A Profitability Analysis of Dairy Feeding Systems in the Northeast

Jonathan R. Winsten, Robert L. Parsons, and Gregory D. Hanson

This study analyzes the use and profitability of three distinct feeding systems; confinement feeding, traditional grazing, and management-intensive grazing from a randomly selected sample of northeastern dairy farms. The confinement feeding farms were significantly larger and produced more milk per cow, while the farms using management-intensive grazing incurred the lowest production costs. Both confinement feeding and management-intensive grazing generated significantly higher rates of return to farm assets relative to farms using a mixed system. Multiple regression analysis confirms the critical importance of herd size, milk production per cow, debt level and veterinary expenses to farm profitability in all production systems.

The viability of different feeding systems used by dairy farmers; particularly the relative performance of management-intensive grazing in the Northeastern U.S.A., is a topic of increasing interest in the popular and scientific literature. The objectives of this study are two-fold. The first is to provide descriptive characteristics of dairy farms using three distinctive feeding systems. The second is to measure the profitability resulting from the three feeding systems and to determine which variables explain differences in profitability. The analysis is based on data obtained from a stratified random sample of dairy farms from Pennsylvania and Vermont. Pennsylvania is the nation's fourth largest producer of milk with dairy farm income representing slightly more than 50% of the state's agricultural revenues. Vermont is the nation's fourteenth largest milk producer and is the state most heavily dependent on dairy which accounts for 74% of agricultural revenues (USDA National Agricultural Statistics Service).

During the 1950 to 1990 period, the average number of cows on Pennsylvania dairy farms increased from 9 to 50 (Pennsylvania Agricultural Statistics Service); on Vermont dairy farms the average herd size increased from 26 to 69 cows (Vermont Department of Agriculture). Herd size has continued to increase as farmers attempt to decrease costs through economies of scale (Rust et al. 1995). The trend toward larger herds has often been associated with the decline in the importance of pasture as a primary forage source on dairy farms. From 1950 to 1990, pasture use declined on most northeast dairies with Pennsylvania dairy farms experiencing an average decrease from 170 to 64 days of grazing per year (Muller and Holden 1994). The reasons cited for this include increased mechanization of on-farm feeding systems, and the logistical problems associated with moving a large number of cattle to and from pastures (Cassel and Brown 1988). The average dairy herd size reached 57 cows per farm in Pennsylvania and 87 cows per farm in Vermont in 1997. The increasing average herd size may be partly explained by decreasing average profit margins per cwt. of milk produced from 1990–1997 (figure 1).[1] This cost/price squeeze illustrates how rising nominal milk prices, when accompanied by production costs that rise equally as fast, or faster, will not raise dairy farm profits per unit of milk produced. With narrowing profit margins, survival strategies include major dairy expansion, increasing milk per cow, and lowering input costs with alternatives such as management-intensive grazing.

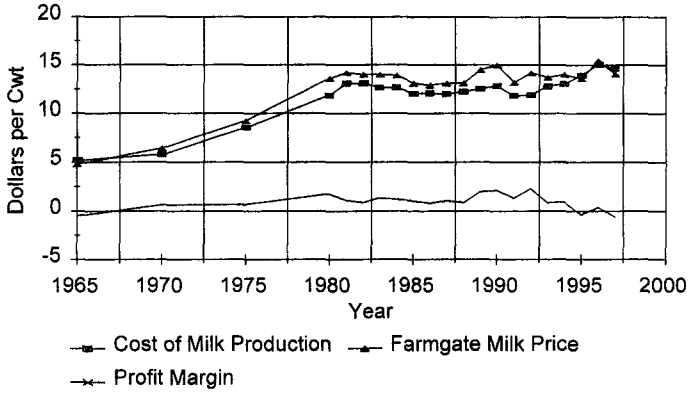
Pasture had long been a key traditional forage

Johathan R. Winsten is a graduate research assistant, Robert L. Parsons is a senior research associate, and Gregory D. Hanson is an associate professor, all with the Department of Agricultural Economics and Rural Sociology at The Pennsylvania State University.

This research was made possible with funding from the United States Department of Agriculture and The John Merck Fund.

[1] Although not shown in the available data, record high milk prices in 1998 did not follow this trend.

Agricultural and Resource Economics Review 29/2 (October 2000) 220–228



Source: Pennsylvania Agricultural Statistics Service
Vermont data not available.

Figure 1. Milk Price, Production Costs and Profit Margin for PA Dairy Farms

for most Northeastern dairy herds (Emmick and Toomer 1991), but pasture was viewed more as a subsistence forage, not as a contributor to higher per cow milk production. Dairy farmers found that milk production per cow could be increased substantially through the use of relatively cheap feed grains. Hence, in a trend that accelerated after the 1950s, the traditionally low nutrient yields from pasture became less important for meeting the feed requirements of high producing herds (Fales et al. 1993).

The cost/price squeeze of the 1990s has led some dairy farmers to closely examine alternative methods to lower costs of forage, with growing attention focused on management-intensive grazing principles first described by French agronomist Andre Voisin (1959). Voisin's intensive grazing principles have become increasingly utilized in the U.S. since the mid-1980s (Fales et al. 1993). Management-intensive grazing is a system where animals graze one section (paddock) of a larger pasture for a short period of time, often 12 or 24 hours, then are rotated through the paddocks allowing previously grazed paddocks to regrow to an optimal level for nutrient yield and quality before regrazing. This approach is also known as rotational, intensive-rotational, or short duration grazing.

Lower milk production costs can be achieved with management-intensive grazing, which results in less forage mechanically harvested, less forage stored, lower supplemental grain feeding, and less labor for feeding and barn cleaning (Hanson et al. 1998a; Jackson-Smith et al. 1997; Winsten and Petrucci 1996; Rust et al. 1995; Elbehri and Ford 1995; Rotz and Rogers 1994; Brown 1990). It has also been suggested that management-intensive grazing lowers somatic cell counts in milk, results in lower veterinary and medicine costs, and improves herd health (Mueller 1996; Muller and Holden 1994; Murphy 1994; Goldberg et al. 1992; Brown 1990).

However, management-intensive grazing requires significant energy use by the grazing animals and makes accurate ration balancing more difficult relative to confinement feeding (Muller and Holden 1994). Because of this, lower average per cow milk production can offset the cost-savings of management-intensive grazing in some cases. Without question, the associated lower milk production has inhibited more wide-spread adoption of management-intensive grazing.

Use of Alternative Feeding Systems in Pennsylvania and Vermont

Information on production system technology and socio-economic characteristics was collected from a mail survey of Pennsylvania and Vermont dairy farmers. Of the 1,837 producers sampled randomly from the population of farms shipping milk in 1996, 1,098 surveys were completed and returned. Analysis of survey results allowed for the categorization of each farm as using one of three feeding systems: confinement feeding, traditional grazing, or management-intensive grazing.

Producers using confinement feeding provided no pasture to their milking herd during 1996. Therefore, all forage provided to the milking herd was mechanically harvested and stored on the farm or purchased (e.g. silage and hay). Traditional grazing provided some pasture for the milking herd, but less than 75% of daily forage requirements, even when adequate pasture forage was

Table 1. Use of Feeding System, Technologies and Farm Characteristics

	Confinement Feeding (n = 427)	Traditional Grazing (n = 580)	Intensive Grazing (n = 58)
Percent of Farms in each Feeding System:			
Vermont (%) (n = 224)	30	58	12
Pennsylvania (%) (n = 874)	42	54	4
Farm Characteristics:			
Crop & Pasture Acres	278[a,b]	209[a,c]	178[b,c]
Milking Herd Size	134[a,b]	62[a]	61[b]
Stocking Density (cows/acre)	0.32[a]	0.26[a,c]	0.33[c]
Technology Use:			
Milking Parlor (%)	34[a,b]	16[a]	17[b]
Total Mixed Ration (%)	55[a,b]	23[a]	25[b]
Dairy Herd Improvement Association (DHIA) (%)	61[a]	46[a]	56
rBST (%)	22[a,b]	12[a]	10[b]
Farm Computer (%)	28[a]	22[a,c]	36[c]
Written Farm Plans (%)	26[b]	24[c]	36[b,c]

Source: Mail survey of Pennsylvania and Vermont dairy farms.
a. Statistically significant difference ($p < 0.05$) between confinement and traditional.
b. Statistically significant difference ($p < 0.05$) between confinement and intensive grazing.
c. Statistically significant difference ($p < 0.05$) between traditional and intensive grazing.

available. The distinction between traditional and management-intensive grazing is based on the percentage of forage provided from pasture and the frequency of pasture rotation. Management-intensive grazing provided at least 75% of daily forage requirements from pasture with a fresh paddock at least every 24 hours when adequate pasture forage was available.

Information in the mail survey indicated that pasture was used in a traditional manner on 50 to 60% of Pennsylvania and Vermont farms (table 1). The data did not show a significant difference between the two states with regard to farms using traditional grazing systems. Approximately 12% of Vermont dairy farms used management-intensive grazing compared to approximately 4% of Pennsylvania dairy farms. This may be due, in part, to the hillier terrain of many Vermont farms which makes cropping more difficult. A larger percentage of Pennsylvania dairy farms used confinement feeding relative to Vermont dairy farms. Comparisons between the two states did not reveal significant differences with regard to crop and pasture acres, herd size, stocking density, cows per worker, milk sold per worker, and milk price received (these results not shown in table 1). Although the distribution of feeding system use differs, the distinction between the two states is not maintained in the remainder of the analysis.

The farms using confinement feeding had, on average, the largest land area and herd size, while farms using management-intensive grazing had the smallest land area. Relative to confinement feeding, traditional grazing and management-intensive grazing farms had significantly smaller herd sizes. Farms using traditional grazing had significantly lower stocking density (cows per acre) than either confinement feeding or management-intensive grazing farms. The literature demonstrates that stocking density is related to nutrient loading and water quality problems (Stout et al. 2000; Fales et al. 1995; Owens et al. 1982). The impact of farming on the environment will be subject to much greater scrutiny in the future, and stocking density will likely play a major role in policy actions to lessen the environmental impacts of livestock production.

Each feeding system can be characterized by the use of certain technologies and management tools (table 1). Results from the mail survey show that farms using confinement feeding more frequently used milking parlors, total mixed rations (TMR) and recombinant bovine somatotropin (rBST) than farms in either of the other groups. Traditional graziers were the least likely to be using any of the technologies included in this analysis, with the exception of rBST. Farms using management-intensive grazing were more likely to use written farm plans/goals and computers than farms in either of the other groups. These results portray distinctive approaches to technology adoption. Farmers using confinement feeding were likely to focus on capital-intensive input innovations for animal productivity, while those using management-intensive grazing tended to focus on information/planning innovations. Farmers using traditional

grazing methods generally lagged the pace of technology adoption.

Analysis of Profitability by Feeding System

Because it would be too costly to gather comprehensive farm financial data from all of the survey respondents, a sub-sample of farms was drawn for this purpose. The 1,098 surveyed farms were grouped by feeding system and herd size and an over-size sample was randomly drawn following stratification procedures recommended by the Pennsylvania Agricultural Statistics Service. Farms were then contacted and asked to participate in the study. Those farms declining participation were then replaced by the next farm on the list until the desired number of farms per state was analyzed. This resulted in a sample consisting of 96 dairy farmers, 72 located in Pennsylvania and 24 in Vermont. Additional production, cost and revenue information was obtained from each of the 96 selected farms through personal interviews conducted at the farm site. Of the 96 sampled farms, 25 were using confinement feeding, 52 were using traditional grazing, and 19 were using management-intensive grazing.

The FINAN module of the FINPACK educational computer software was used to conduct the analysis of 1996 financial performance for each farm. The FINAN module provides year-end analysis of a producer's profitability, liquidity, and solvency position. In addition to whole-farm analysis, FINAN utilizes an allocation procedure to identify revenues, variable expenses, fixed expenses and net income for each crop and livestock enterprise (Center for Farm Financial Management 1993).

During 1996, both Pennsylvania and Vermont experienced cooler and wetter than average growing conditions which are favorable to hay and pasture production. (Pennsylvania Agricultural Statistics Service 1997; New England Agricultural Statistics Service 1997). Milk markets in both states were characterized by higher than average prices. However, high milk prices were accompanied by record high grain prices during the summer months of 1996.

Farms using confinement feeding had an average gross income that was more than twice as large as the farms using traditional grazing or management-intensive grazing (table 2). Since the average herd size of farms using confinement feeding was more than twice as large as the other farms sampled, this result was not unexpected. However, after subtracting cash expenses and accrual adjustments, farms using confinement feeding had an average net farm income that was 80% larger than the farms using traditional grazing and 67% larger than the farms using management-intensive grazing. This suggests that, on average, marginal profit per cow declines as herd size increases.

Milk Production, Farm Income and Expenses

Farms using confinement feeding had the highest milk production, milk sales and gross farm sales per cow while the farms using traditional grazing had the lowest per cow gross farm sales (table 3). Gross farm sales included, in addition to milk, sales of cull cows and calves, feed and other farm products. Higher per cow milk production associated with confinement feeding may have resulted from greater use of the technology innovations discussed above, but may also have resulted from more accurate ration balancing and less energy use by animals fed in confinement.

Statistically significant differences in the average milk price received among the feeding systems, due to possible differences in milk composition or marketing, were not found. Farms using confinement feeding also had the highest level of expense per cow. The farms using management-intensive grazing had the highest average net cash farm income (cash income less cash expense) per cow, $765.

Grain and Veterinary Expenses

Consistent with higher milk production and the absence of pasture-based forage, confinement farms also had the highest grain expense per cow (table 3). However, per unit of output, farms using traditional grazing experienced the highest average grain expense. These results suggest that farms using traditional grazing capture neither the accurate ration balancing associated with confinement feeding nor the higher protein content from pasture forages associated with management-intensive grazing.

Farms using confinement feeding had significantly higher veterinary expenses per cow compared to farms using management-intensive grazing (table 3). This finding is consistent with the view held by many graziers that cows in a management-intensive grazing system are generally healthier than cows fed in confinement (Mueller 1996; Murphy 1994; Brown 1990). However, multiple regression analysis indicated that the only significant determinants of annual farm veterinary expenses are herd size (positive) and use of rBST (positive). The results presented in table 4 show

Table 2. Average Income Statement by Feeding System

	All Herds	Confinement (n = 25)	Traditional (n = 52)	Grazing (n = 19)
CASH FARM INCOME				
Milk Sales	209,819	382,551	147,619	152,773
Dairy Livestock Sales	7,992	13,847	6,168	5,274
Crop Sales	4,020	4,352	4,006	3,625
Government Payments	1,762	3,596	1,222	826
Patronage dividends, cash	1,472	2,602	946	1,427
Other farm income	3,194	4,002	2,864	3,033
Gross Cash Farm Income	$228,259	$410,950	$162,825	$166,958
CASH FARM EXPENSE				
Crop Expenses	13,317	26,185	9,139	7,827
Purchased feed	68,001	122,709	48,587	49,149
Breeding fees	2,588	4,570	1,976	1,657
Veterinary	5,515	11,495	3,543	3,042
DHIA	940	1,286	819	816
Milk Hauling	7,271	11,969	6,077	4,357
Milk Marketing	2,728	4,749	2,276	1,506
Dairy Supplies	5,776	9,977	4,065	4,930
Fuel & oil	4,373	7,922	3,260	2,748
Repairs	13,099	24,231	9,071	9,473
Custom hire	4,896	8,474	2,864	5,829
Hired labor	15,602	40,470	7,354	5,456
Land Rent	5,322	8,068	4,316	4,467
Livestock & Equipment Leases	2,242	6,418	649	1,104
Utilities	5,682	9,741	4,319	4,069
Interest	10,782	20,296	7,082	8,388
Real estate taxes	3,443	5,409	2,852	2,743
Farm insurance	3,680	6,358	2,852	2,424
Dues & professional fees	885	1,536	640	700
Miscellaneous	7,832	12,556	5,931	6,265
Total cash expense	183,974	344,419	127,672	126,950
Net cash farm income	$44,285	$66,531	$35,153	$40,008
Total Inventory Change	6,311	8,388	5,953	4,561
Total deprec. and capital adj.	(1,206)	(1,753)	(1,124)	(709)
Net farm income	$49,390	$73,166	$39,982	$43,860

that culling rate, milk production per cow, use of automatic milking machine take-offs, and the type of feeding system used were not significant determinants of veterinary expenses per farm.

Farm Debt, Machinery Inventory, and Labor Expense

The levels of farm debt per cow or as a percentage of farm assets were not significantly different between the groups in the subsample of 96 producers (table 3); neither was a relationship between farm debt and choice of a feeding system evident from this data set. The lack of difference among average debt levels does not support a previous research finding by Hanson et al. (1998b) that Pennsylvania farmers were more likely to choose a more intensive grazing system when the farm had a higher debt-to-asset ratio.

Conceptually, a pasture-based forage system such as management-intensive grazing can produce milk with less machinery and equipment use than a confinement feeding system. However, these data did not reveal any significant difference in the level of machinery and equipment investment per cow by production system (table 3). The farms using confinement feeding benefitted from increased labor efficiency as measured by cows per worker and milk sold per worker (table 3). This issue becomes an important cost-control factor when the supply of farm labor decreases due to rural labor shortages.

Return to Farm Assets

The rate of return to farm assets is an important indicator of profitability that permits comparison with investments in other agricultural enterprises

Table 3. Average Milk Production, Income, Expenses, Labor Efficiency and Profitability

	Confinement Feeding (n = 25)	Traditional Grazing (n = 52)	Intensive Grazing (n = 19)
Milk Production/Cow (lbs.)	18,239[a,b]	15,229[a]	16,247[b]
Milk Price Received ($)	15.39	15.24	15.47
Milk Sales/Cow ($)	2,804[a,b]	2,321[a,c]	2,508[b,c]
Gross Farm Sales/Cow ($)	3,022[a,b]	2,600[a,c]	2,823[b,c]
Expenses/Cow ($)	2,420[a,b]	2,100[a]	2,058[b]
Net Cash Farm Income/Cow ($)	602	500	765
Accrual Adjustments/Cow ($)	62	117	(16)
Net Farm Income/Cow ($)	664	617	749
Net Farm Income/cwt. milk ($)	3.55	3.86	4.59
Grain Expense/Cow ($)	933[a,b]	820[a]	792[b]
Grain Expense/cwt. milk ($)	5.13	5.44[c]	4.92[c]
Veterinary Expense/Cow ($)	71[b]	60	52[b]
Farm Debt/Cow ($)	1,865	1,817	1,858
Farm Debt/Farm Assets (%)	23	24	20
Machinery and Equip./Cow ($)	1,715	1,392	1,741
Cows/Worker	45.65[a,b]	36.69[a]	35.07[b]
Milk Sales/Worker ($)	840,199[a,b]	564,035[a]	568,626[b]
Return to Farm Assets (%)	7.76[a]	1.01[a,c]	5.83[c]

Source: Primary data from 96 farm financial analyses.
a. Statistically significant difference ($p < 0.05$) between confinement and traditional.
b. Statistically significant difference ($p < 0.05$) between confinement and intensive grazing.
c. Statistically significant difference ($p < 0.05$) between traditional and intensive grazing.

and with the non-farm sector. Rates of return in the farming sector have historically tended to be lower than in nonfarm sectors of the economy. Farms using traditional grazing systems had an average rate of return to assets of 1%, a profitability level that is not competitive with "safe" investments such as savings deposits. This may have been due to having stored forage and labor requirements nearly as large as the confinement feeding farms, but not achieving the same per cow milk production levels. It also may have been due to unobservable management factors such as the ability of the farm manager to utilize an efficient input mix or to make timely production decisions.

Farms using confinement feeding and management-intensive grazing systems attained significantly higher rates of return (table 3). This is possibly related to advantages of production specialization. The average rate of return to assets for confinement feeding farms, 7.76%, is related to higher per cow milk production levels, greater labor efficiency, and fixed costs spread over a larger average herd size. The average return for management-intensive grazing farms, 5.83%, is due to effective cost-control, particularly reduced feed costs.

Explaining Farm Profitability

The results presented above indicate that many distinct differences exist between the feeding system groups. In this section, farm characteristics, management choices, and efficiency indicators useful in explaining the financial performance of a farm are identified with multiple regression analysis. The data used in this analysis are from the 96 farms

Table 4. OLS Coefficients for Explaining Farm Veterinary Expenses

	Coefficient Estimate	p-value
Intercept	−3828.40	0.1451
Milking Herd Size	106.76**	0.0001
Milk per Cow	−0.0862	0.6151
Culling Rate	49.82	0.3040
Use of Auto-takeoffs	−1981.23	0.1560
Use of rBST	4815.60**	0.0006
Confinement Feeding	1062.73	0.4534
Management-intensive Grazing	1098.25	0.4101

Adjusted R-square = 0.7240
*Statistically significant at the $p < 0.05$ level.
**Statistically significant at the $p < 0.01$ level.

Table 5. OLS Coefficients for Explaining Net Farm Income

	Coefficient Estimate	p-value
Intercept	−19532.00	0.6686
Milking Herd Size	292.14**	0.0017
Milk per Cow	4.55*	0.0524
Stocking Density	−308.42	0.8996
Debt per Cow	−10.42*	0.0300
Debt per Cow squared	0.0005	0.3167
Confinement Feeding	2773.68	0.8113
Management-intensive Grazing	5738.81	0.6198
State	12387.00	0.2073
Grain Costs per CWT	−2196.85	0.5438
Forage Costs per CWT	1115.11	0.7476
Vet. Costs per Cow	339.79	0.3628
Vet. Costs per Cow squared	−3.86*	0.0467
Machinery Investment per Cow	−0.7051	0.8730
Milk per Worker	0.0147	0.4575

Adjusted R-square = 0.3995
*Statistically significant at the $p < 0.05$ level.
**Statistically significant at the $p < 0.01$ level.

analyzed with FINAN that were discussed in the previous section. The dependent variable in the regression equation is net farm income (NFI). The coefficient estimates and their p-values are presented in table 5.

The model used in this analysis is constructed with regard to *a priori* expectations based on economic theory in conjunction with previous research results. Numerous studies have shown that larger herd sizes and/or higher milk production per cow are associated with greater profitability (Ford and Shonkwiler 1994; McGilliard 1990; Hadden and Johnson 1989; Zweigbaum 1989; Kauffman and Tauer 1986; Casler 1989). Higher stocking densities are assumed to generate greater net farm income by producing more milk per dollar of fixed investment in land. Since interest payments are an important farm expense, debt level per cow, *ceteris paribus*, should be inversely related to net farm income. This has been shown to be true in several other studies (Ford and Shonkwiler 1994; Hadden and Johnson 1989; Kauffman and Tauer 1986). A squared term is included to check the concavity of debt level per cow with regard to net farm income.

Dummy variables for use of confinement feeding and management-intensive grazing are included. Results from the previous section suggest that both of these systems result in higher profitability relative to traditional grazing. The state in which the farm is located is included to control for market differences between the two states. Grain and forage expenses per cwt. of milk produced are included to measure the importance of feed efficiency on farm profitability. Other studies have shown the importance of reducing forage costs (Hadden and Johnson 1989) and total purchased feed costs (Kauffman and Tauer 1986) per cow; this study uses forage and grain costs per cwt. of milk produced in order to reflect feed efficiency. Veterinary costs per cow are included to measure the importance of herd health; both a linear and a squared term are included in the model assuming that a nonzero optimal level of veterinary expenses per cow exists. Milk produced per worker is a good measure of labor efficiency on each farm and is expected to have a direct relationship to farm profitability, as shown in Ford and Shonkwiler (1994). The assumption that lower machinery and equipment investment level per cow is more profitable, *ceteris paribus*, is also tested; although this was shown to be insignificant on Tennessee dairy farms (Hadden and Johnson 1989).

The estimated model explains 49% of the variation in net farm income, with an adjusted R-square of 0.4, which is in the range of explanatory power seen in other studies. While only 4 of the 14 independent variables have significant coefficients, the model has a highly significant F statistic. Decomposition of the estimated regression variance to form a condition index indicated that potentially degrading multicollinearity was not present in the model (Belsley et al. 1980). The application of White's test for heteroskedasticity did not reject the hypothesis of equal variances.

The variables that were significantly related to farm profitability are herd size (positive), milk production per cow (positive), debt level per cow (negative) and veterinary expenses per cow squared (negative). These results indicate that for each one cow increase in herd size net farm income increased by $292. For each 1,000 lb increase in average per cow milk production net farm income increased by $4,550. The negative and significant coefficient for the level of farm debt per cow in conjunction with the insignificance of its squared term suggests that zero debt per cow was optimal in 1996, after accounting for investment level in the model. The negative and significant coefficient for veterinary expenses squared implies concavity, which does suggest that a nonzero optimal level of veterinary expenses per cow exists.

According to the regression analysis, stocking density, feeding system used, farm location, grain and forage costs per cwt. of milk, machinery and equipment investment per cow and milk produced per worker were not statistically significant. While some of these variables are likely to have an impact on farm profitability, these data do not show the relationship. It is particularly surprising to find

the coefficients for the feed and labor efficiency variables to be insignificant. While the previous section showed the use of confinement feeding or management-intensive grazing to be more profitable than traditional grazing, the results of this regression analysis suggest that producing more milk per cow and having lower debt and veterinary costs were most important for financial success.

Conclusions

The mail survey of Pennsylvania and Vermont dairy farmers shows that farms using confinement feeding have larger herd sizes and land areas, on average, relative to farms using traditional or management-intensive grazing. Farms using confinement feeding were more likely to use technologies that are capital-intensive and/or enhance per cow milk production (e.g. milking parlors, total mixed rations and rBST). Farms using management-intensive grazing were more likely to use technologies related to information and planning (e.g. farm computers and written farm plans/goals). Farms using traditional grazing generally lagged the pace of technology adoption.

The analysis of a unique data set developed in personal interviews of on-going dairy farms in Pennsylvania and Vermont that were selected in a stratified random sample design indicates that farms using confinement feeding experienced a greater than 10% per cow production advantage compared to two grazing-based feeding systems. The confirmation of the confinement system milk production advantage relative to the intensive and traditional grazing systems in a statistically robust sample is an important finding for farm investment planning processes. However, farms using confinement feeding also incurred the highest level of operating expenses. The farms using traditional grazing generally did not perform as well as management-intensive graziers or confinement feeding producers. Management-intensive grazing had the lowest expenses with significant savings on feed costs. In particular, the net farm income per cow, per cwt., and the rate of return to assets suggest that management-intensive grazing was an economically viable option in 1996 for dairy production in the Northeast.

Using multiple regression analysis these data confirmed the results of previous research showing herd size and per cow production as very important determinants of farm profitability. However, this analysis also showed the importance of finding the optimal level of veterinary expenses and the importance of minimizing debt levels per cow, at least for 1996.

The results from this study also confirm that specialization is profitable for northeastern dairy farms. Specialization, in this case, refers to output maximization which is associated with confinement feeding, or to cost minimization which is associated with management-intensive grazing. Management factors play an important role in farm financial success and the broad range of expertise required to manage a dairy farm may influence producers to specialize their production system. Management ability is very difficult to observe empirically and may be the most important factor which differentiates successful from economically struggling dairy farms (Ford and Shonkwiler 1994).

The analysis implies that at the expense of traditional grazing systems, trends toward specialization will continue in the Northeastern dairy industry. That is, traditional producers may become increasingly less competitive in the future, unless or until they move toward a more specialized type of feeding system. The number of farmers that pursue confinement feeding strategies versus those that pursue management-intensive grazing will depend greatly upon their individual preferences toward cropping, scale of the farming operation, available information about each production system technology, availability of financing, future beliefs about the costs and returns and structure of the dairy industry, and the herd size needed to generate enough cash to meet family living expenses. Finally, the role that personal preferences play in managing the technological components of confinement feeding versus intensive grazing systems is an important factor in the future of dairy investment in the Northeast and merits further study.

References

Belsley, D.A., E. Kuh, and R.E. Welsch. 1980. *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity.* Wiley Series in Probability and Mathematical Statistics. New York: John Wiley and Sons, Inc.

Brown, R.J. 1990. "Farmer Experiences with Intensive Grazing." *Dairy Feeding Systems Symposium.* Ithaca, NY: Northeast Agricultural Engineering Service. Page 228.

Casler, G.L. 1989. "Managerial Factors That Affect New York Dairy Farm Profitability." *Cornell Agricultural Economics Staff Paper* (89–12). April.

Cassel, E.K., and R.J. Brown. 1988. "Pasture as a Component of a Forage System for Dairy Cattle." *Pasture in the Northeast Region of the United States.* Ithaca, NY: Northeast Agricultural Engineering Service. Page 21.

Center for Farm Financial Management. 1993. FINPACK. University of Minnesota, St. Paul, MN.

Elbehri, A., and S.A. Ford. 1995. "Economic Analysis of Major Dairy Forage Systems in Pennsylvania: The Role of Intensive Grazing." *Journal of Production Agriculture* 8: 501–507.

Emmick, D.L., and L.F. Toomer. 1991. "The Economic Impact of Intensive Grazing Management on 15 Dairy Farms in New York." *American Forage and Grasslands Conference.* American Forage and Grasslands Council. Page 19.

Fales, S.L., S.A. McMurry, and W.T. McSweeny. 1993. "The Role of Pasture in Northeastern Dairy Farming: Historical Perspective, Trends, and Research Imperatives for the Future." In *Agricultural Research in the Northeastern United States: Critical Review and Future Perspectives*, J.T. Sims, ed. 111–132. Madison, WI: ASA.

_____, L.D. Muller, S.A. Ford, M. O'Sullivan, R.J. Hoover, L.A. Holden, L.E. Lanyon, and D.R. Buckmaster. 1995. "Stocking Rate Affects Production and Profitability in a Rotationally Grazed Pasture System." *Journal of Production Agriculture* 8(1):88–96.

Ford, S.A., and J. Shonkwiler. 1994. "The Effect of Managerial Ability on Farm Financial Success." *Agricultural and Resource Economic Rev.* 23(2):150–157.

Goldberg, J.J., E.E. Wildman, J.W. Parker, J.R. Kunkel, D.B. Howard, and B.M. Murphy. 1992. "The Influence of Intensively Managed Rotational Grazing, Traditional Continuous Grazing, and Confinement Housing on Bulk Tank Milk Quality and Udder Health." *Journal of Dairy Science* 75:96.

Haden, K.L., and L.A. Johnson. 1989. "Factors Which Contribute to the Financial Performance of Selected Tennessee Dairies." *Southern Journal of Agricultural Economics* July:105–112.

Hanson, G.D., L. Cunningham, M. Morehart, and R.L. Parsons, 1998a. "Profitability of Moderate Intensive Grazing of Dairy Cows in the Northeast." *Journal of Dairy Science* 81:821–829.

_____, L. Cunningham, S.A. Ford, L.D. Muller, and R.L. Parsons. 1998b. "Increasing Intensity of Pasture Use With Dairy Cattle: An Economic Analysis." *Journal of Production Agriculture* 11:175–179.

Jackson-Smith, D., B. Barnham, M. Nevius, and R. Klemme. 1997. *Grazing in Dairyland: The Use and Performance of Management-Intensive Rotational Grazing Among Wisconsin Dairy Farms,* Agr. Tech. and Farm Family Inst., Madison, WI.

Kauffman, J.B. III, and L.W. Tauer. 1986. "Successful Dairy Farm Management Strategies Identified by Stochastic Dominance Analyses of Farm Records. *Northeast Journal of Agricultural and Resource Economics* 15(2):168–177.

McGilliard, M.L., V.J. Conklin, R.E. James, D.M. Kohl, and G.A. Benson. 1990. "Variation in Herd Financial and Production Variables Over Time." *Journal of Dairy Science* 73:1525–1532.

Mueller, R. 1996. "Grazers Whip Confines." *Pasture Talk* 2(1):1.

Muller, L.D., and L.A. Holden. 1994. "Intensive Rotational Grazing." *Large Animal Veterinarian* 27–29.

Murphy, B.M. 1994. *Greener Pastures on Your Side of the Fence,* 3d ed. Colchester, Vermont: Arriba Publishing.

Owens, L.B., R.W. Van Keuren, and W.M. Edwards. 1982. "Environmental Effects of a Medium-Fertility 12 Month Pasture Program: I. Hydrology and Soil Loss." *Journal of Environmental Quality* 11(2):236–240.

New England Agricultural Statistics Service. "New England Agricultural Statistics, Annual Bulletin 1997" National Agricultural Statistics Service, USDA.

Pennsylvania Agricultural Statistics Service. 1960–1998. *Statistical Summary and Annual Report.* PA Dept. of Agriculture, Harrisburg, PA.

Rotz, C.A., and J.R. Rodgers. 1994. "Grazing Is Profitable Option for This Pennsylvania Farm." *Hoard's Dairyman* 139(16):643.

Rust, J.W., C.C. Sheaffer, V.R. Eidman, R.D. Moon, and R.D. Mathison. 1995. "Intensive Rotational Grazing for Dairy Cattle Feeding." *American Journal of Alternative Agricultural* 10:147–151.

Stout, W.L., S.L. Fales, L.D. Muller, R.R. Schnabel, G.F. Elwinger, and S.A. Weaver. In press. 2000. "Assessing the Effect of Management-intensive Grazing on Water Quality in the Northeast U.S." *Journal of Soil and Water Conservation* 55(2).

USDA. National Agricultural Statistics Service. 1998. Milk Cows and Production: Final Estimates 1993–1997. Statistical Bulletin Number 952. Washington, DC.

Vermont Department of Agriculture, Dairy Division. Montpelier, Vermont.

Voisin, Andre. 1959. Grass Productivity. Philosophical Library, Inc. New York.

Winsten, J.R., and B.T. Petrucci. 1996. *The Vermont Dairy Profitability Project.* Center for Agriculture in the Environment. DeKalb, IL. Electronic publication. http://farm.fic.niu.edu/cae/caepubs/dairy/vt.dairy.html.

Zweigbaum, W.H., M.L. McGilliard, R.E. James, and D.M. Kohl. 1989. "Relationship of Management and Financial Measures Among Dairy Herds in Virginia." *Journal of Dairy Science* 72:1612–1619.