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Milk and Money

Gerard van der Laan, a third-generation owner of a California dairy farm, stared in frustration at the figures before him, willing them to improve. His dairy milked 2,500 cows three times a day and produced approximately 200,000 pounds of milk daily. Sadly, however, productivity did not always equal profitability.

John, Gerard's son and herd manager, walked through the door. "Got milk?" John asked, stripping off his gloves. Gerard nodded in the direction of the fridge. The younger man poured two glasses, brought them to the table, and sat down next to his father. "What happened? You look like you just got harassed by some environmentalists over manure issues."

Gerard didn't smile. "Feed prices have been shooting through the roof with all these ethanol plants coming on line," he sighed. "Add to that lousy and unpredictable milk prices, and it's getting tough to make a living doing this. When milk prices are high, we can manage with high grain prices. When grain prices are low, we can manage with low milk prices. But when we get these high grain prices and low milk prices . . . it's trouble."

"We don't farm because it's easy," his daughter Sophie reminded him as she entered the kitchen. "We farm because our blood is milk. Or at least that's what they tell me." She squeezed his shoulder gently on her way out the door to continue the biweekly health check for the herd. "I'll catch you boys later."

Gerard sighed and tossed the fax with the latest milk prices from the California Milk Pooling Branch to his son. Stability of prices and returns were especially important to dairy farms because they were by nature less diversified, requiring more specialized equipment and management than the average farm business.

Unfortunately, price stability was as elusive as the Holy Grail. Dairy prices were characterized by extreme volatility, fluctuating month to month, making it difficult to ensure meeting break-even costs. Gerard needed to drastically reduce his risk—fast.

The California Dairy Industry

California led the nation in the production of milk, butter, nonfat dry milk, ice cream, and whey protein concentrates. In 2004 the California Department of Food and Agriculture (CDFA)

reported that the state produced one out of every five glasses of milk and one out of every five pounds of cheese consumed in the United States.[1]

The dairy business generated $47.4 billion in economic activity in the state in 2004 and created 434,200 full-time jobs, according to a study released by the California Milk Advisory Board.[2] The study reported that California had 2,107 dairy farms with 1.7 million dairy cows supplying milk to 139 dairy plants in the state producing fluid milk and other dairy products.

Profits and costs had prompted a transformation of the nation's dairy landscape during the previous few decades. Western states like California had led the charge, and their vision had met with great success.

In the 1970s a new type of dairy farm had begun to emerge in the West. Whereas a large dairy farm at that time was typically family-owned with 100 cows, the new operations were often much more extensive, with between 1,000 and 2,000 cows. The larger dairies were still family-owned, but they relied heavily on hired labor and purchased feed off the farm.

The United States Department of Agriculture (USDA) cited a number of factors that contributed to California's dominance in the industry. These included less expensive land, a favorable climate that permitted large dry-lot operations with lower costs, the availability of production inputs other than land (including consistent, high-quality forage for nutrient planning), access to hired labor, strong population growth that created demand for dairy products, and easy access to markets in population centers.[3]

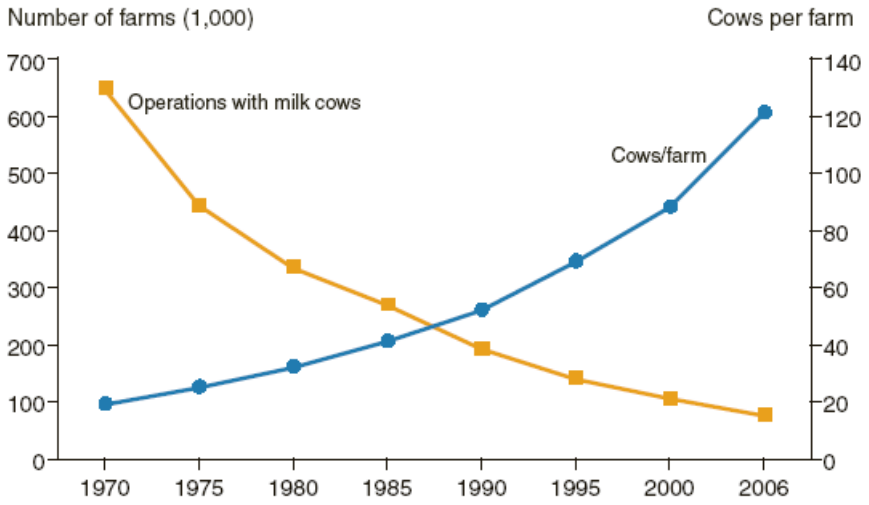
Several recent USDA reports had underscored the trend toward larger dairies and the movement of dairy farming to the West. In 2007 the USDA reported that while the number of U.S. dairy farms had decreased overall, the average size of those in operation had increased (see **Figure 1**).

[1] CDFA, "A Consumer's Look at California's Dairy Landscape in 2004," http://www.cdfa.ca.gov/dairy/pdf/annual/2004/consumer_fact_sheet_04.pdf (accessed November 14, 2007).

[2] California Dairy Press Room (an instrumentality of the CDFA), "California's Dairy Business Has $47 Billion Economic Impact on State; Creates 434,000 Jobs," September 12, 2005, http://www.californiadairypressroom.com/CADNews-economic05.html (accessed November 14, 2007).

[3] USDA, "Economic Effects of U.S. Dairy Policy and Alternative Approaches to Dairy Policy," Report to Congress, July 2004, http://www.usda.gov/documents/NewsReleases/dairyreport1.pdf (accessed November 14, 2007).

Figure 1: Number vs. Average Size of Dairy Farms



Source: James M. MacDonald et al., "Profits, Costs, and the Changing Structure of U.S. Dairy Farming," ERR-47, USDA Economic Research Service, September 2007, http://www.ers.usda.gov/Publications/ERR47 (accessed November 14, 2007), 2.

Between 1970 and 2006, the number of U.S. dairy farms fell 88 percent—from 648,000 to only 75,000.[4] Similarly, the total number of dairy cows in the nation fell from 12 million in 1970 to 9.1 million in 2006. However, the average herd size rose from only 19 cows in 1970 to 120 cows in 2006. The number of U.S. dairy operations with more than 2,000 cows doubled between 2000 and 2006 alone (see **Table 1**). In California, farms with at least 500 cows accounted for 88 percent of milk production in 2006.

Table 1: Changes in the Size Structure of U.S. Dairy Farms, 2000–2006

Herd Size	Number of Operations			Percent of Inventory		Percent of Production	
(no. head)	2000	2006	% Change	2000	2006	2000	2006
1–29	30,810	21,280	–31.0	2.9	1.9	1.8	1.2
30–49	22,110	14,145	–36.0	9.1	6.0	7.7	4.9
50–99	31,360	22,215	–29.2	22.0	16.3	19.4	14.3
100–199	12,865	9,780	–24.0	18.0	14.1	17.3	13.0
200–499	5,350	4,577	–14.4	16.7	15.0	18.0	15.0
500–999	1,700	1,700	0	12.0	12.6	13.7	14.3
1,000–1,999	695	870	+25.2	10.1	12.5	11.6	13.9
2,000+	280	573	+104.6	9.2	21.6	10.5	23.4
Total	105,170	75,140	–25.2	100.0	100.0	100.0	100.0

Source: MacDonald et al., "Profits, Costs, and the Changing Structure of U.S. Dairy Farming," 3.

[4] MacDonald et al., "Profits, Costs, and the Changing Structure of U.S. Dairy Farming," 2.

Despite the decrease in total number of cows, milk production doubled between 1970 and 2006 due to advances in technology and animal health. Total milk production rose, and average milk production per farm grew twelvefold.

Structural changes in the industry reflected new economies of scale. The large dairy enterprises experienced returns that typically far surpassed their costs, whereas smaller farms incurred economic losses that resulted in many farm closures (see **Table 2**).[5] Costs per hundredweight[6] (cwt) of milk produced fell by nearly half as herd size increased from fewer than 50 cows to 500 cows. Operating costs continued to fall at even larger herd sizes, but less sharply.

Table 2: Dairy Costs of Production by Herd Size, 2005

	Enterprise Size (number of milk cows)					
	<50	50–99	100–199	200–499	500–999	>999
Mean herd size	35	69	133	295	666	2,083
Output per cow (lbs.)	15,055	17,149	18,228	19,487	20,719	20,195
($ per hundredweight)						
Total operating costs	12.30	12.94	11.51	11.31	11.07	9.74
Purchased feed	3.60	3.75	4.12	5.00	5.64	5.99
Homegrown feed	5.02	5.07	4.06	3.01	2.58	1.47
Grazed feed	0.41	0.15	0.11	0.10	0.02	0.01
Allocated overhead	17.79	12.56	9.31	6.61	5.00	3.85
Hired labor	0.50	0.80	1.34	1.84	1.80	1.61
Unpaid labor	10.60	6.10	3.13	1.34	0.54	0.17
Capital recovery	5.26	4.56	3.89	2.55	2.03	1.66
Total costs	30.09	25.50	20.82	17.92	16.07	13.59
Gross value of production	17.87	17.56	17.20	17.25	16.56	16.54
Net returns	–12.22	–7.94	–3.62	–0.67	0.49	2.95

Source: MacDonald et al., "Profits, Costs, and the Changing Structure of U.S. Dairy Farming," 9.

Milk Pricing

Dairy was one of the most heavily regulated segments in all of agriculture.[7] The USDA regulated the price of around 70 percent of the nation's Grade A milk prices, but California and several other states fell outside its jurisdiction. U.S. dairy regulation began in the 1930s in

[5] Ibid., 9.

[6] One hundredweight of milk was equal to 100 pounds (approximately 11.6 gallons) of standardized milk.

[7] Historical information related to California dairy regulation is taken from Daniel A. Sumner and Norbert L. W. Wilson, "Evolution of Dairy Policy in California: Our Unique System for Distributing Milk Revenue," *University of California, Davis Update* 3, no. 3 (2000): 3–6.

response to the price collapse and market disruption of the Great Depression. President Franklin D. Roosevelt's Agricultural Adjustment Act of 1933 outlined a number of dairy provisions, including defined marketing areas, minimum prices, and fair trade requirements; however, the constitutionality of the act was quickly challenged. As the policy crumbled, California milk producers demanded state legislation that would accomplish similar goals. In 1935 the Young Act effectively codified the dairy components of the Agricultural Adjustment Act. By the time a federal milk policy was enacted, the California program was firmly established and the state declined to participate. Thus California milk pricing evolved in a slightly different way from the rest of the country.

Marketing milk was done through a processor. All processors, and by extension all California milk producers, were part of the California Milk Pooling Branch. Like the national milk marketing program, California's milk program established minimum prices processors paid for fluid grade or Grade A milk received from dairy farmers.[8] These prices were established within defined marketing areas where milk production and marketing practices were similar. California operated with two marketing areas: Northern California and Southern California. Each marketing area had a separate but essentially identical stabilization and marketing plan.

The prices that California producers like Gerard were paid for their milk was a very complicated "blend" price based on market-wide utilization of milk by class. Essentially, all milk fell into one of five classes: Class 1 (fluid milk), Class 2 (cream, cottage cheese, yogurt, and sterilized products), Class 3 (ice cream and frozen products), Class 4a (butter and dry milk products), and Class 4b (cheese other than cottage cheese). Minimum prices for each class were determined by valuing finished dairy products on wholesale markets. These prices were updated regularly by using formulas to reflect changing market conditions for dairy products. In California, Class 1, 4a, and 4b farm prices were adjusted monthly according to their pricing formulas and the prevailing dairy commodity prices. Class 2 and 3 prices were adjusted every two months.

The notations for and the definitions of the milk prices used in the federal milk marketing order were slightly different from those used in the California milk marketing program. The federal order grouped milk into four classes: Class I (defined as California Class 1), Class II (California Class 2 and Class 3), Class III (California Class 4b), and Class IV (California Class 4a).

All milk produced and shipped to processors in California was "pooled" each month. Once the milk was processed for the different value-added dairy products, the proceeds were distributed to the producers according to a schedule of quota, base, and overbase prices on a per-hundredweight basis ($/cwt). What the dairy producer actually received per hundredweight was called the "mailbox price." The mailbox price varied slightly from the California pool price and from producer to producer due to charges or bonuses assessed by the processor to the producer.[9] The mailbox price was also affected by the components of the milk from dairy to dairy. Dairies with higher fat or "solids-not-fat" received more money for their milk. That is, the less water in the milk, the more money they received per hundredweight.

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[8] All information on milk pricing was taken from CDFA, "Milk Pricing in California," "The History of Milk Pooling," and "Comparison of California and Federal Milk Marketing Orders," http://www.cdfa.ca.gov/dairy/infolib.html (accessed November 14, 2007).

[9] For more information on mailbox prices, see CDFA, "Mailbox Prices," http://www.cdfa.ca.gov/dairy/mailbox_prices_main.html (accessed November 14, 2007).

The California pool price was determined for each month once all of the data was obtained. This created a lag between milk shipments and the determination of the milk price. Producers were paid twice a month at the announced California pool price for the month prior to the actual shipments, thereby requiring a "settlement payment." The settlement payment was the difference between the estimated and realized pricing for a given month. For example, the daily shipment between January 1 and January 15 would be paid to the producers on January 28 at the December price per cwt. However, they would also receive a settlement payment at this time because all December shipments had been paid at the November price (that being the latest known price at the time). The settlement would be a credit or debit depending on whether the December price was higher or lower than the November price. Next, the daily shipments between January 16 and January 31 would be paid to the producers on February 14—also at the December price per cwt, since the January price would still be unknown. The settlement payment for the January shipments would then be included at the end of February, along with payments for shipments made between February 1 and February 15.

The pool prices were very difficult to predict, since they were influenced by national and international demand for California dairy products. Gerard had no idea what he would be paid for his milk when he loaded it on trucks and sent it to processors. Mailbox prices between 2005 and 2007 had ranged from $10.16/cwt to $19.98/cwt, with the 2006 average being $11.28/cwt. As far as he was concerned, this was unacceptable. Financially, he could not handle another 2006.

Rising operating costs were especially troublesome for Gerard because he had no way of passing them on to consumers. Dairy farmers were price takers, not price makers. The price of milk was determined through a complex system of formulas and reference points, but his expenses had no bearing on the price he received.

"What numbers do we really need to hit, Dad?" John asked.

Gerard didn't need to think about it. "Our current production costs are somewhat below $12. So if we could just guarantee $12 per hundredweight, we'd be okay."

"Well, then, let's hedge our bets and talk about options," John replied.

Trading Options on Dairy Futures

Dairy futures are legally binding obligations to buy or sell a specific amount of a specific dairy commodity—milk, butter, nonfat dry milk—that meets set grades and standards on some future date for a prespecified price. All dairy futures contracts require a fulfillment, or binding obligation, on the part of the trader at some time before the contract expires. Futures contracts provide producers of dairy products with a risk management tool. Producers can sell a futures contract and thereby guarantee a fixed price for their products in the future; however, while they are then insured against price decreases in the market, they cannot benefit from price increases.

An option on a futures contract is the right, but not the obligation, to buy or sell a futures contract at a specific price on or before an expiration date.[10] Options contracts are similar to futures contracts but with added flexibility. Options allow hedgers to establish a price floor without giving up the opportunity to benefit from favorable price changes in the future. Buyers must pay a price for the option—called the premium—up front, but their losses are limited to that premium no matter how much the price of the underlying futures contract may fluctuate. There are two different types of options:

- *Put Options*. A put option is the right to sell a futures contract at a certain price. Put options increase in value if prices fall, and they decrease in value if prices rise.
- *Call Options*. A call option is the right to buy a futures contract at a certain price. Call options increase in value if prices rise, and they decrease in value if prices fall.

The price at which the buyer has the right to buy or sell a futures contract is known as the strike price or exercise price of the option. In the milk market, strike prices occur in intervals of $0.25. Thus, if futures are at $12/cwt, strike prices will be available above and below $12 at amounts such as $12.50, $12.25, $12, $11.75, and $11.50. For butter and nonfat dry milk, strike prices occur in intervals of $0.02. Thus, if futures are at $1.20 per pound, strike prices will be available above and below $1.20 at amounts such as $1.24, $1.22, $1.20, $1.18, and $1.16.

Option premiums change as the underlying futures price changes. The amount of the premium is affected by the length of time until expiration, the strike price in relation to the current futures price, and the volatility of the futures contract. Put premiums cost more at higher strike prices since a put owner can sell futures at a higher level. Call premiums cost more at lower strike prices since a call owner can buy futures at a lower price.

When traders discuss option payoffs, they often describe options as at the money, in the money, or out of the money.[11] When an option is at the money, the price of the underlying security (roughly) equals the strike price. When options are in the money, the option holders make money by exercising the option. Thus, a put option is in the money when the strike price is more than the market price of the underlying security, and a call option is in the money when the strike price is less than the market price of the underlying security. When options are out of the money, holders would not gain a profit if the option were exercised, so they allow the option to expire unused. There is no loss associated with not exercising the option other than loss of the initial premium and the trading costs of the initial transaction.

Sellers of dairy commodities, such as dairy farmers, can purchase a price protection against falling prices of their commodities sold in the future by buying dairy put options. For example, a farmer might pay a premium of $0.40/cwt to buy a $12 December Class III milk put option, which is a type of option available for trade at the Chicago Mercantile Exchange. Suppose the trading costs for purchasing the option (fees, commissions, etc.) are $0.05/cwt. If the December Class III milk price ends up being $11/cwt, the option is in the money and will be worth $1/cwt

[10] A discussion of dairy futures and put and call options can be found in the Chicago Mercantile Exchange's primer "An Introduction to Trading Dairy Futures and Options," http://www.cme.com/files/Primer_for_Traders2.pdf (accessed November 14, 2007); in Gregg Ibendahl and John Anderson, "Risk Management Tools for Dairy Farmers: Options on Dairy Futures," University of Kentucky, College of Agriculture, Cooperative Extension Service, AEC-86 (2000); and in Gregg Ibendahl and John Anderson, "Put Options as Price Insurance for Dairy Farmers," University of Kentucky, College of Agriculture, Cooperative Extension Service, AEC-87 (2000).

[11] Further information on options can be found in George Chacko et al., "Note on Basic Option Properties," Case #9-205-105 (Harvard Business School, 2006).

($12 – $11) when it expires. The farmer collects a net gain (ignoring proper discounting) of $0.55/cwt ($1 – $0.40 – $0.05) that helps offset the low mailbox price in December. In this example, the farmer has effectively bought a Class III price floor of $11.55/cwt ($12 – $0.45). If the farmer's December mailbox price is typically $2 above the Class III price, the farmer expects to earn a mailbox price of at least $13.55/cwt ($11.55 + $2), no matter how low Class III prices fall between now and December.[12]

"So, it's like price insurance," Gerard remarked when his son stopped talking long enough to take a breath.

"Exactly," John said. "It's a very low-maintenance risk management strategy. We don't have to do things any differently on the farm, and we don't have to monitor anything once we buy the option. The option is just there if we need it. It allows us to lock in a floor price without giving up any potential upside price gains."

"Great." Gerard felt lighter already. "Let's buy put options to ensure that we'll get a payoff if our mailbox price falls below $12.50."

John was silent. Gerard knew it had sounded too easy.

"The Chicago Mercantile Exchange doesn't actually trade options on the California mailbox price or on the prices of the California milk marketing program, Dad," John said. "You can buy options on Class III milk, Class IV milk, butter, and nonfat dry milk."

Given that the California pool blend price was made up of different dairy products, Gerard was not clear on what category would make the best hedging tool. Trading options would cost money and nerves. Gerard wanted to buy put options on just one of these four prices to ensure his payoff, but the question remained: which one? Certainly he should use the one that most closely tracked his mailbox price. John had collected data on their mailbox price and the announced prices of Class III milk (per cwt), Class IV milk (per cwt), butter (per pound), and nonfat dry milk (per pound) for forty-one recent months (see the spreadsheet that accompanies this case for details).

For a start, Gerard wanted to hedge his price risk for the milk production in a specific month about six months' down the road.

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[12] This example is based on a similar one found in Leigh Maynard, "Dairy Situation and Outlook: Fall 2001," http://www.uky.edu/Ag/AgEcon/pubs/esm/esm_27/esm_27-4.pdf (accessed November 14, 2007).

Questions

1. Suppose Gerard's mailbox price in a specific month is $12.50. Predict the prices of Class III milk, Class IV milk, butter, and nonfat dry milk, respectively, in that month.

2. Which of the four dairy commodity prices is most closely related to Gerard's mailbox price? Justify your answer.

3. Gerard decides to buy put options only on the dairy future for the commodity whose price is most closely related to his mailbox price. He wants to be 95 percent sure that his options are in the money if the mailbox price falls below $12.50. Which dairy commodity futures options should he buy? And for what strike price?

4. Suppose the mailbox price in a specific month is $11.50. Provide a point estimate for the value of the put option Gerard bought (based on your analysis for the previous question) that expires in that month. Can he be 95 percent assured that his net price (mailbox price plus payoff from the option but before premium and transaction costs) would exceed $12.50?

5. Gerard realizes that he needs to include the option premium and trading fees in his calculations. How would these costs alter the analysis?