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Comments on Proposal 19
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- The USDSS is a large and computationally complex model which solves a fairly simple task—assemble milk at farms and move it to plants to be manufactured into dairy products that are distributed to consumers across the 48 states.

- The model is constrained by the location of milk production and the volume and components at the county level. A few states, such as Wisconsin and California, report milk production at the county level but most do not. We estimate county milk production for states that don't report by using NASS Ag Census data for dairy cow numbers at the county level and apportion NASS state milk production using those.

- The USDSS accounts for component levels which vary by region. NASS reports butterfat at the state level and that butterfat is used in the counties within the state. Protein and other solids levels are estimated using the FMMO data to establish a relationship between butterfat and the other components. We use regression analyses is employed to estimate the other component levels. As a final check on milk volume and components, state and national totals are calculated and calibrated to be precisely equal to NASS data for the month and year of interest.

- Dairy product processing is constrained by actual plant locations, the approximate size (capacity) of the plants and the products produced there. A proprietary database of these plants is maintained and updated with popular press news items, FMMO, PMO, AMS and personal communication with industry participants. The plant capacity values sum to about 90 percent of NASS milk volume in the 48 states.

- Dairy products are constrained by the components required for their manufacture. We have established an extensive spreadsheet which details final product components and the make procedure which produces them from raw milk or intermediate dairy products such as cream, skim, condensed, filtered milks in various forms and skim or nonfat dry milk powder.

- Domestic and export use of final products are distributed to counties of the 48 states or ports for overseas shipment. The volumes of these products are constrained to the volumes sold to consumption (demand) at locations or exported through those ports. We utilize per capita demand, as calculated by ERS, and multiply by the county population. In previous iterations of the model, ERS had done per capita demand estimates by region, age and ethnic strata. That hasn't been updated in many years so we are now using just a national per capita value. However, California has higher SNF standards for low fat fluid milk and we enforce that standard on fluid sales in that state. We also have data from AMS which indicates variable preferences for butterfat content in fluid milk by region and we also utilize that in our estimates.

- Transportation associated with raw milk assembly, final product distribution, or interplant shipments are constrained to take place by the shortest distance over actual road networks. This is not the shortest distance calculated by "the great arc" of the earth, but rather the actual miles that a truck must travel over named roads. There are 9,436,323 of these "arcs" (routes) that the model can traverse which connects all geographic points in the model.

- Cost of transportation is calculated using a highly detailed economic engineering model. The model begins with a the concept of a hauling firm which describes their vehicle fleet (active and reserve trucks), fuel, oil, tire and interest rate costs per unit, etc. It also cost accounts for overhead and maintenance for the fleet. Individual tractor values are identified such as how many axles (tires), type of fuel, unloaded and loaded milage, insurance, fees, etc. Tanks on straight chassis trucks and trailers pulled by tractors are similarly input. Employees are identified and their wage and overtime (if applicable) rates as well as benefits are accounted for.

- From the individual data, various routes are assembled which must use one of the trucks (tractor-trailer or straight chassis), one of the employees, and describe the route: how far from the firm to the first farm, how many farms will be loaded on that route, what distance and how long does it take to get from the first farm to the last farm on that route, what distance and time does it take to get from the last farm to the plant, how long does it take to unload and wash the tank and how long does it take to get back to the garage. Does this truck and/or driver make more than one route in a day? Are there any tolls or fees along the route? Does the loaded truck switch drivers or tanks? Overtime pay is calculated for any employee on a route that exceeds the normal workday time.

- We sample from a variety of engineered firms including small 1 and 2 truck haulers to large fleets. We also assemble a variety of routes from multiple small farm pickups to switching trailers at very large farms. We also look at short routes close to plants to longer haul routes to a distant plant. We can also calculate plant-to-plant hauls of intermediate products like cream or skim milk. And, we can look at distribution costs from plants to population centers. Dozens of our example route costs are used to estimate a non-linear function of hauling costs per mile based on the length of the route, driver wages, and fuel costs per gallon.

- Cost of transportation differs for bulk raw milk or fluid intermediate product, refrigerated and unrefrigerated trailers. Costs differ regionally by fuel costs and labor wages. Road weight limits are restricted to the most constrained state the route passes through. For example, Michigan has the least restrictive weight limits and allows a gross vehicle weight of 164,000 lbs. However, if the truck passes into Indiana or Ohio, the GVW is now restricted to those state limits of 129,400 lbs. If the truck further passes into Illinois or Pennsylvania their GVW is only 80,000 lbs. The model can take a cost advantage of the Supertankers within Michigan and other high GVW states, but if the route crosses into a more restricted state, then that more restricted state's limit becomes the limiting weight.

- **The model's task is to minimize the costs of milk assembly, dairy product processing and final product distribution while respecting all constraints.**

- Just as a side note, cost minimization yields the same outcome as profit maximization in a perfectly competitive market.

- The model's primary solution is one of physical flows: as in xxx pounds of milk were shipped to plant yyy and made into zzz pounds of product aaa which was then distributed to iii and jjj. This is referred to as the "primal" solution.

- An optimization model, like the USDSS, can also express the "dual" solution which is in terms of dollars. A dual, sometimes called a "shadow price", really tells us how much could be saved if a constraint was relaxed by one unit. If you think about a fluid milk plant, you could ask how much would the next 100 lbs of milk be worth at that location if it just showed up at the plant. That relaxed constraint may let the model move milk and dairy products around the country in a different way that saves the entire system some money. That is what the dual values at fluid plants are reflecting. Another interpretation is "at what price would the processor at that location be indifferent between receiving the next cwt of milk". If you are asking more than that amount, the model knows that it could go elsewhere and procure milk from another source for less cost.

- A shadow price is calculated for any constrained value in the USDSS model. We are usually only reporting on the values at Class I fluid plants, but there are also values for the other classes. Further, there are dual values for farm milk at all locations. It should be noted that these dual values will be qualitatively related but not equal across the country or even within proximately to one another across different constraints. I.e., the farm value of milk will be somewhat different to a nearby plant value for milk based on what the model can do with another unit.

- The optimization model can only report dual values at points of constraint. For example, Class I dual values are only calculated at fluid milk plants. Values in locations where there is no fluid plant are estimate post-processing with a geographic interpolation know as "Kriging", or Gaussian process regression. A raster image is created which estimates a weighted value from the nearest 12 points (known dual values at Class I plants). This value is weighted by distance from the point of interest. The smooth surface (commonly referred to as a "heat map") can then be outlined by isoclines which are lines of equal value. Or, the values of the raster can be projected back down onto a geographic area, like a county, and the average of those values can be calculated. That is what we do rounding the county values to the nearest 10¢. This also explains why we might not see the minimum value reported in the county values because the average of the raster points—which will contain a 0 value—may not average to 0 but rather round to 10¢. We then add a fixed value, as specified by the group asking for the model values, to get our Class I values. In the recent years, that amount has been $1.60.

- We do try to be responsive to the concerns and observations of the folks looking at the model results. It has been these comments that have pushed us to refine the model over the last 30 years. For example, in these model runs, it was observed that spatial values in Michigan seemed as though they wouldn't move milk in the way it was needed. Further reflection of the USDSS fluid plant shadow prices appeared to be as expected, but the county interpolation values were not. We realized that the Kriging algorithm was using points in western New York and Wisconsin as being in the nearest 12 plant locations. The Great Lakes are not navigable by tanker truck and we needed to make a change to our post-processing estimates. This was done by constructing a "geographic fence" down the Great

Lakes that the Kriging algorithm must go around. When this was done, Michigan's county values looked appropriate and our thanks go to that NMPF committee for pointing out a short-coming of the model which has now been corrected.

- Any model is a simplification of reality, but in my opinion, the USDSS model is the most complete and systematic means that we have of considering spatial milk values across the country. We have been developing this model for more than 30 years. Over that time, we have refined the model and made it much more sophisticated and we have addressed concerns that folks have expressed through many iterations. For instance, the model now accounts for milk and dairy products at the component level and not the "milk equivalent" value that it was originally built around. The costs of milk transportation are quite detailed and include tires, insurance, capital replacement, fees, etc., as well as fuel and labor that differ by region of the country.

- If we are going to have questions or concerns about model results, we need to talk about the inadequacies of the model structure, or about the quality of the data used in the model. The rest of the results are just math which I believe are being done correctly.

- The model does not include items such as restrictions of bridges and tunnels during certain hours of the day. This can add a legitimate cost to servicing an area like New York City. We have not incorporated instances like the bridge and tunnel example because the added complexity may not be worth the effort. But this is a place where professional judgements might be made which would supersede the model results. This kind of "price alignment" may alter the dual values by nickels, dimes or possibly quarters over small areas.

- The model could be further refined in many ways. Currently we identify 20 final dairy products and 11 intermediate products (dairy products that can be used in the manufacture of final dairy products). Our fluid milk category include both conventional fluid products as well as other products like organic, A2, lactose reduced, etc. These could be further broken out into separate products but the FMMO recognizes these all as Class I products and hence our aggregation of the category.

- There are other items that the model does not consider including the FMMO regulation itself. There are important reasons why the model does not and, we believe, should not consider this regulatory system. The USDSS was designed to inform about an efficient marketplace, oftentimes for purposes of developing regulations. Imposing those regulations upon the model could cause a departure from market efficiency which is not a stated goal of Federal Orders.

- Larger value changes imposed over larger regions suggest a significant shortcoming in the model structure or data. Such shortcomings should be brought to the attention of the researchers for correction in current or future model use. We have gladly and willingly considered changes in the past which have resulted in improvements employed in the present model iteration. If we were requested to re-run the model with larger value changes imposed over large regions, we would need to understand the reasons for the change so we could adjust the model to assign this additional cost. We also would want to run the model with those changes so we can ensure that the surrounding counties and states adjust appropriately to the changes in a certain area. We have not been asked to do so.

- The USDSS model results reflect an “efficient” market. I.e., milk movements are optimal to achieve lowest costs to the system. Any market will have some friction which result in departure from the optimal solution. This can happen when there are contractional obligations between parties which may move milk from regions to plants where the model would rather access other supply locations.

- In my opinion, the price surface represented by regulation should reflect an efficient market and not have market inefficiencies hard-wired into them. A minimum price regulation allows higher prices to accommodate inefficiencies while encouraging and rewarding movement toward a more efficient solution.

- The price surface of the USDSS model reflects an “economic current” analogous to an ocean current. It is possible to move against the current, but it is more difficult and the current will try to move product in a market efficient direction.

- Price differences from any two points in the model will not cover full costs of transportation. If price incentives greater than full costs occur in the model, then more milk than is needed would be enticed to move to capture the rewards. The price surface reflects incentives to move milk in the direction of greatest need.

- Just as a thought experiment, consider a farm that is located 100 miles from two processing plants. One is west of the farm and one is southeast of the farm. The 100 mile hauling charge is the same to supply either plant but the plant to the west has a zoned price that is $3.00 and the plant to the southeast has a zoned price that is $3.10. The farm should choose to sell milk to the southeast plant to net a larger price. This moves milk in the efficient market direction.

- Contractional obligations that move milk in a non-optimal, or non market efficient, way can and do happen. This is not disallowed in FMMOs, but in my opinion should not be encouraged either. At a micro level, there has been criticism of multiple milk haulers driving past farms carrying milk from other farms to plants. The additional cost to the system for this behavior has been voluntarily reduced by "swapping" farm milk loads going to plants and only having a single hauler traversing the roads. If the original contractual relationship had been reinforced in the regulations, the firms would not have had the incentive to find the more efficient solution of doing a swap. Market inefficiencies can and do move toward a more efficient market with economic incentives. Without incentives, the markets will not achieve efficient milk movements.

- Dr. Nicholson and I have worked hard to provide a sophisticated and detailed analysis of efficient milk and dairy product flow movements that I hope will be of use to the participants in the industry and this proceeding. I would be happy to answer any questions or provide any further insights into the model's design and outputs so it can be of the highest use possible for these proceedings.