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Introduction

A number of dairy producers in Utah and probably elsewhere denounced the milk tax last summer as being counterproductive. The claim (usually made by small producers) was that financial obligations of providing for debt service and family living dictated that they must increase production if price fell. Discussions with a number of producers about the Dairy Diversion Program indicates that many who chose not to sign up did so after some analysis. They made the nonparticipation choice because they determined (rightly or wrongly) that their volume of business during the life of the program and thereafter would not provide them with sufficient income. They reasoned that with prices as they are now and with probable decreases after the end of the program that they would not be able to meet financial obligations. They, therefore, have chosen to maintain or expand herd size and production.

Some additional background on Utah dairies may be helpful. An estimated 40 percent[1] of the dairies have the following characteristics:

1. A herringbone milking parlor with four or five stalls on each side,
2. Parlor and milking equipment are less than ten or fifteen years old,
3. Free stall housing and outside feeding are common, although some have built lounging stalls into older open sheds,
4. Herd size is usually between sixty and one hundred cows,

5. Several families (frequently multiple-generation) are often involved in the management and operation. Hired labor dependence is very minimal.
6. Production levels are reasonably good in most situations (DHIA average is 16,700 lbs. milk in the state).
7. Debt level is usually quite high.
8. Milking time is usually not more than two hours per milking. Most of the milking help also works on the farm or has an off-farm job so that milking is somewhat of a "let down" from other activities (no pun intended).
9. Many of these dairies seem to be in a transition state. The intent is to expand, but that has not occurred.
10. Opportunities for expansion of off-farm work is limited.

Conventional explanations of firm behavior support the distinct, historical trend toward fewer but larger dairy farms in Utah and elsewhere. As operators see the opportunity to move from one set of short-run cost curves to another lower set, they have increased herd size as they have found it increasingly profitable or necessary to expand production. Farmers have taken advantage of economics of size by moving toward the minimum point on their long-run cost curve. Visualizing the traditional set of short-run average cost curves with the envelope of a long-run average cost curve and the associated marginal cost curves, it is certainly possible to have different supply responses for short and for long run and depending on whether the dairyman was at the far left or at the minimum point of a U-shaped long-run average cost curve. It is appropriate to suggest that a price decline could force the adjustments that had not been made in response to profit motive.

It becomes evident from any study of the dairy enterprise in Utah that it would be profitable to expand herd size in most situations like those described above. These dairies are not organized for optimal efficiency, primarily because of the limited use of the heavy capital investment in parlor and milking equipment (Atwood 1984). Expansion of other facilities to handle more cows would be relatively inexpensive. It is pertinent to ask why these dairies have not already expanded to efficient size. Reasons for this departure from the norm probably include: (1) internal capital rationing or risk aversion, (2) external capital rationing, (3) leisure preference, and (4) lack of knowledge of the shape of cost curves.

Alternative Explanations of Supply Response

Some situations seem to lead to "irreversibility of supply" in the agricultural sector. Chambers and Vasavada (1983) review several theories that have been proposed. Some deal with fixed input supply, fixed income requirements, and "asset fixity." This was empirically tested by Chambers and Vasavada and found to be nonexistent for materials, capital, and labor. A complete explanation seems to be lacking.

In the situation of a number of dairy farmers in Utah a utility maximization model may apply. Assume that only income and leisure are relevant. Leisure is defined as a lack of management responsibility. Simpson and Kapitany (1983) deal with this kind of model where the farmer can consume goods and services earned by working on or working off the farm. The dairyman is faced with constraints and choices. He has a limited amount of time. Milk cows generate income, so that leisure must be given up for each cow milked. There is a positive level of income that is required for debt service and family living requirements.

In Figure 1, $U^{\emptyset}U^{\emptyset}$, $U^{\emptyset\emptyset}U^{\emptyset\emptyset}$, and U^1U^1 are all possible indicators of utility preference between income and leisure. Before a milk price decline which decreases the budget constraint from $C_{\emptyset}$ to C_1, there is equilibrium at A. $U^{\emptyset}U^{\emptyset}$ indicates tangency to the budget line which implies efficiency. However, $U^{\emptyset\emptyset}U^{\emptyset\emptyset}$ could as well be the case. With a decrease in price, the adjustment is made to increase cows to maintain the income restraint at Y and leisure is reduced from $L_{\emptyset}$ to L_1. Clearly, the dairyman is worse off and may now be on utility curve U^1U^1 at B. Income is maintained.

Plausibility of the Income Maintenance Hypothesis

A linear programming model was constructed to simulate a typical northern Utah dairy farm. The model simultaneously evaluates the financial aspects of rations, cow quality, cropping and land management decisions, facility expansion, and prices. The objective in the model is to maximize the annual returns to owner's labor, management, and capital. The alternative activities for attaining that objective are cropping to produce marketable commodities, cropping to produce livestock feed, milking cows, buying feed, and buying labor. The resource restrictions of the farm are cow facilities capacity, milk parlor capacity, owner's labor, cows of different quality, and cropland of

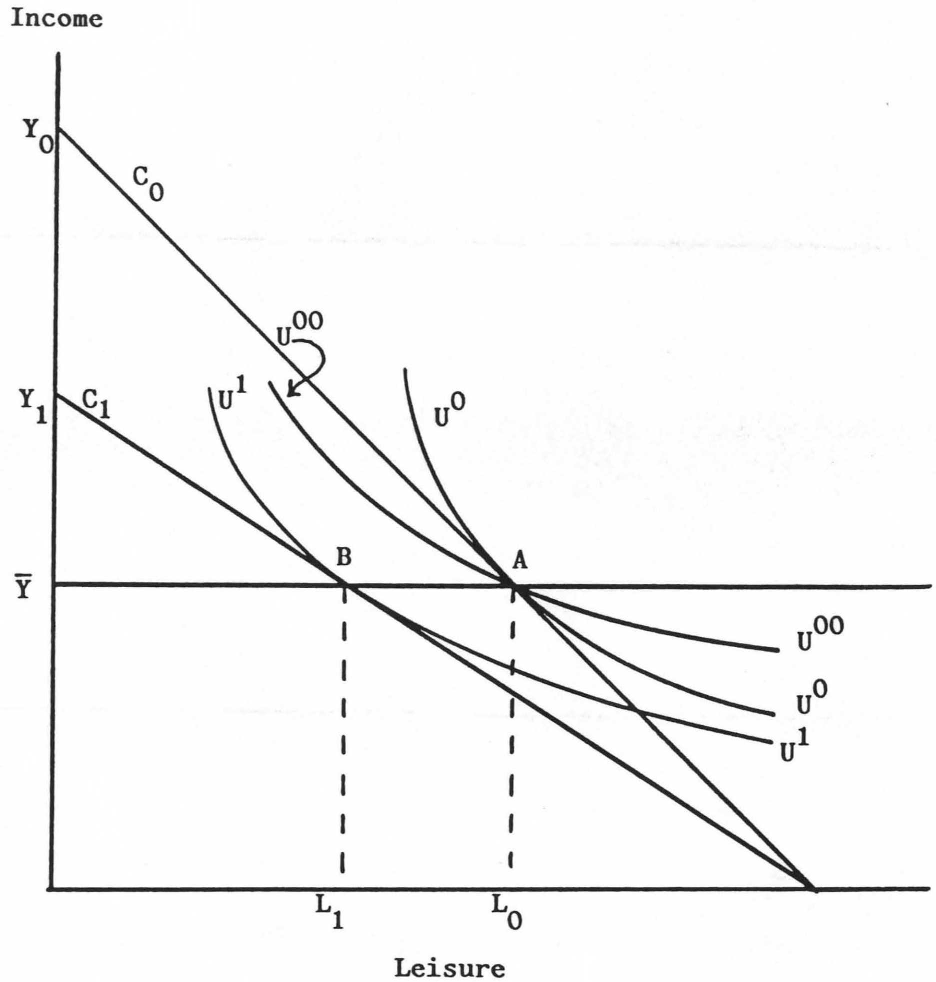

FIGURE 1. A Utility Model of Dairy Production Indicating Response to a Price Decline

different quality. Other constraints are for cow nutrient requirements and crop mix specification.

The farm that was simulated in the model is much like the situation of many farms described earlier. It has a double-five herringbone parlor. At present, 125 cows are in the herd for which buildings and equipment are available. Land in the farm contributed to a somewhat larger than average feed production base.

The solutions to the model indicate some interesting results. As expected, shadow prices for cows and for milking facilities declined as price of milk was lowered from $12.50 per cwt. to $11.50 per cwt. The shadow prices derived in the model are shown in Table 1. In addition to these shadow prices for additional cows, the shadow price for additional units of milking facilities was derived. This amounted to $823.30 for each unit of cow capacity at $12.50 per cwt. milk price and $683.30 for each unit of cow capacity at $11.50 per cwt. milk. These marginal values, which are on an annual basis, can be used to calculate the maximum profitable investment for each type of cow. This was considered for the case where part of the facilities were unutilized, and, so, the facility's cost of adding an additional cow is zero. It also can be done for the case where adding an additional cow requires an additional facility.

Where the farm has unused facilities, the maximum profitable cow investment calculation assumes that there will be no annual facilities cost for the added cow. The calculation is done by adding the marginal value of the facilities to the marginal value of a type of cow. Into

TABLE 1. Shadow Prices for Cows by Cow Production Levels by Milk Price and Shadow Price of Milk Production Facilities for the Model Farm

	Milk Price (per cwt)	
Production Level	$12.50	$11.50
	------$ per cow-------	
14,000 lb.	0.00	0.00
16,000 lb.	172.50	152.50
18,000 lb.	332.50	292.50
20,000 lb.	538.90	479.00
22,000 lb.	752.10	562.10

that result divide the sum of the depreciation rate and interest rate assumed for the cow investment. This was done for each type of cow at milk prices of $12.5Ø and $11.5Ø and interest rates of 8, 12, and 16 percent. The results are presented in Table 2. The assumed depreciation rate was 25 percent for cows. Note that these calculated maximum investment levels are well above the purchase price of cows in every situation studied.

If the dairy farm must build additional facilities to take care of added cows, the maximum profitable cow investment levels still can be calculated. Data or assumptions are needed on capital investment in facilities required per cow, depreciation rates on cows and facilities, and an interest rate. The annual investment cost of the facilities is the interest rate plus the facilities depreciation rate multiplied by the per cow investment in facilities. The analysis ignores appreciation, inflation, and property tax considerations. The cost of investment in the cow is assumed to be a result of the cow depreciation rates and the interest rate. The maximum cow investment levels are calculated by the following steps. First, the interest rate plus the facilities depreciation rate are multiplied by the $1,5ØØ per cow capital cost of the facilities. The results represent the portion of the marginal value of the cow to be used for annual facilities cost. Note that the marginal value of the cow is the change in annual returns to owner's labor, management, and capital associated with a one-head change in the level of that cow type. The annual facilities cost derived above is deducted from the marginal facilities value. The remaining marginal facilities

TABLE 2. Derived Maximum Profitable Cow Investment Levels for Two Milk Prices and Three Interest Rates when Simulated Farm has Unused Facilities

Cow Type	Interest Rate (%)	Milk Price ($/cwt): 12.50	Milk Price ($/cwt): 11.50
14,000 lb.	8	2,485	2,070
	12	2,216	1,846
	16	2,000	1,666
16,000 lb.	8	3,000	2,533
	12	2,676	2,259
	16	2,415	2,039
18,000 lb.	8	3,485	2,957
	12	3,108	2,637
	16	2,805	2,380
20,000 lb.	8	4,121	3,522
	12	3,676	3,141
	16	3,317	2,834
22,000 lb.	8	4,758	3,773
	12	4,283	3,365
	16	3,829	3,037

value is added to the marginal value of the cow. Into that result is divided the interest rate plus cow depreciation rate. The result is the maximum profitable investment per cow. These calculations were made for milk prices of $12.50 and $11.50 and interest rates of 8, 12, and 16 percent. The assumptions made are $1,500 per cow investment in facilities and depreciation rates of 25 and 15 percent for cows and facilities, respectively. The results are presented in Table 3.

Tables 2 and 3 indicate that the decrease in milk price lowers the maximum profitable investment levels per cow by a substantial amount. The absolute amount depends on the interest rate and whether or not facilities are limiting. For a milk price of $11.50, the model solution gives an annual shadow price of $683.30 for facilities. That value would support a per cow investment rate of well over $1,500 given realistic depreciation and interest rates.

Conclusions

For most types of cows and some interest rates, it would be profitable to add cows even if milk price is lower. This is especially true if the facilities are already available for the cows (milking herd at less than facilities capacity). With milking parlor and equipment representing up to two-thirds of facilities cost, it is probable that many dairymen, like those described earlier in this paper, could still expand their dairy enterprise profitably with a decline in milk price since facilities would cost $500 per cow or less. It also is true that it would have been even more prfofitable to have expanded before a milk price decline. For various reasons, they had not reached efficient

TABLE 3. Derived Maximum Profitable Investment Levels for Two Milk Prices and Three Interest Rates when Facilities are Already Fully Utilized on the Simulated Farm

		Milk Price ($/cwt):	
Cow Type	Interest Rate (%)	12.50	11.50
14,000 lb.	8	1,439	1,024
	12	1,122	751
	16	866	532
16,000 lb.	8	1,955	1,486
	12	1,581	1,164
	16	1,280	904
18,000 lb.	8	2,439	1,911
	12	2,014	1,542
	16	1,671	1,245
20,000 lb.	8	3,076	2,476
	12	2,581	2,046
	16	2,183	1,700
22,000 lb.	8	3,712	2,727
	12	3,149	2,270
	16	2,695	1,902

size. An income or cash flow squeeze could cause them to seek more efficiency. A larger operation will be required to maintain absolute amounts of owners' returns. Judging from the considerable noise made about the milk tax and the low response to the diversion program, there must be a number of producers who will be squeezed into a more efficient size for their dairy. They may find it impossible to make sufficient returns, but our analysis suggests a possibility for greater returns than they now have if they add good cows. No suggestion is made that dairy farmers in the aggregate will increase production in response to a price decrease. To do so is to assume, as Secretary Block (1983) says that "we could have a system under which if we needed more milk, we could just lower price." Large dairies (dairies where most labor is hired) and any other situation where overcapacity in part of the facilities does not exist likely would conform to the traditional and expected supply response. But, our analysis suggests that lack of downward flexibility may make the aggregate supply elasticity be very low in response to lower prices.

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