would represent a combination of price and quantity where dairy markets would equilibrate—the quantity produced exactly matches with what buyers wish to purchase. This is the competitively determined price that is the target for price regulation. As a practical matter, markets are ever-changing and we cannot observe those equilibrium price-quantity values in anything like real time. A practical solution to this problem is that FMMOs have regulated minimum prices that must be paid and have tried to set that standard somewhat below the market-clearing price.

The combination of a low enough price mover and geographically different Class I values has historically allowed blended pool values to represent an approximate spatial price for producer milk. Any differences could be made up with voluntary premiums paid above the regulated minimum. A real concern is with minimum pricing setting the regulated level above the market-clearing price. At that point, producers are willing to supply more milk to markets than consumers wish to purchase. This would certainly be evidence of "disorderly marketing".

This has occasionally happened in the Pacific Northwest and less frequently in other FMMOs. However, because most of the milk in these regions is cooperatively marketed, the cooperative can, under FMMO regulation, re-blend the lower milk price back to its member-owners. The same mechanism cannot be implemented for proprietary transactions.

The concern with a California FMMO is that our current product price formulas may not set the Class III minimum price low enough to allow the western markets to clear on a regular basis. Higher transportation costs and additional surplus milk supplies suggest that the competitive price difference between the major cheese producing regions of the country has grown.

Two solutions present themselves to assure orderly markets. One is that the minimum price be calibrated to be just below the lowest value of milk in the country. The other is that regional manufacturing prices differ by enough to reflect the geographic market values. The problem with a flat, but lower, minimum price is that the price may be so low in the higher value regions of the country as to be meaningless if premiums are asked to carry too much of the value. A better solution may be to reflect the regional price variation with a price surface as we do with Class I milk.

As recently as the early 1990s, we did not have a Class IV milk price. However, in 1993 USDA separated manufacturing milk prices into Class III (milk used for cheese) and a Class IIIa (milk used to make nonfat dry milk). The IIIa price was regionally different and used a product price formula driven by the Central States nonfat dry milk powder price for states east of the Rockies and the Western nonfat dry milk price, which was generally 2 to 6 cents per pound lower for the Western states. Product price formulas with regionally-distinct product prices could serve the purpose. Alternatively, a manufacturing price differential could be added to the class price mover as long as the class price mover reflects a value below the lowest level.

Whey Practices in the U.S.

The price of whey can have a great impact on producer prices and input costs for cheese manufacturers. Indeed, whey prices have been at the center of much of the discussion of the California milk price issue. On the one hand, producers paid under the California state order have argued that the value of dry sweet whey has not been fully captured in the 4b milk price. California plants on the other hand, have argued that very little dry sweet whey is produced in the state and many smaller plants regulated in FMMOs have complained that they are being charged for the value of whey but not able to capture that value in product sales.

I am in the process of surveying cheese plants across the U.S. to better understand the current utilization of whey in this country. Although I am still receiving responses from plants I thought that it might be useful to provide a summary of participant responses to date.

Descriptive Statistics

To date, I have received 88 responses to the survey. Some are not yet complete and have been excluded from this report. There are 62 completed surveys that I will use to characterize U.S. plants. These 62 plants are located in 16 states. Table 1 describes the range of processing volumes and Table 2 shows the status of plant regulation.

Table 1. Number of Cheese Plants by Milk Volume in a Processing Day.	
Less than 100,000 pounds of milk per day	11
Between 100,000 and 1 million pounds of milk per day	16
Between 1 and 3 million pounds of milk per day	23
More than 3 million pounds of milk per day	12

Table 2. Regulation of Cheese Plants.	
Federal Order pool plant	26
Purchase milk from a cooperative who pools the milk	14
Regulated under a state order	13
Unregulated cheese plant	9

Twelve of the plants receive whey from other plants to process along with the whey produced in their own plant. Not surprisingly, all of the plants processing less than 100,000 pounds of milk per day are selling or disposing of all of their whey. Fifteen percent of plants processing from 100,000 to 2 million pounds of milk per day process a portion of their whey into some form of product for sale. 83 percent of plants processing more than 2 million pounds of milk per day are processing some or all of their whey into a final product for sale.

Of the plants not processing a final product, about 15 percent are disposing whey by land spreading or fed to local livestock. All plants disposing of whey incur the hauling cost but some also pay to dispose of the whey beyond the cost of hauling. The average distance to dispose of whey was about 85 miles although some plants had options as close as 20 miles.

The remaining plants not processing a final product are selling or transferring whey in various forms to another plant. These plants averaged about 65 miles to the receiving destination but the range was from 2 to 250 miles. Figure 6 shows the distribution of distance for the plants in a box plot.

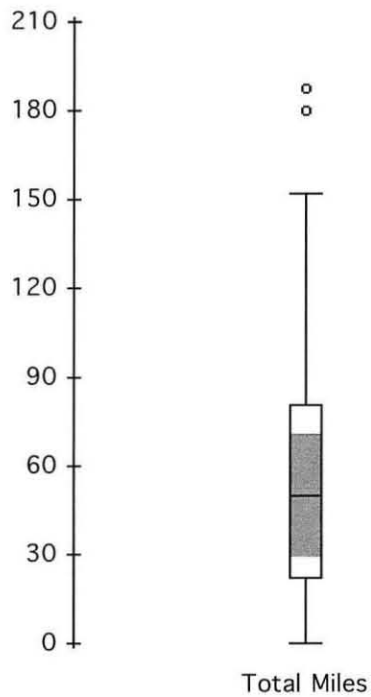

Figure 6. Distance from Cheese Plant to Whey Processing or Disposal.

Using a cost of transportation model that was developed at Cornell University[6] and has since been updated to version 4.0, I have estimated the hauling cost per hundredweight of whey in a fully loaded tractor-trailer. Hauling is estimated to cost about $1.79 per cwt. for the 250-mile destination, $0.46 per cwt. for the 2 mile destination, and about $0.88 per cwt. for the average 65 mile destination.

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6 Pratt, J, Wasserman and Trerise, *Milk Hauling Cost Analysis Version 2.0,* March 1994, R.B. 94-02, Cornell University, http://dairymarkets.org/PubPod/Reference/Library/Pratt,Wasserman&Terise(94-02).03.1994.pdf

Virtually all of the cheese plants are separating the cream from the whey stream. Many of the plants transporting the whey to an aggregator or other plant for final processing do some initial processing of the product. 54 percent are pasteurizing the whey and about 69 percent are cooling the whey. 87 percent are concentrating the whey by reverse osmosis and/or ultra-filtration processes prior to shipment. Figure 7 shows the total solids in the whey products shipped from the cheese plants to other plants for further processing. The average total solids was about 23 percent. The transportation cost to deliver a pound of solids in the average concentration of whey, the average distance, would be \$0.88 ÷ 23 lbs = 3.83¢ per pound.

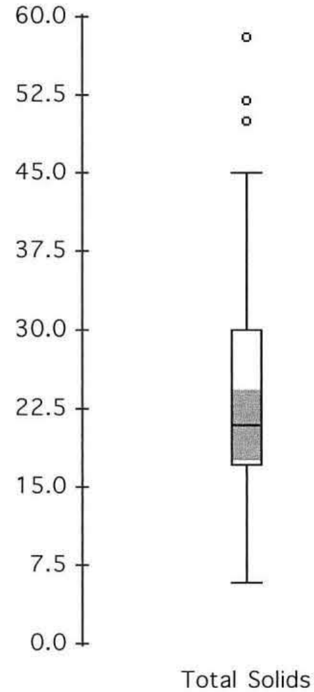

Figure 7. Percent of Total Solids in Whey Shipped for Further Processing.

A few years ago, I conducted a study of the costs of ultra-filtration of milk. There were significant economies of scale in those plants. Figure 8 shows the processing costs that were estimated at various plant sizes for concentration to about 3 times (3X) its initial solids content. This 3X concentration is about the average of the plants reported in Figure 7.

The plants shipping this semi-processed whey averaged about 1 million pounds of milk per processing day. That volume of whey processed through ultrafiltration is estimated to cost about 60¢ per hundredweight of whey. The raw whey from these plants averaged about 6.7% total solids or about 8.96¢ per pound of whey solids processed (\$0.60 ÷ 6.7 lbs).

Obviously, there is quite a range of transportation distance these plants have reported. There is also quite a range of processing being done by plants transporting their whey to final product processors. But using average values, there is something like a 12.79¢ (3.83¢ + 8.96¢) cost per pound of solids being incurred by plants that are not processing their whey into a final product for sale.

I have taken the Other Solids value per pound as announced by AMS from January 2000 to September 2015 and added the additional average transportation and processing costs as calculated above (12.79¢) to them. They are displayed in the histogram in Figure 9. This graphic shows the frequency of the estimated value per pound of solids that a cheesemaker would need to recover in the transaction with a final whey product processor to break even.

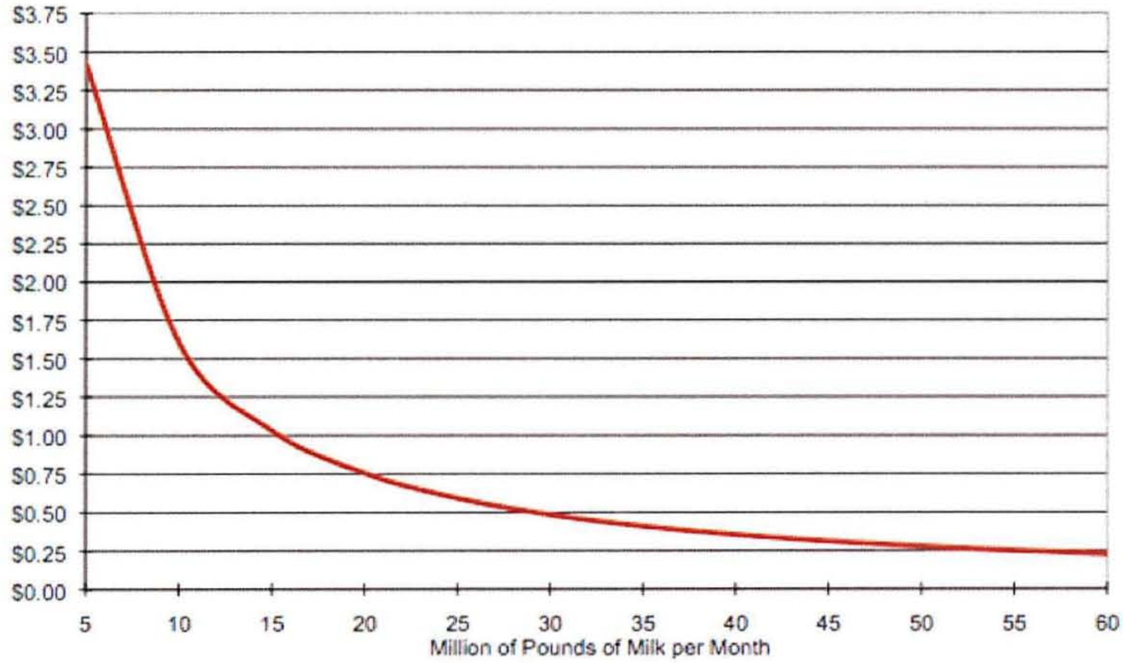

Figure 8. Processing Costs per Hundredweight of Milk in Ultrafiltration Plants.

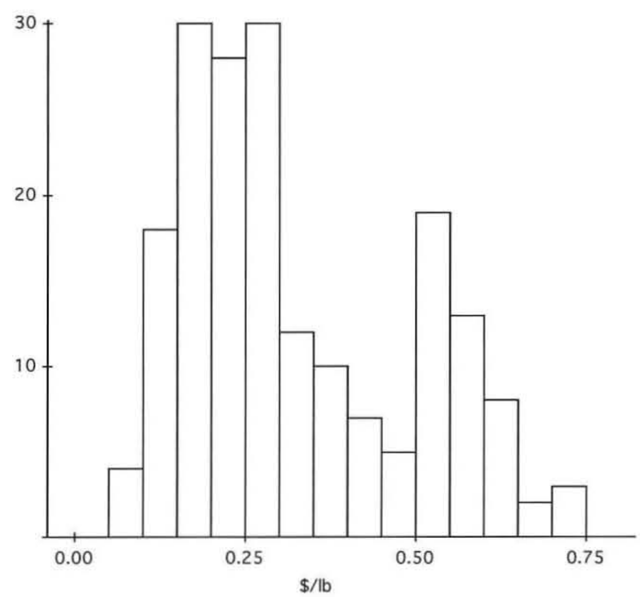

Figure 9. Frequency of Cost per Pound of Other Solids, Processing and Transportation, From January 2000 through September 2015.

The survey has indicated that there are several methods employed to arrive at a value for whey sold, whether raw or partially processed, that is transferred from a cheese plant. Table 3 shows the percentage of responses to several of the methods used.

Table 3. Method Used To Determine a Value for Whey Sold to Another Plant	
On a solids basis as a percentage or multiple of a publicly reported dry whey price.	28%
On a solids basis as a specified discount or premium applied to a publicly reported dry whey price.	0%
On a solids basis as a percentage or multiple of a publicly reported WPC-34 price	4%
On a solids basis as a specified discount or premium applied to a publicly reported WPC-34 price.	20%
On a liquid basis per hundredweight	20%
Other (most often explained as fixed price per pound of solids)	28%

I did not ask respondents to provide any specific formulas so I cannot deduce what their income was relative to costs they might have incurred.

Summary

I have many friends and acquaintances employed in the California dairy industry—producers, cooperatives and processors—and I am well aware of the problems they have been addressing over the last several years. It is my measured opinion that there has been room for a higher milk price for producers than was regulated by the California state order. But it is my caution to regulators when considering the implementation of a uniform manufacturing price from coast to coast that the markets will punish a price that is above clearing levels. I would fear that imposing our current Federal Order Class III product price formula upon the California dairy industry could, over time, affect cheese plant profitability sufficiently to cause a significant shift in ownership of cheese plants from proprietary firms to a cooperative structure where losses can be re-blended back to members.

As long as product price formulas are used for milk price regulation, the value of whey is likely to be a controversy. Dairy farmers demand to capture whey's value in the regulated price. If whey products were valuable enough, like the cheese co-product, small and medium size plants might be able to afford the capital investment necessary to capture the value of the whey. However, only the largest plants are able to invest in today's drying technology.

The smallest cheese plants are not trying to compete by producing commodity products. They are trying to produce differentiated cheese products whose value can carry the cost of discarded whey. It is the mid-sized cheese plants who are probably caught in the most difficult place—~~to~~ too large to significantly differentiate a product and ~~to~~ too small to afford a dryer.

I don't have answers to many of the concerns raised by the stakeholders in the California dairy industry, but I have done enough research with the sector to be convinced that spatial prices and whey values should be carefully considered by regulators.