Summary Statement for Testimony on Spatial Values of Milk Used in Fluid Processing

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by

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1 Introduction

Judge Strother and personnel of AMS Dairy Programs, I am appearing before you to offer a summary of my written prepared statement describing in more detail the results of a recent research project that analyzed differences in the spatial values of milk in the contiguous United States, in particular the spatial differences in values at fluid milk processing plants. I am an agricultural economist with more than 30 years of experience in the analysis of dairy markets, including the spatial evaluation of milk values. I am not here to advocate for any specific policy action but rather to offer my insights into the spatial differences in the economic values of milk. This is a summary of research performed in collaboration with Dr. Mark Stephenson, who recently retired as the Director of Dairy Policy Analysis at the University of Wisconsin—Madison. It does not represent an official statement of the University of Wisconsin—Madison.

The analyses that I will report are based on spatial economic models that have a long history of development beginning in the 1980s at Cornell University[1]. Earlier versions of these models have provided evidence about spatial milk values for previous Federal Milk Marketing Order hearings, notably in 1998. For the past 20 years, I have been the lead researcher responsible for the further development and updating of data for these detailed spatial economic models, in collaboration with my former Cornell and UW colleague Dr. Mark Stephenson. Analyses based on these models have appeared in refereed academic journal articles[2] [3] and book chapters[4]and have been used by state government and industry groups to support investment decisions[5].

[1] Novakovic, Andrew and James Pratt. *Geographic Price Relationships Under Federal Milk Marketing Orders*. Agricultural Economics Research Bulletin 91-8, Cornell University September 1991.
[2] 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.
[3] Nicholson, C. F., X. He, M. I. Gómez, H. O. Gao and E. Hill. 2015. Environmental and Economic Analysis of Regionalizing Fluid Milk Supply Chains in the Northeastern U.S. *Environmental Science and Technology*, 49:12005–12014. DOI: 10.1021/acs.est.5b02892
[4] Nicholson, C. F. and M. I. Gómez. 2022. "Market and Supply Chain Models for Analysis of Food Systems", in C. Peters and D. Thilmany (eds.), *Food Systems Modeling: Tools for Assessing Sustainability in Food and Agriculture*. Elsevier / Academic Press.
[5] Nicholson, C. F. 2023. Assessment of Milk Price Impacts and Transportation Cost Savings for an Extended Shelf Life Fluid Milk Plant in Janesville, Wisconsin. Reported submitted to the Wisconsin Department of Agriculture Trade and Consumer Protection, April 2023.

A summary of the key findings of this research is as follows:

1) Analysis with a detailed spatial economic dairy supply chain model that accounts for all sources and uses of milk and dairy components provides location-specific milk values consistent with the lowest possible systemwide costs, providing a competitive benchmark for those values.

2) The analyses suggest that there are considerable differences between the values of milk at fluid plants derived from spatial economic modeling and the current values of Class I differentials, differences as large as $3.00/cwt.

3) These differences between current spatial economic values at fluid milk plants and current Class I differentials arise due to substantive changes over time in the locations of milk production, the composition of dairy product demand, changes in the locations of demand for dairy products given regional population shifts and the costs of transporting farm milk to plants, transporting dairy products between plant locations and distributing products to final demand locations.

4) Review and adjustment of spatial values generated by the model for the purposes of revising Class I differentials are appropriate to account for local circumstances and institutional factors not included in the model analysis. Any quantitative model is, by definition, a simplification of reality, and the USDSS does not directly represent existing commercial relationships that can be important determinants of the locations and volumes processed in existing operations.

2 Description of the U.S. Dairy Sector Simulator

Spatial milk values are calculated using the US Dairy Sector Simulator (USDSS). The USDSS is a highly detailed mathematical spatial optimization model, but at its core solves a practical problem: how to get milk from dairy farms to plants to be processed into various dairy products and distribute those products to consumers with the 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. For the US dairy industry as a whole, the USDSS minimizes the systemwide cost of assembling milk at plants, making final and intermediate dairy products and transporting them to other plants and locations of final demand. The model includes the principal costs between the farm gate and the retail locations for the consumer. The model minimizes this total cost subject to the physical constraints (mass balance and required product composition) that we have imposed upon the system.

The most recent spatial milk values derive from two versions of the USDSS model: a large version with data disaggregated at the county level (3108 counties), and a smaller version with a few hundred multi-county regions. Both the large and small models yield similar quantitative values and patterns of spatial milk prices.

3 USDSS Model Outputs

There are two types of results provided by the USDSS: 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.

An example of the primal output from the smaller USDSS model (Figure 5) shows milk assembly flows, processing locations and distribution flows to final demand locations[6]. Green lines represent milk assembly flows from farms to plants whereas orange lines represent the distribution of finished products from plants to demand locations. Plants are shown as black triangles. The size of assembly and distribution flows are represented by the relative thickness of the lines. The size of plant-location triangles indicates the relative volume of product processed at each plant.

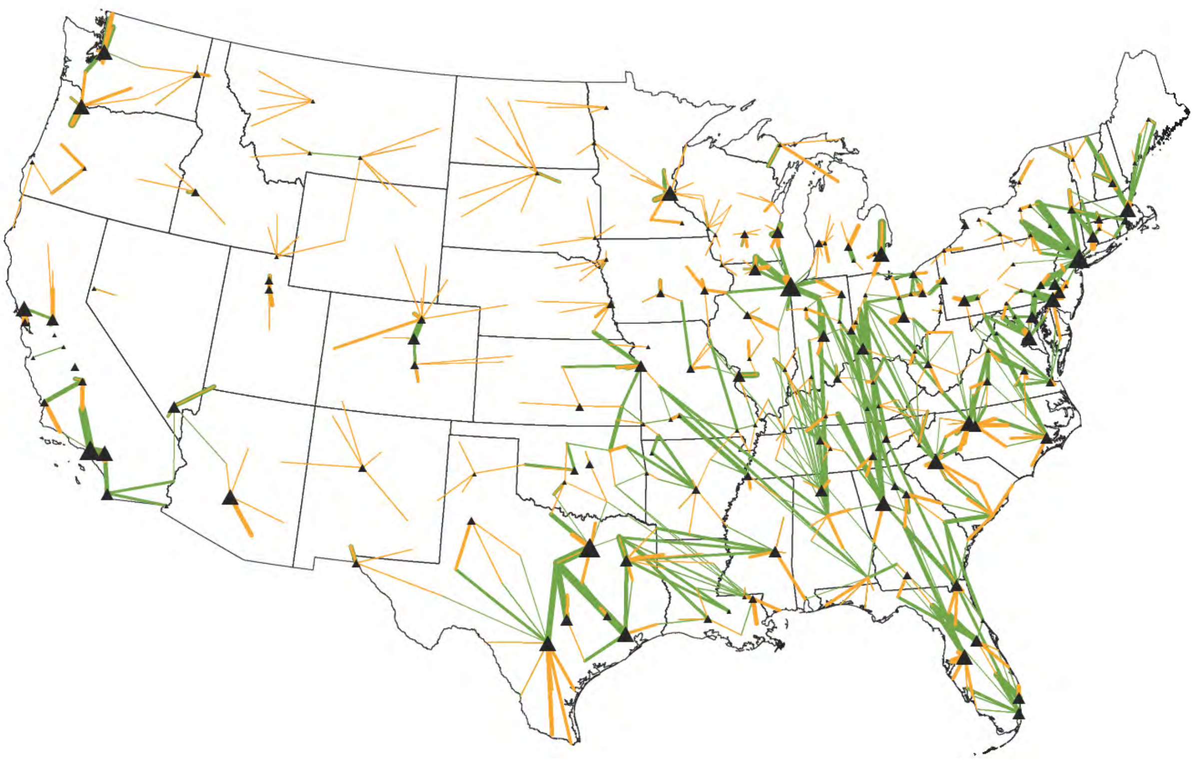

Figure 1. Milk Assembly at Fluid Plants and Packaged Milk Flows (small USDSS model), May 2021

The dual solution shows the spatial value of milk, or more specifically, the "marginal value" of milk at a processing location or at a supply location as for raw milk. Thus, the "dual values"

[6] It is difficult to visualize the larger model because there are far more individual transportation lines, so the smaller model results are used to illustrate the basic idea.

provide estimates of the spatial value of milk, and are key results reported for the purposes of this component of the hearing. Dual values are calculated by the USDSS at all milk plant locations across the country, although our focus here is on the values for fluid milk processing plants. This price surface indicates estimated spatial values of milk for each county location in the contiguous United States, consistent with the spatial aggregation used for Class I differentials.

However, the indicated spatial milk values should not be interpreted directly as Class I differentials. The values should be thought of as "price relatives", that is, the difference in values across locations. The Agricultural Marketing Service (AMS) of the USDA used results from a previous version of the USDSS model results as input in the 1998 Federal Order hearings. Differences between the model-generated relative spatial values of milk compared to those for current Class I differentials suggest a potential need to modify Class I differentials.

4 Factors Affecting Price Relatives in the USDSS

The USDSS shows the spatial milk values at a given point in time, but it is also relevant to consider the drivers of changes in these values. Three factors constitute the important causes of change in the spatial milk values—the price relatives. These factors are changes in the milk supply, demand for dairy products, and transportation costs. The detailed written statement describes the substantive changes in the location of U.S. milk production during the past decade. It also documents changes in the product mix for U.S. industry and in the locations of population. Transportation costs have changed over time due to the cost of purchase or lease of the vehicle, driver wages and benefits and fuel costs.

5 USDSS Results for Spatial Milk Values at Fluid Milk Plants

The USDSS was simulated using both the smaller (multi-county) and large (county-level) versions with 2021 data, with similar quantitative results and patterns. The models are run for the months of May 2021 and October 2021 to represent both the flush and short months of the year.

The general pattern is lower values in the north and western regions and rising into the south and eastern area of the U.S. The pattern of these values mirrors the current Class I differential structure and reflects the relative surplus and deficit regions of milk. However, the current Class I differentials range from $1.60 to a high of $6.00 while the model suggests that the price surface is steeper moving towards the Southeast (high values more than $7.00) reflecting both changing regional production and demand, and higher transportation costs.

Spatial milk values for October 2021 have a pattern similar to that in May 2021, but with spatial values into the Southeast indicating an even steeper price surface and reaching a maximum value of more than $8.00. The seasonal differences in value (Figure 17) indicate a fairly steep rise in values from St. Louis through Atlanta and down to Miami along the I-75 corridor. The western portions of the U.S. show very few seasonal differences in the calculated spatial values of milk.

The differences between the May 2021 spatial milk values and the current Class I differentials are considerable (Figure 2). In particular, there is a band from about Norfolk, Virginia through Montgomery, Alabama where current Class I differentials appear to be well below the model-calculated spatial value of milk at the assumed $1.60/cwt minimum differential. There are also a few cities, such as Charleston, West Virginia, Cleveland, Ohio, and Chicago where current Class I differentials are considerably below USDSS model estimated spatial milk values. The U.S. is roughly divided between east and west (approximately along the Mississippi River) which separates regions where differentials are modestly low (West—up to about $0.80) to areas where the difference may cause difficulties encouraging milk to move to where it is needed. Probably the reason that there is a ridge where there is a northern ridge in the Southeast where current differentials are significantly below calculated values is because of the changes made in 2008 to the 2000 differentials. At that time, the biggest changes (up to $1.80/cwt) were made to Florida values. More modest increases were made to Georgia and Alabama and even less to states further north.

A similar pattern of differences exists between USDSS calculated differentials for October 2021 and the current Class I differentials (Figure 3), but with somewhat smaller differences in Florida, Georgia, Tennessee and Kentucky.

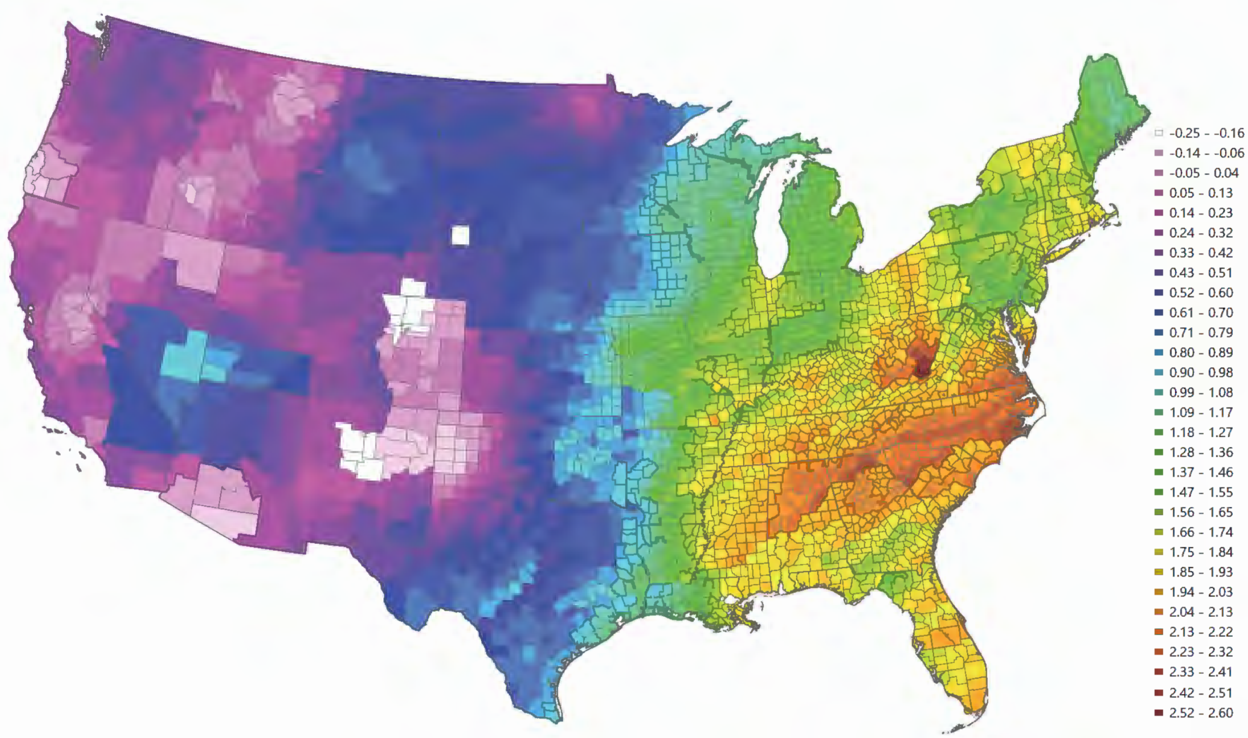

Figure 2. Difference Between USDSS Estimated May 2021 and Current Class I Differentials

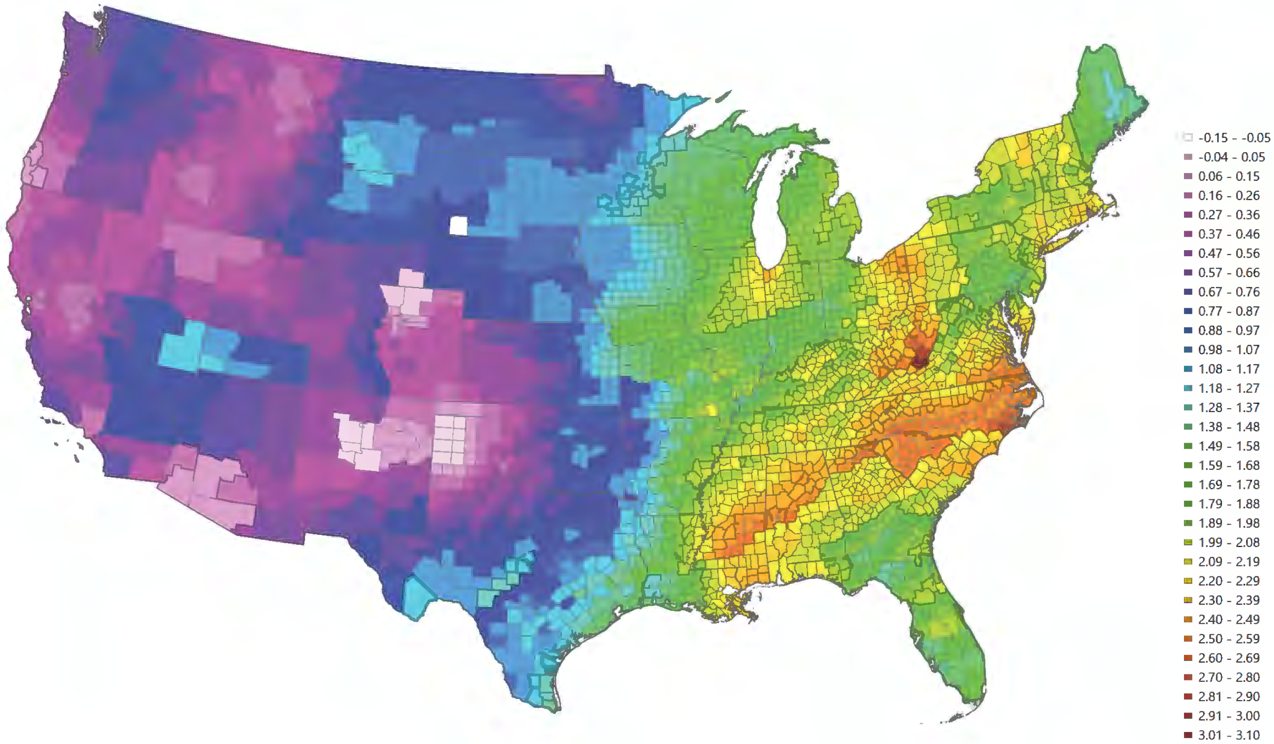

Figure 3. Difference Between USDSS Estimated October 2021 and Current Class I Differentials

7 Concluding Comments

There have been formal studies of the spatial value of U.S. milk for about a century. However, it has been approaching three decades since nationwide spatial values of milk have been systematically evaluated using the U.S. Dairy Sector Simulator (USDSS) model. Over this time, there have been considerable changes to where milk is produced and where population growth has taken place. There have also been substantial changes to transportation costs. Milk supply, demand, and transportation costs all have an impact on the spatial value of milk. The USDSS captures many aspects of these fundamental determinants of values in U.S. dairy supply chains to estimate spatial milk values that can inform the setting of Class I differentials.

The USDSS provides a competitive benchmark for the differences in spatial milk values, and analysis for two months in 2021 indicates values at fluid milk plants considerably different from current Class I differentials. As noted, the differences arise from the combined effects of changes in the locations and amounts of milk supply, changes in the nature and location of dairy product demand, changes in the locations and capacity of dairy processing facilities and changes in transportation costs.

The USDSS provides evidence of the need for change in Class I differentials because it represents a spatial economic benchmark, but other factors such as existing commercial relationships can be important determinants of spatial organization. The model results provide relevant input for differences in county values but may need to be adjusted based on additional information about the characteristics of particular locations. Any quantitative model is, by definition, a simplification of reality, and the USDSS does not directly represent existing commercial relationships that can be important determinants of the locations and volumes processed in existing operations. In fact, a review of results from a previous version of the USDSS model was used as input into an adjustment process employed by AMS to specify differentials in 1998.

There is an analogy here to the use of models that generate the weather forecasts familiar to all of us. The outputs of large-scale weather models are used as key inputs, but forecasters often adjust this "model guidance" with professional judgment to arrive at a more accurate forecast for a particular locality.

Thank you very much.