Understanding the milk-to-feed price ratio as a proxy for dairy farm profitability

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ABSTRACT

This research examines the definition, historical pattern, and utility of the milk-to-feed price ratio (MF) as a measure of dairy farm profitability. The MF was generally an acceptable proxy of profitability in an annual sense from 1985 to 2006. The MF was steady at an average of 2.8 from 1985 to 2006 even as average annual milk price in nominal terms increased from \$12 to \$14/hundredweight. An alternative proxy for profitability is income over feed costs, which is measured in dollars per hundredweight. Comparison with an actual profit measure, rate of return on assets, is used to examine the appropriateness of the proxies. The volatility from 2007 to 2009 resulted in MF being a poor measure of profitability over that period. The implication is that MF is not the preferred measure of profitability when a significant change in the pattern of one or both price series occurs. Income over feed cost is a better measure of profitability in periods of volatility.

Key words: cost of production, economics, income over feed costs, profit

INTRODUCTION

Feed prices are the single largest milk production expense (USDA-ERS, 2010). All else equal, dairy farmers realize a smaller profit margin when feed prices are high relative to milk price received. The USDA National Agricultural Statistics Service (USDA-NASS) calculates a milk-to-feed price ratio (MF) as a proxy for milk production profitability. The MF is defined as the all-milk price, in dollars per hundredweight (cwt; 1 cwt = 45.36 kg), divided by a feed index, which is the cost of 100 pounds of a representative feed. The USDA-NASS has reported this value monthly since 1985. Other livestock sectors use similar ratios to indicate profitability. For example, the hog-corn price ratio has long been used as a proxy for profits in the hog industry (Blosser, 1965; Meilke, 1977) and the broiler-corn ratio is used to proxy profit in the poultry industry (Goodwin et al.,

2007). These output price-input price ratios are used because they are easily and quickly calculated from readily available industry information to gauge current profit levels.

Criticisms of the ratios include the argument that they can be difficult to understand because they are not in dollar terms and that the level of the ratio does not appropriately reflect the level of relative profitability (Meilke, 1977; Bailey and Ishler, 2008). The latter criticism is more pertinent to the use of the MF. For example, when the MF is 3.0 and the milk price is \$12/cwt, that implies a \$4/cwt feed cost and a margin of \$8/cwt over feed costs. However, that same 3.0 MF when milk price is \$18/cwt reflects a much larger margin of \$12/cwt over feed costs. Consider the average Michigan values in Table 1. From 1985 through 2006, the Michigan MF averaged 3.07 and income over feed costs (IOFC) averaged \$10.00/cwt. In 2007, the Michigan MF decreased below the long-term average value because of high feed prices, but an exceptionally high milk price meant that IOFC increased to an all-time high nominal value of \$14.43/cwt. In 2008, the Michigan MF decreased to what historically was considered a very low average of 2.11, with slightly lower milk prices and higher feed prices than the previous year, whereas IOFC decreased only to \$11.74/cwt. The decline in the Michigan MF continued in 2009 when it averaged 1.75 whereas IOFC declined to \$7.20/cwt. The lack of correspondence between the MF and IOFC calls into question the utility of the MF as a measure of profitability.

For many years, milk price has driven variation in the MF while feed prices, especially corn prices, have been low and stable. However, in recent years, volatility in corn and soybean prices became major factors in driving MF variation. The 10-yr average (1997–2006) US price for corn was \$2.49/bushel (bu; 1 bu = 56 lb = 25.40 kg), whereas prices in 2008 exceeded \$7/bu for a brief period and averaged \$4.78/bu for the year (USDA-NASS, 2009). These high corn prices have the effect of pulling acres out of soybeans and hay, which increase those feed prices. Even when a farm is not purchasing cash feed, if grain and alfalfa hay prices increase, the opportunity cost of feeding homegrown crops to cows has also increased.

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Table 1. Michigan milk and feed average values¹

Period	All-milk (\$/cwt)	Corn (\$/bu)	Soybeans (\$/bu)	Hay (\$/ton)	Feed ² (\$/cwt)	MF ³	IOFC ⁴ (\$/cwt)
1985–2006	13.64	2.25	5.83	81.53	4.50	3.07	10.00
2007	19.68	3.42	7.56	115.42	6.49	3.03	14.43
2008	19.04	4.81	11.07	154.58	9.03	2.11	11.74
2009	13.40	3.63	10.18	146.33	7.66	1.75	7.20

¹All-milk price (USDA, 1985–2010). Corn (\$/bu, 1 bu = 56 lb = 25.40 kg), soybeans (\$/bu, 1 bu = 60 lb = 27.22 kg), and hay (\$/ton, 1 ton = 2000 lb = 907.18 kg) refer to prices received by farmers (USDA, 1985–2010). cwt = hundredweight (= 45.36 kg).

²Feed cost calculated as [(price of corn, \$/bu)/56 × 51] + [(price of soybeans, \$/bu)/60 × 8] + [(price of alfalfa hay, \$/ton)/2,000 × 41].

³MF = milk-to-feed price ratio. Calculated as all-milk price/feed price per cwt of feed, where feed cost is calculated as above.

⁴IOFC = income over feed costs. Calculated as shown in main text.

This research examines the MF and analyzes its use and information content. The ratio is examined as a proxy for profitability. We also consider situations when the MF is not a good measure of profitability and why those situations occur. Comparisons of the MF and IOFC to an actual profit measure, the rate of return on assets (**ROA**), are used to examine the appropriateness of the proxies.

MATERIALS AND METHODS

Definitions

The milk-to-feed price ratio is the price of 1 pound (**lb**; 1 lb = 0.4536 kg) of milk divided by the price of 1 lb of feed. Thus, one interpretation is that it is the number of pounds of feed that can be purchased with the revenue generated by 1 lb of milk. The milk price used in the ratio is the “all-milk” price, which is a weighted average of prices paid at the processing plants for milk from farmers (Novakovic, 2009). The all-milk price is used because the information is available and broadly applicable across the United States. It includes both Grades A (fluid quality) and B (manufacturing quality) milk. Today, though, the vast majority of milk is Grade A and is used for beverage milk as well as manufactured dairy products. Because the price is at the plant, the all-milk price does not consider hauling costs, producer assessments, cooperative dues, or any other marketing cost that the farmer bears. Thus, the all-milk price is generally higher than the mailbox price that farmers actually receive.

The USDA calculates a representative feed price using corn, soybean, and hay prices received by sellers at the farm level, not including transportation to the farm where it will be fed. The cost of 100 lb of 16% protein dairy cow feed is calculated as

$$\begin{aligned} \text{feed cost, } \$/\text{cwt} = & [(\text{price of corn, } \$/\text{bu})/56 \times 51] \\ & + [(\text{price of soybeans, } \$/\text{bu})/60 \times 8] \\ & + [(\text{price of alfalfa hay, } \$/\text{ton})/2,000 \times 41]. \end{aligned}$$

The cost of 100 lb of feed is weighted 51% corn cost per pound, 41% alfalfa cost per pound, and 8% soybean cost per pound. This is not likely any actual farm ration; corn, soybeans, and alfalfa hay are common energy, protein, and forage components of a typical dairy ration and their prices are correlated with available substitute products. The MF is calculated as

$$\text{MF} = \text{all-milk price } (\$/\text{cwt}) / \text{feed cost } (\$/\text{cwt}).$$

It does not generally require 1 lb of feed (either as fed or in DM terms) to produce 1 lb of milk. Assuming standard moisture contents of 12% for corn, 10% for soybeans, and 12% for hay (NRC, 2001), the USDA ration is 88.16 lb of DM. Converting feed cost to dollars per hundredweight of milk produced requires a transformation using feed efficiency, which is defined as pounds of milk per pound of feed on a DM basis (Britt et al., 2003). Although feed efficiency can vary widely depending on the ration and other management factors, this analysis uses 1.4 as a representative value (Britt et al., 2003). A feed efficiency of 1.4 means that 0.714286 lb of feed DM are required to produce 1 lb of milk because the 100 lb of DM from the USDA diet would produce 140 lb of milk. Of course, the efficiency of feed conversion not only differs across herds at any given time but also has improved over time with technology, genetic, and management advances, which improved feed efficiency, so the value we use is merely representative.

Income over feed cost is defined as

$$\text{IOFC} = \text{all milk price (\$/cwt)} - \left[\frac{\left(\frac{P_c}{56} \times 51 \right)}{0.88} + \frac{\left(\frac{P_s}{60} \times 8 \right)}{0.90} + \frac{\left(\frac{P_h}{2,000} \times 41 \right)}{0.88} \right] \times (1/\text{FE}),$$

where P_c is the price of corn (\$/bu), P_s is the price of soybeans (\$/bu), P_h is the price of hay (\$/ton), and FE is feed efficiency. This value can be adjusted to reflect the daily per cow IOFC, rather than per hundredweight, using the average daily milk production level. The percentages of corn, soybeans, and hay are the same as in the MF. The IOFC is a dollar measure rather than a ratio. Unlike the MF where the quantity of feed is always 100 lb, the quantity of feed in the IOFC is adjusted to be the quantity of feed to produce 100 lb of milk. Thus, although the information content is very similar between MF and IOFC, the measures are not identical.

To determine whether the MF or IOFC is an acceptable proxy of profitability requires an actual measure of profitability. The most preferred measure of profitability for comparisons across operations and over time is the ROA (Gloy et al., 2002; Hadley et al., 2002; Gloy and LaDue, 2003), which is defined as

$$\text{ROA} = \text{operating profit/average total farm assets.}$$

Operating profit is calculated as net farm income plus interest charges less the value of unpaid operator labor and management. Interest expense is added back to net farm income in calculating operating profit because rate of return on assets is a measure of returns to all assets regardless of the source of financing. Net farm income is gross cash farm income less cash expenses plus or minus change in inventory values plus or minus change in capital asset value. Average asset value is calculated as the average of beginning and ending farm assets. In this application, asset value is measured using market values. Rate of return on assets measures the amount of profit generated per dollar of asset. A larger ROA indicates more profit generated per dollar of assets utilized. Because ROA accounts for the amount of unpaid labor and management, use of debt financing, and farm size, it is a particularly useful measure of farm financial performance (Gloy et al., 2002).

Data

The appropriateness and utility of MF were examined using annual data from 1985 through 2009. Data for US all-milk, corn, soybean, and alfalfa hay prices were collected from USDA-NASS (1985–2010). The corn, soybean, and alfalfa hay prices were those received by farmers. Because they are farm prices received, these prices are not affected by hauling costs, similar to the all-milk price.

Table 2. United States annual average summary statistics, 1985–2009¹

Period	All-milk (\$/cwt)	Corn (\$/bu)	Soybeans (\$/bu)	Hay (\$/ton)	MF ²	IOFC ³ (\$/cwt)
1985–2009						
Average	13.81	2.47	6.32	95.39	2.82	9.73
SD	1.86	0.70	1.62	21.08	0.45	1.46
Minimum	12.11	1.56	4.43	64.64	1.77	6.93
Maximum	19.13	4.78	11.30	162.83	3.62	13.64
CV	0.13	0.28	0.26	0.22	0.16	0.15
1985–1994						
Average	12.83	2.22	5.85	81.04	2.91	9.22
SD	0.51	0.27	0.68	11.27	0.33	0.47
Minimum	12.20	1.56	5.00	64.64	2.58	8.38
Maximum	13.68	2.49	7.21	95.98	3.62	9.81
CV	0.04	0.12	0.12	0.14	0.11	0.05
1995–2009						
Average	14.47	2.64	6.63	104.96	2.76	10.07
SD	2.15	0.85	1.98	20.86	0.52	1.78
Minimum	12.11	1.86	4.43	82.26	1.77	6.93
Maximum	19.13	4.78	11.30	162.83	3.58	13.64
CV	0.15	0.32	0.30	0.20	0.19	0.18

¹All-milk price (USDA, 1985–2010). Corn (\$/bu, 1 bu = 56 lb = 25.40 kg), soybeans (\$/bu, 1 bu = 60 lb = 27.22 kg), and hay (\$/ton, 1 ton = 2000 lb = 907.18 kg) refer to prices received by farmers (USDA, 1985–2010). cwt = hundredweight (= 45.36 kg).

²MF = milk-to-feed price ratio. Calculated as all-milk price/feed price per cwt of feed, where feed cost is calculated as [(price of corn, \$/bu)/56 × 51] + [(price of soybeans, \$/bu)/60 × 8] + [(price of alfalfa hay, \$/ton)/2,000 × 41].

³IOFC = income over feed costs. Calculated as shown in main text.

Michigan is used as an example state with annual data available from 1996 through 2009. Michigan statistics for all-milk, corn, soybean, and alfalfa hay prices were collected from USDA-NASS (1996-2010). For profitability, the annual average ROA from the Michigan State University Dairy Farm Business Analysis Summary (Nott, 1996–2001; Wittenberg and Wolf, 2002–2010) were used.

Data Analysis Methods

Summary statistics used include the mean, standard deviation, and coefficient of variation, which is the ratio of the standard deviation to the mean. By standardizing the variation with the mean of that variable, the coefficient of variation allows comparison of the relative variation of 2 series. The summary statistics and correlations were calculated in Microsoft Excel (Microsoft Corp., Redmond, WA).

RESULTS AND DISCUSSION

Summary Statistics and Historical Patterns

There are many ways to summarize and examine the MF and its underlying series that illuminate patterns. Historically, the MF has tended to move toward a band

between 2.5 and 3.0. Figure 1 displays US annual average MF and IOFC for the period from 1985 through 2009. The MF over the entire period averaged 2.82 and the IOFC averaged \$9.73/cwt (Table 2). From the figure it is clear that the 2 measures are correlated. One criticism of using a ratio is evident: the MF implies different levels of margin (profitability) depending on the milk and feed price levels. For example, consider 2007 when the US MF averaged 2.82, which was exactly at the historical average, yet the IOFC averaged \$13.64/cwt, representing the highest annual average recorded over the entire period examined.

One advantage of the MF is that it accounts for the relative inflation of milk and feed prices if comparisons are made over time. Figure 2 displays the annual average nominal farm prices received for milk, corn, soybeans, and hay. Milk price was relatively steady at the beginning of the period. Recall that the milk price support affected farm milk prices consistently until the early 1990s. Since the mid-1990s, the all-milk price has displayed a great deal of variation. Corn and soybean prices were low and steady for most of the period examined with a couple of exceptions. Hay prices showed a steady upward trend beginning in 2001. All prices increased dramatically in 2007.

Table 2 displays summary statistics for the milk and feed prices over the entire period as well as broken down

Figure 1. United States milk-to-feed price ratio (USDA, 1985-2010) and income over feed costs (IOFC; author calculation), annual averages 1985-2009. Color version available in the online PDF.

into 2 periods, 1985 to 1994 and 1995 to 2009. The choice of periods was driven by the increasing variation in milk prices. The coefficient of variation of milk was 0.04 in the early period and increased to 0.15 in the later period. The minimum and maximum annual average values both occurred in the later period. As mentioned earlier, increased volatility in milk prices has been a primary driver of MF variation.

Corn and soybeans are major world commodities and the prices respond to the international supply and demand situation. Annual average corn and soybean prices were relatively stable and low until 2007. The corn price averaged \$2.22/bu from 1985 to 1994 and \$2.30/bu from 1995 to 2006 before averaging \$3.38/bu in 2007, \$11.30/bu in 2008, and \$10.05/bu in 2009. Soybeans averaged \$5.86/bu from 1985 to 2006 before averaging \$7.74/bu in 2007, \$11.30/bu in 2008, and \$10.05/bu in 2009. The coefficient of variation more than doubled for both commodities in the period from 1995 to 2009 relative to the period from 1985 to 1994.

Unlike corn and soybeans, hay is not traded on international markets, so prices are driven largely by national and regional supply shocks such as inclement weather. The variation of hay prices increased by almost 50% in the more recent period (1995–2009) relative to the earlier period (1985–1994).

As the single largest cost of production, feed is a primary driver of milk supply. However, milk supply does not adjust immediately to changes in feed costs. Dairy farms have large capital investments with large fixed costs and adjust relatively sluggishly to changes in cost instead focusing on longer term relationships. Most dairy farmers raise at least a portion of their feed requirements and often prepay feed purchases as a tax management strategy and thus do not realize immediate changes in cash feed costs if they are using feed inventories. Regardless, cash feed prices represent the opportunity cost of home-grown feed, and those farmers who can make more selling crops than feeding cows would be expected to move in the direction of selling those crops if that relationship continues over time.

The frequency of US MF for the period from January 1985 through December 2009 was examined using a histogram (Figure 3). The standard rule of thumb has been that an MF value greater than 3.0 was profitable and encouraged an increase in milk production, whereas a value below 3.0 was not profitable and was a contractionary market signal. Monthly values in 2009 were all-time lows, with the first 9 mo of the year below 2.0, which highlighted the extreme financial stress dairy farms could experience. Of the 300 monthly observations, 124 of them occurred between 2.5 and 2.99,

Figure 2. United States annual average corn, soybean, all-milk, and hay prices, 1985–2009 (USDA, 1985–2010). Color version available in the online PDF.

Figure 3. United States monthly milk-to-feed price ratio frequencies, January 1985–December 2009. Color version available in the online PDF.

making it the most common category. The next most common category was between 3.0 and 3.49 for 66 mo, although that was only slightly more common than the 2.0 to 2.49 category for 60 mo. Of the monthly observations, 33 were in the very high 3.5+ category whereas the remaining 17 were less than 2.0. All of the observations with MF value less than 2.0 occurred in 2008 and 2009. Some of those low values indicated a respectable profitability margin, whereas most indicated zero or

negative profitability. Regardless, the old MF rules of thumb appeared to be irrelevant in the past 3 yr.

The Michigan situation during the period from 1985 through 2009 was quite similar to that of the United States with respect to prices as well as MF. The Michigan MF averaged 2.93 over the entire period whereas IOFC averaged \$10.52/cwt, with a peak of \$14.43/cwt in 2007. Michigan posted higher MF and IOFC values than the United States over this period because of a

Figure 4. United States and Michigan milk-to-feed price ratio versus Michigan rate of return on assets (ROA) and Michigan income over feed costs (IOFC), annual averages 1996–2009. Color version available in the online PDF.

slightly higher average milk price and slightly lower average feed cost. The correlation between Michigan and US prices for corn (0.99), soybeans (0.99), hay (0.89), and milk (0.95) indicate that Michigan patterns were quite similar to the average US pattern.

Average financial performance measures for Michigan dairy farms were available from 1996 through 2009. Over this period, ROA across farms averaged 6.27%, with a low of -3.8% in 2009 and a high of 11.3% in 2007. Figure 4 compares the Michigan MF, US MF, Michigan ROA, and Michigan margin from 1996 to 2009. The correlation between Michigan MF and Michigan ROA was 0.66. Meanwhile, the correlation between Michigan IOFC and Michigan ROA was 0.84, indicating that IOFC was a better proxy for profitability over this period.

The correlation between the annual Michigan MF and ROA was lower than the correlation with IOFC because in 1997, 2003, and 2005 MF and ROA moved in opposite directions relative to their values from the prior year. Those 3 cases reflected changes in milk prices that did not affect ROA in the concurrent year. In 2007 both series increased but the ROA increased much more relative to its historic level than did MF. The MF was a modest 3.03, whereas the IOFC was an all-time high nominal value of \$14.43/cwt. The implication is that the MF is likely a poor proxy for profitability when large changes from historic ranges of the price series occur.

On an annual basis, it appears that the MF has historically been a workable proxy for dairy farm profitability for much of the past 25 yr. As noted above, the majority of this period (1985–2009) had low and relatively stable feed prices. The period during which the MF did not perform as well as IOFC was in the last couple of years when the feed prices increased dramatically.

CONCLUSIONS

Since 1985, the US MF has averaged 2.82 and the farm milk price has often changed in reaction to the feed prices to maintain this relationship. From 1985 through 1994 the all-milk price averaged \$12.83/cwt, whereas from 1995 through 2009 the all-milk price averaged \$14.47/cwt. Interestingly, although the milk price was much more volatile in the latter period, the milk to feed price ratio had an almost identical average near 2.9 during each period.

A strength of the MF is that it accounts for relative inflation of the 2 price series. A weakness of the MF is that a constant MF can occur even when there is a change in the margin over feed costs or profitability. Milk-to-feed price ratio is a good measure of profit-

ability when the changes are largely driven by 1 price series, as was the case with fairly constant feed prices (on an annual basis) for most years between 1985 and 2006. The recent volatility in feed prices has made the MF less relevant as a relative measure of profitability.

Because the absolute level of margin is not constant across milk and feed price levels, it is likely that IOFC is a better proxy for profitability when we see a major price regime change, as has been the case in the past couple of years. With the feed price volatility increase and no sign of a decline in milk price volatility, IOFC is likely to remain the preferred profitability proxy for the foreseeable future. Thus, although the average US MF may again settle down to an average around 2.9, we might look instead for the US IOFC margin to tend toward the average of about \$10/cwt. Because IOFC is fairly easy to calculate with readily available price data once a feed efficiency value is specified, we suggest that this measure be adopted to replace MF.

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