What Is "The Basis," How Is It Measured, and Why Does It Matter?

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Presented at the
NCR-134 Conference on Applied Commodity Price Analysis,
Forecasting, and Market Risk Management
St. Louis, Missouri, April 19-20, 2004

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Basis behavior is generally considered to be the major determinant of hedging success or failure. In the course of our work as contract designers for Chicago Mercantile Exchange Inc., we have come to the conclusion that there are many misconceptions and incorrect statements made about "the basis" among practitioners and academics alike. Our work suggests that basis values, how they are measured, what they represent and how they are interpreted may differ widely from one commodity contract to another due to differences in the specifications of the underlying futures market, as well as differences in the structure of the underlying cash market.

INTRODUCTION

We receive frequent feedback from the users of CME's commodity contracts, and there seems to be a great deal of confusion among market participants about the subject of basis. Many times when people contact us with complaints about basis-related contract performance, they blame a particular contract for things that it isn't designed to do and can't possibly accomplish. What we propose to do is provide some clarification on a number of basis-related issues, in the hope of bringing about some fresh thinking about the general subject of basis as it applies to commodities.

To begin, let's define basis as "cash minus futures" – not the other way around. Basis certainly plays an important part in hedging, but our thinking is colored by how we first learned about futures: a grain-oriented approach that relied on the concept of storage and carrying charge markets. That's fine for storable commodities like grain, but futures on non-grain commodities have some important structural differences that need to be recognized, and understood, to use these non-grain contracts effectively. Just as we shouldn't try to drive a square peg into a round hole, we need to stop trying to force every futures contract to fit into the "US No. 2 yellow corn" model.

Notice that we put "the basis" in quotes in our title, because we find that many people treat it like it's carved in stone. "Basis" isn't a single number, even for someone who always operates in the same market with the same commodity. It's really just the difference between two prices – a residual, if you will – and because it's a residual it likely will be less well-behaved than either the cash price or the futures price from which it is derived.

We need to recognize the importance of cash prices in calculating basis. Typically, the cash price component in a basis calculation is taken for granted. But a cash price series isn't always available, and even when it is available, it may not be an accurate reflection of cash market conditions. How much volume and how many individual transactions went into that cash price? Does it represent a valid "test" of the market, or is it just a nominal quote? What type of price is that cash price: a single transaction, a midpoint of the range, a simple average, a weighted average, or something else? The answers to these questions can have a big impact on the basis values that are calculated and the conclusions that are drawn from them.

We also need to recognize the time/space/form differences between the cash market and the futures contract specifications. Are we measuring and comparing the same things in both markets? If not, then it's a type of cross-hedge, and basis performance will be reduced. The more time/space/form differences between cash and futures prices, the less reliable and predictable the basis, all else being the same.

As mentioned earlier, a big part of our jobs is writing and maintaining futures contract specifications. Here are a few broad categories for classifying futures contracts based on their contract specifications:

- Storable vs. non-storable commodity
- Discrete vs. continuous production
- Physical delivery vs. cash settlement
    - For physical delivery:
        - Delivery during trading (multiple price delivery) vs. delivery after trading (single price delivery)
        - Single location vs. multiple location delivery
    - For cash settlement:
        - Single day vs. multi-day index
        - Fixed composition vs. variable composition index

These characteristics can be grouped into two categories: product characteristics that are inherent, and contract characteristics that are designed. Product characteristics include such things as the degree of storability and type of production (continuous or discrete). Contract characteristics include physical delivery, multi-price delivery and all-month listing. A further grouping can be made that categorizes commodities as semi-processed (energy, metals, meat, lumber), crops, and livestock and milk. These groupings result in the following table:

	PRODUCT CHARACTERISTICS		**CONTRACT CHARACTERISTICS**		
	Storable	**Continuous Production**	**Physically Delivered**	**Multi-Price**	**All Months**
Crude Oil & Products	X	X	X		X
Natural Gas	X	X	X		X
Metals	X	X	X	X	X
Pork Bellies	X	X	X	X	
Lumber	X	X	X		
Oilseeds & Products	X		X	X	
Grains	X		X	X	
Cotton	X		X	X	
Orange Juice	X		X	X	
Coffee	X		X	X	
Cocoa	X		X	X	
Sugar	X		X		
Live Cattle		X	X	X	X
Feeder Cattle		X			
Hogs		X			
Milk		X			X

By grouping the commodities in this fashion, it can be seen that the livestock and milk category differs the most from the others in that the commodities are not storable and production is continuous. It is our contention that because of these differing characteristics, livestock and milk must be thought of differently than the other commodities when analyzing basis patterns.

Feeder cattle, hogs and milk have different contract characteristics than the other commodities, the chief one being that they are not deliverable. Originally all started as deliverable contracts but due to cash market difficulties they were converted to cash settlement. Even the live cattle market has had difficulties in deliveries and suggestions have been made to make that contract non-deliverable, all of which further points out the need to think of these commodities as being different from the crops model for basis analysis.

HOG BASIS

In order to discuss basis for hogs, it is important to understand the USDA reports from which cash prices can be taken. These reports have been part of the mandatory reporting system since April 2001. The relevant reports that underlie the futures contract are HG213 for contracts through February 2003 and HG201 for contracts beginning April 2003. These two reports reflect national slaughter costs for the prior day. The slaughter cost reflects the value of hogs slaughtered on a given day and may consist of several purchase periods from prior days. Further, the HG201 report that is used now reflects net values (with premiums and discounts included) for the current carcass weight (195-205 lbs.) and the current lean percent (53-55%). The CME Lean Hog Index is a 2-day weighted average of national negotiated and formula transactions reflected in these reports.

	Initial Futures Index	**Current Futures Index**	**Cash Price**
Period of Use	1997-2003	2003-present	2001-present
Report Number	HG213	HG201	HG200
Price	Slaughter Cost	Slaughter Cost	Purchase Price
Type	Base (weighted average)	Net (weighted average)	Base (weighted average)
Period	Prior Day	Prior Day	Prior Day (plus am & pm)
Location	National	National	National (plus regionals)
Backfat	0.80-0.99”	Current	0.9-1.1”
Carcass Weight	Current	Current	185 lbs.
Transaction Types	Negotiated & Formula	Negotiated & Formula	Negotiated & Formula

The cash price that is usually followed by many producers and researchers, however, is reported in HG200, a daily national base purchase price for a 185 lb. animal of 49-50% lean. Base purchase prices are also available in regional and intra-day reports. Prices based on both negotiated and formula transactions are noted on all reports.

Because of the number of different reports and price types, a discussion of hog basis should begin with an attempt to define what prices are being used for the cash market. Once that is established, a comparison can be made between the chosen cash price and the price underlying the futures. For example, if the Iowa-Southern Minnesota afternoon negotiated base purchase price is chosen, it can be seen that this price may differ from futures prices because of:

- A difference between regional and national values,
- A difference between negotiated and formula transaction values,
- A difference between base and current weight,
- A difference between base and current leanness,
- A difference in timing between purchase and slaughter, and
- A difference between afternoon and prior day values

After understanding these differences, the usual basis comparisons can be more fully understood.

MILK BASIS

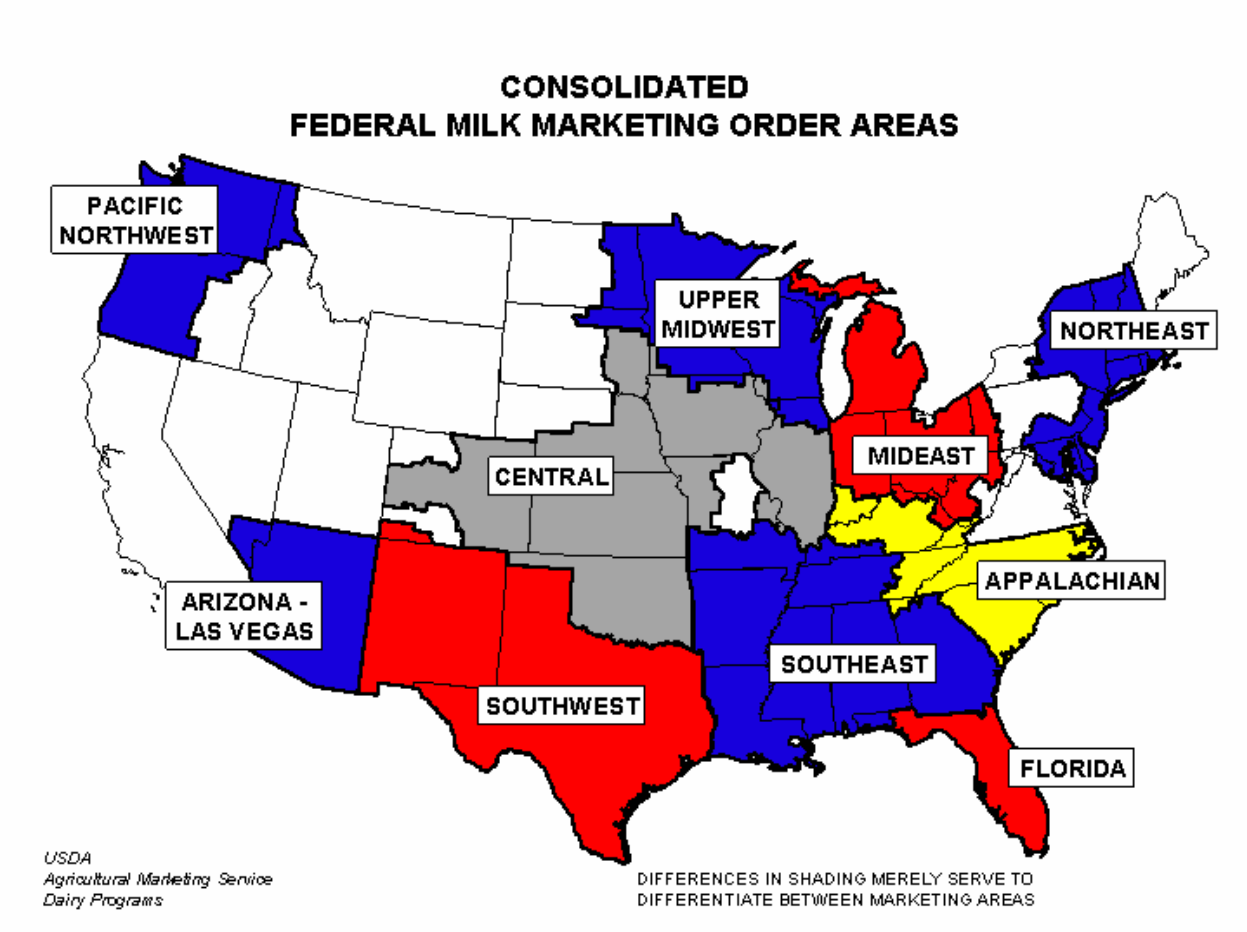
Before discussing Class III Milk basis, a brief overview of the dairy pricing system is necessary to understand the intricacies of this unique system. Over the past 120 years, a complex pricing system has evolved to deal with the production, assembly and distribution of milk. Within this government regulated system there are a number of built in programs to protect dairy farmers. These programs include price supports for milk, butter, cheese, nonfat dry milk and dry whey, Federal Milk Marketing Orders, import restrictions and export subsidies.

For 50-plus years, the price support program has been the main driver of the overall dairy program and is the foundation of the entire price structure for bulk milk. This program, coupled with a support price program for butter, cheese, and nonfat dry milk operated by USDA's Commodity Credit Corporation (CCC), help keep the dairy markets in balance.

Another important aspect of the dairy program is the Federal Milk Marketing Orders. Orders have existed since the 1930s and the goal of the Orders is to provide an orderly flow of raw fluid-grade milk from the farmer to the processor and to set minimum prices that the farmer will receive for his milk. Milk as the consumer knows it is not how the Federal Orders view it. Milk is divided into four Classes based on its utilization:

- Class I – Drinking or Fluid Milk
- Class II – Ice Cream and Yogurt
- Class III – Cheese
- Class IV – Butter and Nonfat Dry Milk

There are currently 10 Federal Milk Marketing Order Areas in the US which include: Northeast, Appalachian, Florida, Mideast, Southeast, Upper Midwest, Central, Southwest, Arizona-Las Vegas and Pacific Northwest. The Western marketing order was recently disbanded; California is a self-regulating market.



To set these minimum prices, a "mover" was developed to link the price support program to the Federal Orders, so that changes in one program are reflected in the other. The mover was developed to align the unregulated and regulated milk markets. The first mover was the M-W price and was used from 1968 to mid-1995. This was manufacturing grade or "Grade B" milk produced in Minnesota and Wisconsin. As Grade B milk production diminished, the M-W mover was replaced with the Basic Formula Price (BFP).

The BFP came into use in mid-year 1995 and ran through 2000, using the prices of butter, cheese and nonfat dry milk in formulas to adjust the M-W price, which was still available to calculate minimum price that Class III price handlers were required to pay dairy farmers. By adding these differentials for butter, cheese and nonfat dry milk to the BFP, prices for Class I and II could be determined.

In order to make the pricing system reflect the current market conditions, the government tweaked the BFP into the current class price formula structure. These new formulas became effective in 2001 and are still in use today with milk being broken down into four classes. Prices for the four classes are determined by the values of cheese, dry whey, butter and nonfat dry milk.

The values of cheese, dry whey, butter and nonfat dry milk are compiled by the USDA's National Agricultural Statistical Service (NASS). NASS sends mandatory surveys to dairy plants on a weekly basis to collect wholesale prices and quantities sold. NASS then uses that pricing information in the class formulas to derive the prices for Class I, II, III and IV milk:

Class I Price = (Class I Skim Milk Price x 0.965) + (Class I Butterfat Price x 3.5)
where:

- Class I Skim Milk Price = Higher of Advanced Class III or IV Skim Milk Pricing Factors + applicable Class I differential
- Class I Butterfat Price = Advanced Butterfat Pricing Factor + (applicable Class I differential ÷ 100)
- *Note: Advanced pricing factors are computed using applicable price formulas listed below, except that product price averages are for two weeks.*

Class II Price = (Class II Skim Milk Price x 0.965) + (Class II Butterfat Price x 3.5)
where:

- Class II Skim Milk Price = Advanced Class IV Skim Milk Pricing Factor + $0.70
- Class II Butterfat Price = Butterfat Price + $0.007
- Class II Nonfat Solids Price = Class II Skim Milk Price ÷ 9

Class III Price = (Class III Skim Milk Price x 0.965) + (Butterfat Price x 3.5)
where:

- Class III Skim Milk Price = (Protein Price x 3.1) + (Other Solids Price x 5.9)
- Protein Price = ((Cheese Price – 0.165) x 1.383) + ((((Cheese Price – 0.165) x 1.572) – Butterfat price x 0.9) x 1.17)
- Other Solids Price = (Dry Whey Price – 0.159) x 1.03
- Butterfat Price = (Butter Price – 0.115) x 1.20

Class IV Price = (Class IV Skim Milk Price x 0.965) + (Butterfat Price x 3.5)
where:

- Class IV Skim Milk Price = Nonfat Solids Price x 9
- Nonfat Solids Price = (Nonfat Dry Milk Price - 0.14) x 0.99
- Butterfat Price = (Butter Price – 0.115) x 1.20

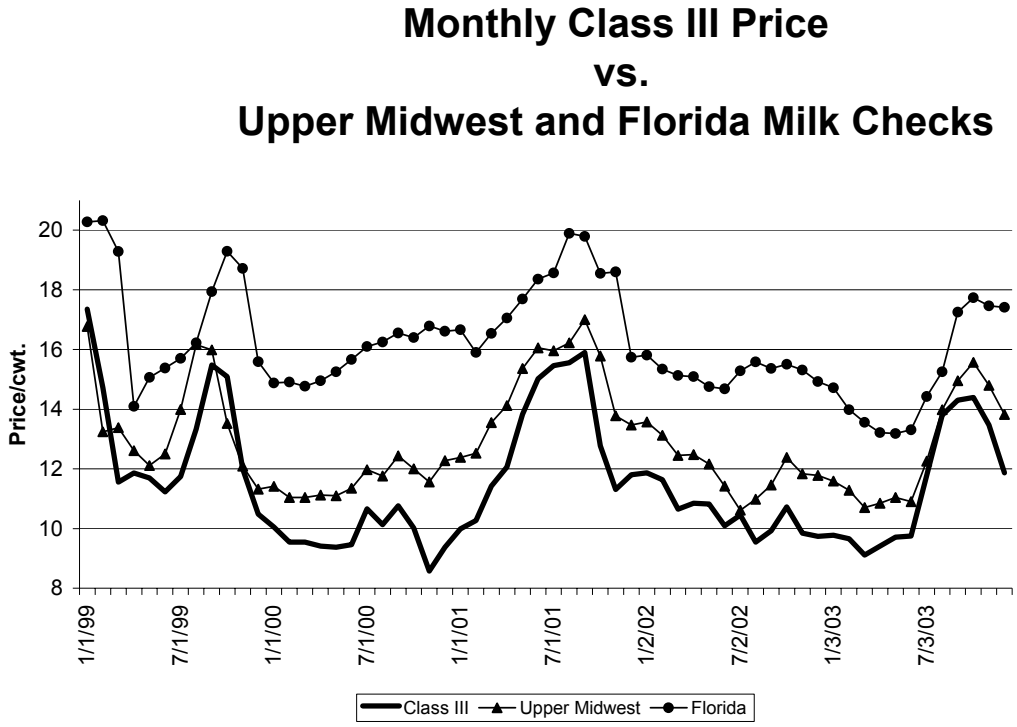
Dairy pricing is more complex than most people realize. As a result, milk basis differs from other commodities because a milk price is not strictly based on grade or transportation. Milk prices reflect market location, utilization, quality and season.

When calculating basis, a dairy farmer needs (as a rule of thumb) three years of "mailbox" checks to determine a viable historical basis. The mailbox price is the gross price minus hauling, promotion and marketing charges. After accounting for the various service charges, the farmer needs to see how his milk was utilized among Class I, Class II and Class IV milk relative to Class III milk. Finally, a producer needs to account for what type of premiums he received for the quality and component content of the milk he produced. All of these factors can alter the milk basis of each dairy farmer. Besides understanding the information on the mailbox

check, the Federal Milk Marketing Order is also vital in calculating the milk basis because Orders determine the utilization of the bulk milk.

Let us look at three Federal Milk Marketing Orders in regard to basis. The Florida Order has the highest Class I (Fluid Milk) utilization, and the Upper Midwest Order has the highest Class III (Cheese Milk) utilization. By plotting the final monthly NASS Class III price with each Order's mailbox price, one can get a better understanding on how these Orders differ.

Florida, with its high Class I utilization, had the largest deviation from the actual Class III price. At the same time, the Upper Midwest Order, made up of Wisconsin & Minnesota, had a correlation of .90 between the mailbox check and the final Class III price.



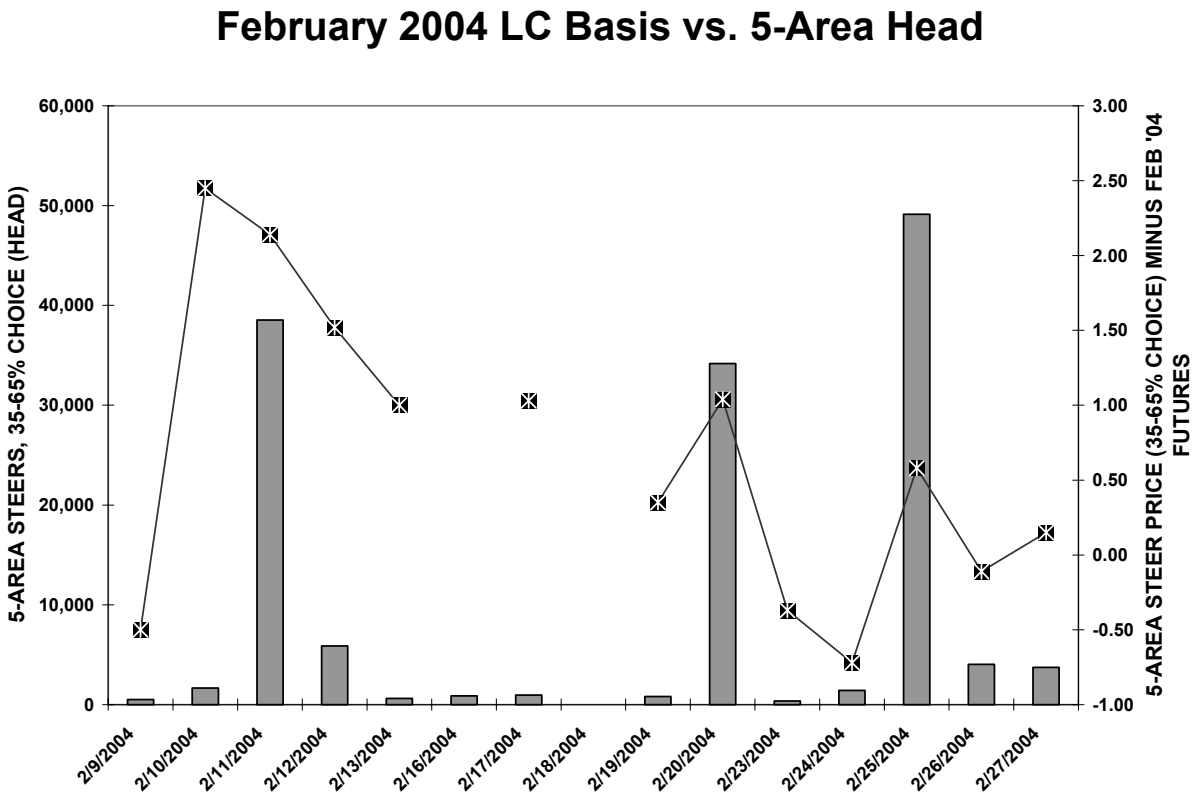
It is important to remember that with all the complexities within the dairy program, it all comes down to location and class utilization, be it Class I, II, III or IV, which is vital in determining basis.

LIVE CATTLE BASIS

For our final example, let's look at live cattle futures, beginning with an overview of its product and market characteristics. Using the characteristics presented at the outset:

- Nonstorable: Perishable; quality changes rapidly over time
- Continuous production: No connection between futures prices in different contract months
- Physical delivery: Delivery costs = upper bound on futures over cash (premium), but no lower bound on futures under cash (discount)
- Delivery during trading: Cash price is determined independent of futures price
- Multiple delivery points: Currently 12; "cheapest to deliver" principle applies
- Cash market price: Price established infrequently; quality of cattle unknown and variable

Notice that the only similarity between slaughter cattle and corn is that both are physically delivered, and even then the delivery processes are far from identical. Given these important differences, there is little reason why we should expect the live cattle basis to look or act anything like the corn basis. In fact, we would propose that the basis values for live cattle should be calculated using a volume-weighted cash price, because there is so little volume underlying the reported cash price on most days of the week. An example for February 2004 is presented here, with transaction volume superimposed over the daily basis values:



A volume-weighted basis value can be calculated, using each day's basis value weighted by the volume of trade in the underlying cash market. It follows that a volume-weighted basis value, which reflects the economic impact of basis levels on market participants, may differ

substantially from a "traditional" basis value in which each day's observation receives equal weight.

SUMMARY AND CONCLUSION

From these three examples – hogs, milk, and live cattle – we have demonstrated that a universal basis model cannot be applied to all contracts and be expected to provide accurate results. Market participants must understand not only the cash market in which they operate, but also the specifications of the futures contract used in the hedge. These examples also underscore the need for some new thinking about the general subject of basis and how it applies to commodities.