by Steve Martin

The "shadow price" principle

A FREQUENT request I receive from clients is to determine the value of various ingredient options for their rations. The term for this desired value or cost is a "shadow price."

It might be as simple as evaluating a price offering for canola into a ration that is currently using soybean meal, or maybe to check the potential of using a local byproduct like wet brewers grain, whey, or potato waste. This question gets even more complicated when attempting to determine the value of a different forage option.

The answers to these questions not only determine what might be ordered to go in a commodity bay or the help make a decision on a long-term grain contract, it could also be the beginning of a business relationship with a neighbor. The shadow price of the ingredient might even be the final encouragement needed to buy ground to plant and harvest the evaluated forage or grain product.

All of these decisions revolve around the many options from the numerous feed ingredients that are available to be used in a balanced ration. The tool that makes this biological/economical analysis possible is the linear programming (LP) function found in most ration software.

When the LP function is paired with a dynamic biological model, this tool becomes even more valuable. The less popular term for what it does, which brings mixed emotions from most dairy producers, is "least-cost formulation."

Cow-sense always needed

This poor opinion of letting a computer decide what to feed cows was earned by early application of the process, which left good cow-sense out of the equation. The mathematical tool must be married with the "art" of feeding cows to build a balanced ration and realistic shadow prices for ingredients.

The challenge with this process is that while the math is always right, the answer is not. A "solved" solution in a LP is always mathematically correct if it truly solves, but the connection between the math and the bunk is not so straightforward.

The key to letting the ration model choose and combine a particular group of ingredients to meet a set of animal requirements is to be sure that there are options available. My nutrition professor at Auburn University drilled this into our young brains by reminding us to only solve for a few nutrients at a time. This is the key to making this work for arriving at a real shadow price for an ingredient. The LP needs flexibility to solve and feed sources to meet nutrient requirements.

To illustrate this point, let's consider an example that relates to a dairy that has an option to start using high quality local grass hay in place of trucked-in alfalfa hay. The dairy producer asks his nutritionist to determine the value of the grass hay to see if the price will allow the local farmer to be profitable in the new endeavor.

The nutritionist and client are both thinking about the higher level of protein supplied in alfalfa hay, so they make sure they are together on the cost of additional protein sources that will allow the grass hay to compete in the ration. But is that the only issue they need to worry about?

It could be that at first the ration model is struggling to use the grass hay because to do so it might need to reduce ration forage percent. That causes concern for the producer, because it relates to cow health. If the constraints on the model have a minimum forage that matches the current level, the grass hay will struggle to show good value.

So to solve that problem we remove the forage percent minimum and use a better measure like uNDF from forage to account for the fact that grass hay has a higher content of it for cow health than alfalfa does. Now the LP can offer a shadow price for the grass hay, since the model offered it a little more room in the diet to include the needed protein meal.

Problem solved, right? Maybe not.

As the nutritionist continues working through the LP process, the shadow price on the grass hay still seems way too high. Through a little more study, it is noted that the formula is only hitting minimum calcium levels. Hmmm? Surely calcium, which is the cheapest nutrient in the ration, is not holding up the process to obtain a real shadow price for the nice grass hay being considered.

Well that depends upon whether the ration model has the flexibility to still meet calcium requirements when feeding the grass hay.

Since grass is much lower in calcium than alfalfa, if the diet is to continue supplying the same calcium as it does with alfalfa hay you must offer another calcium source. If the only source is the lactation mineral blend, then feeding more of the mineral will adversely impact the shadow price of the grass hay. After offering limestone to the ingredient list, all of a sudden the ration solves with a reasonable shadow price for the grass hay.

The point is that unless the nutrient requirements were adjusted to allow for a little lower forage percent while maintaining fiber levels for cow health, and unless there was an ingredient offered to solve the calcium problem, the inflexible math in the ration model's LP would not give a true shadow price for the grass hay.

Without being sure that the right ingredients are offered and the appropriate nutrient requirements are set, an erroneous shadow price may have been offered. In such a case the neighboring farm that hoped to supply grass hay would have missed the opportunity. In addition, the dairy producer would lose the chance to work with his neighbor to buy local forage and likely reduce his feed cost.

A recent real-life example for me related to various high-end protein ingredient options for one of my clients.

We had 5 or 6 different feed options to help meet the high metabolizable protein needs of his high producing cows. I presented a report that showed a few ration options side by side with their resulting cost. The client noted I had included soy hulls in the diet, even though none were available for the farm. "Why the soy hulls?" was his question. My answer had to do with "space" in the diet.

Programs need "space"

To make a true comparison and offer real shadow prices for the various protein sources, I need to let the model have some space to either use or not use when arriving at the various solutions. In this situation, we did not want to let feed rates change for corn silage, alfalfa hay and straw. Keeping them locked, while also not allowing changes in starch, meant something had to give. Soy hulls at up to 1.5 pounds was the answer.

I wasn't telling my client he needed another commodity bay to house the soy hulls, but I did need to put them in the formulation to let the various protein options really compete on equal ground and offer a shadow price that I could stand behind.

In this situation, having the flexibility to use a little soy hulls allowed the protected amino acid with a very low feed rate to compete with blood meal at a moderate feed rate and even with bypass soybean meal or distillers with the highest feed rate.

Once the protein source that priced the best compared to its shadow price was chosen, we could loosen up the ration a touch to not need the soy hulls for a ration solution while knowing that we picked the option that truly had the best value.

Linear programs are difficult. They are not flexible and they don't understand cows. Using raw math ability to determine the value of possible feed ingredients is filled with potential errors. It's necessary to take much care in making sure that an unreasonable and unintended nutrient or ingredient restraint is not incorrectly inflating the shadow price of the ingredient in question.

Using LP to be sure that diets are built to find every possible feed cost advantage is good business. Not using LP and thus "calculating" rations through trial and error or simple intuition will never offer the best balanced ration value to the cows. Being sure that LP is used in a strong, dynamic nutrition model will insure that ingredient values are correctly calculated and you are feeding for the bottom line.

The author is founder of Dairy Nutrition and Management Consulting LLC, which works with dairies and heifer growers in Texas, Oklahoma, New Mexico, Kansas, Colorado and Washington.