Testimony on USDSS Dual Values

Presented at the

Federal Milk Marketing Order Hearing

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by

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[1] I retired from the University of Wisconsin in November 2022 as the Director of Dairy Policy Analysis and the Director of the Center for Dairy Profitability.

BACKGROUND

Judge Clifton and personnel of AMS Dairy Programs. My name is Mark W. Stephenson, Ph.D. I am returning to Carmel and this hearing to clarify questions about the “dual values” from the U.S. Dairy Sector Simulator model (USDSS). AMS had asked questions about a few specific county shadow price values found in the original appendix which didn’t conform to expectations of data presented earlier in the hearings by Dr. Charles Nicholson. I have spoken with Dr. Nicholson and I have gone back into archival data of the earlier model runs that we have conducted using 2016 data. There were several runs which examined various scenarios that we were interested in. I did find what we refer to as our “baseline” data run and I am presenting those results here. A baseline represents data that have been carefully collected and scrutinized for accuracy. The scenarios from baseline results might be where we impose a non-existing plant or another question of interest to compare to the baseline. My mistake in the data I had previously presented is that I had used one of our scenario documents rather than our baseline model run.

The USDSS solves a complex task of simulating assembly of raw milk from dairy farms across the contiguous 48 states and shipping it to plants where dairy products are manufactured to be distributed to consumers across those same states. The model’s task is to find the most efficient (low cost) movements of milk assembly, product processing and distribution of final products, subject to many constraints.

The optimal solution is described as product flows through the supply chain, as in milk from farms to plants, dairy product manufacturing, and distribution of final dairy products to consumers. The optimal solution is referred to as the “primal” solution. However, a linear optimization problem with a single solution also yields a “dual” solution which looks at the optimal solution from another perspective.

The dual values are sometimes called “shadow prices”, “marginal values”, or in the case of the USDSS transshipment model—“price relatives” because of the geographic nature of the values. There can be several interpretations of these dual values, but in their most simple form they represent the dollar amount that the entire dairy system, as represented by the USDSS, could save if the model could relax the constraint at a geographic point by one unit.

In the USDSS we report that value as dollars per hundredweight. In other words, if one more cwt of milk was available at a particular geographic point, the model could reconfigure the solution to save the dual value. From the perspective of the market, it also represents the maximum dollar amount that a participant would be willing to pay for the next cwt of milk at that location.

CALCULATED DUAL VALUES

The current version of the USDSS does not begin with hundredweight of milk, but rather it begins with pounds of milk components. This refinement was made several decades ago to allow the model to better represent the variability of components in milk production and to balance the use of those components at the plant level. Milk composition has varied by individual cows, farms, breeds, region of the country, and over time. Obviously, we can’t isolate all of those influences, but we can make sure that they are consistent at the state and national level for the month that we are modeling. For some time periods, the volume of milk production may not have risen, but over the past several years, component levels have increased and do influence the outcome of the model.

Using all data available to us, we estimate milk component production at the county level. These components will exactly add up to the NASS reported values for butterfat at the state level. Protein and other solids are calculated by updated regression values from a variety of sources including Dairy Programs statistical reports.

We have extensive spreadsheets which calculate the components used to make final dairy products in the plants, and utilizing data from the Economic Research Service (ERS) and Dairy Programs, we estimate per capita consumption of the final products at the demand points in the model.[2]

With all of the component values from farm to consumer, we conduct a mass balance calculation to check for accuracy. It is typical in our calculations to have a small surplus (1 to 2 %) of components (butterfat is somewhat more surplus than SNF). We attribute this surplus to the normal losses referred to as "shrink" by the industry which is a result of the transport and manufacturing processes.

The USDSS actually reports the dual values of butterfat, protein and other solids at geographic points. **When we are reporting cwt values at those points, we calculate the AMS standard values of milk per hundredweight as the dual values of the components at: 3.5 lbs of butterfat, 3.1 lbs of protein and 5.9 lbs of other solids.**

THE ZERO POINT

If an optimization problem is feasible and has an optimal solution, then it will also be true that at some location(s) in the transshipment model there will be one or more dual values that are 0. This means that at those locations any additional milk cannot be used in a way where the model can lower the total cost by doing something different. Since the model solves all flows of the primal simultaneously, the dual values are all related. That includes component values at the farm, plant and consumer.

I was previously asked about where the "zero" value was in the data I presented. Note that the zero will occur at a single point within a county, and the ultimate value for that county will be higher given its incorporation of other non-zero values in the county because of Kriging used to interpolate the values between points. Then the value could also be adjusted due to rounding. In the baseline model run, Bosie, Idaho is in fact the low Class I shadow price point with a value of just more than 13¢ per cwt. When the Kriging algorithm is run to interpolate county values, the average values in Boise County Idaho round to 20¢… a value that is shared by several counties in Idaho and Montana.

[2] Butterfat preferences in fluid milk differ by region and those are captured in the model data. Higher SNF requirements also exist for lower fat fluid milk in California and that is also modeled.

RELATIVE VALUES OF MILK BY USE

I have supplied a map labeled as Figure 3 in my previous testimony (Exhibit MIG - 16 - CORRECTED, submitted into testimony as Exhibit 451) which shows the relative values of Class I shadow prices minus Class III shadow prices at all counties in the contiguous 48 states. I have redone that map with the baseline 2016 values (Figure 4 of this testimony, MIG Exhibit 16E). Qualitatively, its values are very similar to the Figure 3 map in my previous testimony. Red regions represent locations where marginal milk is more valuable to a cheese plant than it is to a fluid plant. Green colored counties is where marginal milk is more valuable to a fluid plant and grey colored counties are where the marginal value is about equal. The data that underly this new map is found at MIG Exhibit 16D. The corrected data does not change my prior conclusions regarding the lack of need to a nationwide "incentive" to attract milk for fluid use.

I thought that it might be helpful if I introduced one further visual chart showing the range of the absolute values in these two classes summarized by the 11 Federal Orders. Figure 5 displays the range of Class I shadow prices by order in the left-hand Box and Whiskers plot (shown with a blue "^" symbol on the chart). The right-hand B&W plot for each order shows the range of values for Class III shadow prices (shown with an orange "^^" symbol on the chart). This is found at MIG Exhibit 16F.

Although there is variation in values by class in each order, it is clear that Class I dual values have a much wider range than do the manufacturing classes. If there is an adequate nearby milk supply for fluid milk, then the dual value for Class I can be fairly low. If there isn't and either raw milk must be transported to Class I facilities in deficit areas, or packaged fluid milk must travel longer distances to supply consumer demand, then the shadow price for Class I becomes relatively large.

In contrast, Class III plants tend to be located near their milk supply so raw milk does not need to travel long distances. And, butterfat and solids-not-fat can be sent long distances as nutrient-dense finished cheese products at a relatively low cost. The model needs both fluid and cheese, as well as other dairy products, to satisfy consumer demand. In relatively surplus regions like the Central Order and the Upper Midwest Order, the value of milk in cheese plants is of greater value than it is in a fluid plant of those orders.

In many orders, like the Mideast, about half of the counties would find that cheese plants can out-compete fluid plants for raw milk, but in the remaining counties, cheese and fluid plants are on a fairly equal footing with only a few observations where fluid out-competes for raw milk supplies. In areas like Florida, the model unambiguously needs raw milk in fluid plants.

SUMMARY

The USDSS dual values help to illuminate the competitive surface of prices for the U.S. dairy industry. Manufactured dairy products—particularly cheese—have grown in importance to the point where in many locations fluid plants have difficulty attracting raw milk supplies.