Competitiveness of management-intensive grazing dairies in the mid-Atlantic region from 1995 to 2009

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ABSTRACT

This paper used farm income tax returns (Schedule F) data from 62 dairy farmers who milked 200 cows or fewer in western and central Maryland and southwestern Pennsylvania (hereafter, the mid-Atlantic region) to assess the relative financial performance of management-intensive grazing (MIG) and confinement dairy operations over the 15-yr period from 1995 through 2009. Data were not available from all farmers in all years; on average, the sample analyzed contained 11 MIG farms and 26 confinement farms. Management-intensive grazing operators were more profitable on a per hundredweight, per cow, and per acre basis, and no less profitable on a whole-farm basis. Even though the confinement operators had higher gross income than MIG operators, their expenses exceeded those of MIG operators. Profits of MIG operations were less variable as well, so that MIG operators faced less income risk. Increased reliance on grazing has other benefits as well. Grazing seems to be a much healthier practice for dairy cows. Veterinary, breeding, and medicine costs per cow are much less for cows that are pastured than those raised in confinement systems. Because they are healthier, cows that are grazed can be milked longer (or culled less frequently). As a result, MIG operators have a larger number of higher quality animals for sale (e.g., bred heifers). Management-intensive operations are also less labor intensive. Reductions in crop production and in the time cows spend in the barn led to significant reductions in field work and cleaning operations in the barn. Costs of hired labor were thus substantially lower in MIG operations than in confinement operations. Land requirements likely impose the principal limitation on the size of intensive grazing operations. In the mid-Atlantic, for instance, grazing operations need 1.5 to 2.0 acres of pasture for every dairy cow/calf equivalent to provide sufficient grass to support a dairy operation. Pasture land for MIG operators must be contiguous to the milking parlor and located no

farther than a cow can walk to and from twice a day. That requirement likely limits the maximum size of an intensive grazing operation, especially in areas where land prices and rents are high, as they are in much of the mid-Atlantic.

Key words: management-intensive grazing, profitability, risk analysis, mid-Atlantic region

INTRODUCTION

The US dairy industry has been changing rapidly, consolidating into fewer, larger operations. Between 2000 and 2006, for instance, the number of dairy operations in the United States fell by 26%. That entire decline occurred in operations with <500 cows; the number of operations with 1,000 to 1,999 cows increased by about 25%, whereas the number of operations with ≥2,000 cows doubled. Data from the US Department of Agriculture Agricultural Resource Management Survey indicate that large farms exhibit significant economies of scale: larger herds make it possible to spread fixed costs of housing facilities, milking equipment, and machinery over a larger volume of output, thus lowering average production costs (MacDonald et al., 2007). Demand for milk has not risen as rapidly as productivity, leading to downward pressure on prices. As a result, smaller dairies that have been a mainstay of traditional rural landscapes in many parts of the United States have found it difficult to compete (Mosheim and Lovell, 2009; Nehring et al., 2009; Winsten et al., 2010).

Those competitive pressures have led some dairy operators to experiment with land-intensive production systems as an alternative to traditional capital-intensive production systems. Studies using data from short-term experiments and single-year farm records indicate that management-intensive grazing (MIG) systems can be more profitable than confinement systems because lower operating costs more than offset the lesser milk production. Controlled experiments (White et al., 2002; Fontaneli et al., 2005) and budgeting studies (Hanson et al., 1998; Dartt et al., 1999; Gloy et al., 2002; Tozer et al., 2003; Kriegl, 2005; Taylor and Foltz, 2006) have shown MIG operations to be at least as profitable as traditional confinement operations—in

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total net farm income as well as per cow net income. Multivariate regression analyses have reached similar conclusions (Gloy et al., 2002; Gillespie et al., 2009).

Intensive grazing operations may also have a competitive advantage in managing risk. Milk prices have become more variable over the past 2 decades, subjecting dairy operators to greater risk. Lower operating and capital costs tend to make MIG operations less vulnerable to price fluctuations (Winsten et al., 2000) as well as offering lower barriers to entry for young farmers (Taylor and Foltz, 2006). Greater reliance on grazing has been shown to improve animal health in several respects as well (see Winsten et al., 2010 for a brief survey). And MIG operations are thought to have superior environmental performance in terms of reduced sediment erosion (Digiacomio et al., 2001), lower phosphorus runoff (Winsten and Stokes, 2004; Bishop et al., 2005), increased carbon sequestration (Guo and Gifford, 2002), and provision of wildlife habitat (Renfrew and Ribic, 2001).

This paper used farm income tax returns (Schedule F) data from 62 dairy farmers in western and central Maryland and southwestern Pennsylvania (hereafter, the mid-Atlantic region) to assess the relative financial performance of MIG and conventional dairy operations over the 15-yr period from 1995 through 2009. We compared income and expenses on a per farm, per hundredweight of milk, and per cow basis to assess performance in terms of household income and productivity. We also compared income and expenses on a per acre basis to assess the potential effects of land constraints. The data allow the use of methods that control for year-to-year fluctuations in weather, prices, and similar factors, enabling more robust comparisons of financial performance than is possible with single-year data. Additionally, data spanning multiple years allow comparisons of the riskiness of income on a per farm basis to assess the vulnerability of household income to fluctuations in milk prices and input costs. Those multiple comparisons allow evaluation of the economic viability of MIG systems compared with similarly sized confinement dairy systems.

MATERIALS AND METHODS

Data

The data in this study come from the Maryland Dairy Farm Business Summary, a program of the University of Maryland Extension (Western Maryland Research and Education Center, Keedysville) that helps farmers analyze their operational strengths and weaknesses. Since 1995, the program has collected data on income, expense, and profit from 1040 Schedule F forms from

62 participating farmers. Not all 62 farms participated each year. Pooling all farm-level observations across the years 1995 to 2009, the data set contained 556 observations in total. All dollar-denominated variables were adjusted for inflation with the Consumer Price Index for the Northeast region.

Although the sample used in this study was self-selected, consisting of farmers who voluntarily sought assistance from University of Maryland Extension, it was largely representative of dairy operations in the state. Comparisons with data from the Census of Agriculture (Table 1) for the years overlapping with the sample used here (1997, 2002, 2007) indicated no difference between operations in the sample used in this study and the state population of dairy operations in terms of the distribution of herd sizes in 1997 and 2002 or in terms of the distributions of net profit or of revenues from sales of milk, cattle, and crops in 2002. The sample used here did differ from the state population in having fewer operations with <50 cows in 2007, fewer operations with sales <\$100,000 in 1997 and 2007, fewer money-losing operations in 2007, and no operations with >500 acres in 1997, 2002, and 2007.

Two different types of dairy farms were analyzed: conventional confinement operations and MIG operations. Management-intensive grazing operations are characterized by a short period of intensive grazing by many animals on a small paddock and then a rotation to another paddock, usually after each milking or daily. Animals do not return to the first paddock until the grass has fully recovered, usually in 3 to 6 wk, depending on time of the season, weather conditions, and rotational system. As a result of a greater reliance on pasture as feed, MIG operators typically grow less field crops than traditional confinement operators. In this study, MIG operations were defined as farms whose herd rations included at least 30% DM from pasture for a minimum of 4 mo, a criterion that is also used for certifying milk as organic. Management-intensive grazing operators in the study ranged from 4 to 8 mo of pasture production, with the average of 6.7 mo. The number of months that a MIG operator can utilize pasture will, of course, vary by geography and climate. All farmers in this study were located within a 125-mile radius of each other in western and central Maryland and southern Pennsylvania.

Of the 62 farmers in the sample, 43 used conventional production systems throughout the entire sample period and 14 used MIG systems throughout the entire sample period. The remaining 5 switched from conventional to MIG systems during the sample period. The average length of participation was 8 yr.

All of the farms included in this study were on the smaller end of the dairy herd size spectrum. Within that

Table 1. Comparison of sample with all Maryland dairy farms

Year	Source	No. of farms by herd size (no. of cows)					Total	Pearson χ^2
		1 to 49	50 to 99	100 to 199	200 to 499	500+		
1997	Census	220	400	211	43	6	880	8.63
	Sample	3	21	12	0	0	36	
2002	Census	179	268	197	42	8	694	6.60
	Sample	4	18	16	3	0	41	
2007	Census	180	198	131	47	7	563	18.45***
	Sample	2	16	18	3	0	39	
		No. of farms by net profit (\$1,000)					Total	
		<-50	-50 to -10	-10 to 10	10 to 50	>50		
2002	Census	48	34	78	151	321	632	8.03
	Sample	0	3	5	16	17	41	
2007	Census	27	39	57	111	331	565	9.80**
	Sample	1	1	2	15	20	39	
		No. of farms by sales of milk, cattle and crops (\$1,000)					Total	
		<50	50 to 100	100 to 250	250 to 500	>500		
1997	Census	64	160	449	156	60	889	32.95***
	Sample	0	2	14	19	1	36	
2002	Census	49	128	251	188	82	698	7.84
	Sample	0	3	20	12	6	41	
2007	Census	37	61	196	158	113	565	10.81**
	Sample	0	1	11	13	14	39	
		No. of farms by acreage					Total	
		1 to 69	70 to 139	140 to 219	220 to 499	500+		
1997	Census	34	107	224	379	145	889	33.22***
	Sample	1	8	17	2	0	28	
2002	Census	34	94	143	292	135	698	36.80***
	Sample	2	9	18	4	0	33	
2007	Census	35	96	140	190	104	565	26.49***
	Sample	2	14	14	4	0	34	

, * indicate statistically significant differences between Census and Sample at the 5% and 1% levels, respectively.

range, however, confinement operators had larger dairy operations than MIG operators, with herd sizes 20% larger on average and milk production 58% greater on average (Table 2). Confinement operators also had more land than MIG operators; not surprisingly, MIG operators had more pasture acreage and less crop acreage than conventional operators, both in total and on a per cow basis. Confinement operators produced more milk and thus generated more revenue than MIG operators. But confinement operators also incurred greater expenses.

Methods

Systematic differences in returns and expenditures between confinement and MIG dairy systems were analyzed using ANOVA with fixed effects for confinement versus MIG operation and year, with the latter used to control for systematic differences across years due to weather, market conditions, and technological trends during the survey period. Separate models were estimated for milk production, profit, each category of

sales, and each category of expenditures. Each model contained fixed effects for type of operation (confinement versus MIG) and year. Formally, the model estimated for response variable Y on farm k in year t was $Y_{kt} = a + bI_{kt} + c_t + e_{kt}$, where I_{kt} is a fixed effect for type of operation, c_t a fixed effect for year, and e_{kt} a random error. An alternative specification using year-specific random effects yielded results virtually identical to those reported here. This procedure adjusted for year-to-year variations due to weather, short-run price fluctuations, and similar factors.

The productivity of MIG and confinement operations was compared per hundredweight of milk, per cow, and per acre of land. Evaluating costs and returns per unit of output is the most common method of assessing productivity. It allows an evaluation of competitiveness, because costs and profit margins can be compared with price. Putting costs and returns on a per cow basis adjusts for scale of operation according to herd size. Land may be a limiting factor in operational scale as well, especially in MIG operations whose size may be

Table 2. Descriptive statistics for dairy farmers using management-intensive grazing versus confinement, 1995 to 2009¹

Variable	Mean	SD	Minimum	Maximum
Management-intensive grazing				
Average number of cows/year	86	29	37	195
Farm acreage	283	134	115	700
Pasture acreage	152	60	53	280
Crop acreage	132	108	0	600
Pasture acres/cow	1.8	—	—	—
Crops acres/cow	1.6	—	—	—
Annual milk production (cwt)	12,320	5,605	2,670	42,955
Gross income (\$)	268,565	111,946	71,658	871,990
Total expenses (\$)	213,664	98,532	58,557	718,055
Profit (\$)	54,901	42,443	-81,653	187,917
Number of farmers/study	19	—	—	—
Average years in study/farmer	8.6	4.9	1	15
Average farmers in study/year	10.9	3.1	4	15
Confinement				
Average number of cows/year	103	43	22	200
Farm acreage	318	145	90	845
Pasture acreage	52	39	0	141
Crop acreage	266	133	60	704
Pasture acres/cow	0.5	—	—	—
Crop acres/cow	2.7	—	—	—
Annual milk production (cwt)	19,523	8,692	3,761	41,527
Gross income (\$)	411,630	194,058	87,364	1,013,933
Total expenses (\$)	363,493	178,227	66,951	910,419
Profit (\$)	48,137	56,003	-196,096	315,236
Number of farmers/study	48	—	—	—
Average years in study/farmer	8.3	4.6	2	15
Average farmers in study/year	26.1	4.2	17	32

¹Table 2 reports simple sample averages with no adjustment for year-to-year variations in overall averages.

constrained by the need to walk cows from pasture to the milking parlor. Assessing productivity on a per acre basis adjusts for scale of operation in this dimension. Output was measured in terms of both milk production (measured in hundredweight) alone and in terms of revenue; the latter includes sales of crops and cattle as well as adjusting milk production for quality, as indicated by price. Income from conventional and MIG operations was then compared on a whole-farm basis to assess how well these 2 production systems performed in generating household farm income.

The relative riskiness of returns under confinement and MIG systems was compared by estimating the standard deviations of profit over the sample period for each conventional and MIG operation. Separate ANOVA models for the means and standard deviations of profit in conventional and MIG operations were estimated using farm-specific fixed effects, which were used to adjust for the influence of operator managerial ability, land quality, asset composition, and other unobservable factors that remain constant over time. These estimated means and standard deviations were used to compute 75% lower confidence limits of profit as a measure of risk-adjusted income (e.g., Musser et al., 1981). Any difference in these lower bounds reflects a systematic difference in income risk that is directly attributable to the nature of MIG and conventional

dairy systems. The profit level attained at least 75% of the time by each system was calculated as $L_i = E_i - K S_i$, where E_i is average annual profit under production system i , S_i is the standard deviation of profit under production system i , and $K = 0.577$ is calculated using a one-sided Chebyshev inequality.

As stated, the main analysis focused on 62 farms with ≤ 200 cows. However, a full sample of all farms that participated in the Maryland Dairy Farm Business Summary would include an additional confinement dairy with an average herd size of 401 cows. Additionally, 2 of the 62 farms included in the main analysis had more than 200 cows in some years and were thus excluded from the analysis in those years. The main analysis also included 4 MIG operations that became certified organic producers and thus received a price premium for their milk during several years. To check the robustness of main results, all models were re-estimated for the full sample and for the full sample excluding MIG operators in years in which they sold organic milk.

RESULTS AND DISCUSSION

Productivity Comparisons

Per Hundredweight. Confinement farmers produced more milk on an annual basis than MIG op-

Table 3. Average annual values (per cwt of milk) between 2 types of dairy farms, management-intensive grazing (MIG) versus confinement, based on Form 1040 Schedule F, 1995 to 2009¹

Form 1040 (Schedule F) item	Farms with ≤ 200 cows		
	MIG	Confinement	Difference
Milk sales (\$/cwt)	19.47	18.43	-1.04***
Crop sales (\$/cwt)	0.09	0.28	0.20***
Cattle sales (\$/cwt)	1.85	1.10	-0.75***
Income, other (\$/cwt)	1.14	1.21	0.07
Gross income (\$/cwt)	22.55	21.03	-1.52***
Car and truck (\$/cwt)	0.06	0.04	-0.02
Chemical expenses (\$/cwt)	0.13	0.49	0.36***
Conservation expenses (\$/cwt)	0.03	0.02	-0.01
Custom hire (\$/cwt)	0.42	0.60	0.17***
Depreciation (\$/cwt)	2.45	1.88	-0.57***
Purchased feed expenses (\$/cwt)	5.78	5.62	-0.16
Fertilizer expenses (\$/cwt)	0.48	0.67	0.18***
Freight and trucking (\$/cwt)	0.58	0.72	0.14***
Fuel (\$/cwt)	0.49	0.47	-0.02
Insurance, other than health (\$/cwt)	0.24	0.29	0.05*
Interest (\$/cwt)	0.89	0.72	-0.16**
Labor (\$/cwt)	0.50	1.03	0.53***
Rent or lease (\$/cwt)	1.18	0.93	-0.25***
Repairs and maintenance (\$/cwt)	1.22	1.45	0.23***
Seeds and plants (\$/cwt)	0.46	0.43	-0.03
Supplies (\$/cwt)	1.11	0.85	-0.26***
Taxes (\$/cwt)	0.17	0.15	-0.02
Utilities (\$/cwt)	0.57	0.48	-0.09***
Veterinary, breeding, and medicine (\$/cwt)	0.53	0.94	0.41***
Other expenses (\$/cwt)	0.49	0.74	0.26***
Total expenses (\$/cwt)	17.80	18.58	0.78**
Net profit (\$/cwt)	4.75	2.45	-2.30***
Net profit (metric; \$/kg)	0.105	0.054	-0.051***

¹Income and expense numbers are expressed in consumer price index (CPI)-adjusted dollars.

*, **, ***Significant difference between MIG and confinement dairies at the 10, 5, and 1% levels, respectively.

erators. But MIG operators earned more profit per hundredweight of milk produced (Table 3). This higher profitability of MIG operators, when compared with confinement operators, stemmed primarily from lower expenses and secondarily from higher sales of cattle. Management-intensive grazing operators also received a higher price for milk.

Notable revenue and expense differences were as follows. Intensive grazing operators earned more from sales of cattle per hundredweight of milk produced. Higher cattle sales more than compensated for lower crop sales, so that MIG operators averaged higher total revenue per hundredweight of milk produced (an average price difference partially attributable to sales of organic milk, as discussed below). At the same time, MIG operators incurred lower expenses per hundredweight of milk produced than confinement operators, most notably in terms of veterinary and labor costs. The MIG operators in the sample also incurred greater depreciation costs, possibly because of the smaller denominator of milk output or because capital assets, unlike variable cost components, could not be flexibly adjusted for smaller scale operations under MIG when farmers switched from previous confinement operations.

Greater revenues and lower expenses per hundredweight of milk produced add up to higher net profits per hundredweight of milk: MIG operators earned 94% more per hundredweight of milk than confinement operators (\$4.75/cwt vs. \$2.45/cwt). This difference in profitability was similar to that found by Gillespie et al. (2009), whose analysis of a national sample of dairy operations found that pasture-based systems averaged profit per hundredweight of milk about 29% greater than confinement systems.

Per Cow. Herd size is the standard measure of scale in dairy operations. Operations at a disadvantage in terms of cost and profit per hundredweight of milk produced may be able to compensate by expanding their scale of operation; that is, by increasing herd size. As noted above, confinement operations in our sample were larger on average than MIG operations. That greater scale of operation might make up for lower revenues, higher costs, and lower profits per hundredweight of milk produced.

Confinement operations exhibited substantially greater milk productivity than MIG operations on this basis: milk production was 31% higher on confinement operations than MIG operations (Table 4). Confinement

Table 4. Average annual values (per cow) between 2 types of dairy farms, management-intensive grazing (MIG) versus confinement, based on Form 1040 Schedule F, 1995 to 2009¹

Form 1040 (Schedule F) item	Farms with ≤ 200 cows		
	MIG	Confinement	Difference
Milk production (cwt/cow)	144	188	43***
Milk sales (\$/cow)	2,752	3,443	691***
Crop sales (\$/cow)	12	49	38***
Cattle sales (\$/cow)	240	206	-34**
Income, other (\$/cow)	143	221	78***
Gross income (\$/cow)	3,147	3,920	774***
Car and truck (\$/cow)	7	8	1
Chemical expenses (\$/cow)	22	96	73***
Conservation expenses (\$/cow)	2	3	1
Custom hire (\$/cow)	60	115	55***
Depreciation (\$/cow)	362	347	-15
Purchased feed expenses (\$/cow)	809	1,045	236***
Fertilizer expenses (\$/cow)	69	120	51***
Freight and trucking (\$/cow)	82	136	54***
Fuel (\$/cow)	67	86	19***
Insurance, other than health (\$/cow)	31	54	23***
Interest (\$/cow)	120	132	11
Labor (\$/cow)	66	193	127***
Rent or lease (\$/cow)	168	174	6
Repairs and maintenance (\$/cow)	175	270	95***
Seed (\$/cow)	67	79	12*
Supplies (\$/cow)	161	156	-5
Taxes (\$/cow)	22	28	5*
Utilities (\$/cow)	78	87	10***
Veterinary, breeding, and medicine (\$/cow)	81	179	98***
Other expenses (\$/cow)	60	139	78***
Total expenses (\$/cow)	2,511	3,456	946***
Net profit (\$/cow)	636	464	-172***
Milk production (metric; kg/cow)	6,532	8,528	1,996***

¹Income and expense numbers are expressed in consumer price index (CPI)-adjusted dollars.

*, **, ***Significant difference between MIG and confinement dairies at the 10, 5, and 1% levels, respectively.

operators also sold more milk per cow than MIG operators; as a result, gross income per cow was 25% higher for the confinement operators than for MIG operators. Management-intensive grazing operators, however, had higher cattle sales per cow than confinement operators. Cows that are grazed have a longer productive life and the annual culling percentage for the herd is lower (Hanson et al., 1998). As a result, MIG operators sell more higher-value bred heifers and young stock, in contrast to confinement farmers who sell more lower-value culled milk cows (White et al., 2002).

Higher output per cow in confinement operations came at a cost: total expenses per cow were higher for confinement operators. One obvious source of greater expense was purchased feed. More notable, however, were greater average costs of labor and veterinary, breeding, and medical expenses. Together with purchased feed, these 3 categories accounted for almost half the difference in total expenses between these 2 production systems.

Nearly all the confinement operations in this study used Holstein cows. Holsteins are a heavier breed than the Jerseys and cross breeds used by MIG operators.

Holsteins produce more milk and thus require more feed. Additionally, confined cows consume feed with a lower moisture content than grazed cows feeding on high-moisture pasture; thus, confined cows consume more feed (and are accordingly able to produce more milk).

Hired labor expenses per cow in confinement operations were roughly 3 times those in MIG operations (\$193/cow vs. \$66/cow). Dairy farmers, in general, have high labor requirements because of the need to milk twice a day as well as complete field work. One advantage of grazing is that farmers can reduce their field work. Management-intensive grazing operations also require less labor for barn cleaning, manure hauling, and feeding because the animals spend less time in the barn and more time feeding themselves. White et al. (2001) found that 85% of defecations and urinations occur in the pasture for the grazing herd, greatly reducing the amount of manure to be handled in the confinement system barn. This reduced labor requirement allows MIG operators to rely relatively more on unpaid family labor and less on paid hired labor than the confinement operations.

Veterinary, breeding, and medicine costs per cow in MIG operations were less than half those in confinement operators (\$81/cow vs. \$179/cow). A strong argument can be made that grazing is healthier for a cow than being confined. For example, Washburn et al. (2002) found that pastured dairy cows had lower incidence of mastitis than those dairy cows in the confinement system, and the confinement herd had more cows culled because of mastitis problems than the grazing herd.

Although confinement farmers had higher gross income per cow, they also had higher total expenses per cow. As a result, the confinement farmers had less profit per cow than MIG operators. These differences were larger than those found by Gillespie et al. (2009), who did not find differences in net profits.

Per Acre. Some farmers are able to grow their farm business and increase profits by acquiring more land. For other farmers, land is often the most limiting resource. Increasing farm size through land rental or purchase is problematic for dairy farmers. Crop farmers, by comparison, can rent or purchase land located long distances from their home operation. Crop equipment can be moved when highway traffic is at a minimum, and it is easier for crop farmers to haul harvested grain back to the farm than it is for livestock farmers to haul bulkier forage crops, such as hay and corn silage, back to the farm. For both confinement farmers and MIG operators, dairy manure is difficult to transport and can only be carried short distances to be spread on crop land. Management-intensive grazing operators face an additional problem in that cows can only walk so far to be milked. Grazing pastures must be contiguous to the main farm operation so that animals can be moved easily from barn to field twice a day. Consequently, dairy farmers are often limited to renting or buying land only from neighbors. All of these factors dealing with land constraints can lead dairy farmers to focus on maximizing profits per acre.

As one might expect given the high land requirements of MIG systems, confinement operators produced more milk per acre, sold more milk per acre, and had greater crop sales per acre (Table 5). At the same time, confinement operators incurred greater expenses per acre than MIG operators. Those greater expenses, combined with lower cattle sales, cancelled out advantages in milk production, milk sales, and crop sales, so that confinement operators earned less net profit per acre than MIG operators (\$183/acre vs. \$232/acre).

Farm Business Comparisons

Farm Profit. The bottom line for dairy operation systems is how well they perform in generating a livable household income for the farm families that operate

them. The relative performance of confinement and MIG operations on a whole-farm basis was similar to their relative performance per cow or per acre operated. Confinement operators produced more milk (19,727 cwt vs. 11,908 cwt) and had higher milk sales than MIG operators (Table 6). Confinement operators also had higher crop sales and income from other sources (e.g., cooperative distributions, agricultural program payments, crop insurance, custom hire, fuel tax credit). Confinement operators also had higher cattle sales. As a result, gross income was substantially higher for confinement operators than for MIG operators (\$414,048 vs. \$260,298). At the same time, confinement operators incurred much greater expenses than MIG operators. Some of these differences in expenses were attributable to crop production; for example, spending on fertilizers, fuel, seed, and chemicals. Because confinement operators had more crop equipment than MIG operators, their depreciation and maintenance costs were higher. Also, confinement operators produced more milk so their freight and trucking expenses associated with shipping milk were higher. Overall, then, confinement and MIG production systems generated the same average incomes for small dairy operators in the mid-Atlantic region. Further, those incomes are approximately equal to the annual real median household income in the United States as a whole (Semega, 2009).

Income Risk. Although both confinement and MIG systems generated roughly the same average levels of income, confinement operations were noticeably riskier (Table 7). As a result, the level of income met or exceeded 3 out of every 4 yr was approximately 40% higher under MIG systems than under confinement systems. Thus, MIG systems appear to be a more consistent, more reliable source of household income than confinement systems.

Robustness of Results to Inclusion of Larger Operations and Exclusion of Organic Producers

Almost all of the results obtained from analysis of the subsample of farmers with herds of ≤ 200 cows were comparable to those of the full sample and the full sample excluding farmers selling organic milk (Table 8). The main differences were as follows. First, when organic producers were excluded from the analysis, gross income per hundred weight of milk (average price of milk received) no longer differed between MIG and confinement operations. Intensive grazing operations did, however, receive higher net profit per hundredweight of milk sold than confinement operators. Second, intensive grazing operations earned higher net profit per acre; that difference was not statistically significant in the full sample with or without organic producers, however.

Table 5. Average annual values (per acre) between 2 types of dairy farms, management-intensive grazing (MIG) versus confinement, based on Form 1040 Schedule F, 1995 to 2009¹

Form 1040 (Schedule F) item	Farms with ≤ 200 cows		
	MIG	Confinement	Difference
Milk production (cwt/acre)	47	68	21***
Milk sales (\$/acre)	910	1,244	334***
Crop sales (\$/acre)	3	13	9***
Cattle sales (\$/acre)	79	70	-9*
Income, other (\$/acre)	44	77	33***
Gross income (\$/acre)	1,037	1,404	368***
Car and truck (\$/acre)	3	2	-1
Chemical expenses (\$/acre)	6	32	26***
Conservation expenses (\$/acre)	1	1	0
Custom hire (\$/acre)	14	37	23***
Depreciation (\$/acre)	116	127	12
Purchased feed expenses (\$/acre)	267	387	119***
Fertilizer expenses (\$/acre)	21	39	18***
Freight and trucking (\$/acre)	26	47	21***
Fuel (\$/acre)	23	31	8***
Insurance, other than health (\$/acre)	13	17	4**
Interest (\$/acre)	41	45	4
Labor (\$/acre)	25	64	39***
Rent or lease (\$/acre)	49	58	9*
Repairs and maintenance (\$/acre)	52	95	42***
Seed (\$/acre)	19	26	8***
Supplies (\$/acre)	51	53	2
Taxes (\$/acre)	9	9	-1
Utilities (\$/acre)	26	30	5***
Veterinary, breeding, and medicine (\$/acre)	23	63	40***
Other expenses (\$/acre)	21	51	31***
Total expenses (\$/acre)	805	1,221	416***
Net profit (\$/acre)	232	183	-48***
Net profit (metric; \$/ha)	573	452	-121***

¹Income and expense numbers are expressed in consumer price index (CPI)-adjusted dollars.

*, **, ***Significant difference between MIG and confinement dairies at the 10, 5, and 1% levels, respectively.

Third, when the full sample was used—with and without organic producers—confinement operations earned greater profit per farm. But there was no difference in profit; hence, the result was qualitatively the same as that obtained from the main analysis.

General Discussion

The foregoing comparisons indicate that MIG operations exhibited financial performance at least equal to that of confinement operations in the mid-Atlantic, at least for dairies of the relatively small sizes included in our sample. Management-intensive grazing operations produced less milk but incurred substantially lower costs. Management-intensive grazing operations were more profitable than confinement operations per hundredweight of milk produced and per cow and were no less profitable on a whole-farm basis (i.e., once size of operation was taken into account). Lower upfront expenditures made MIG operations less vulnerable to fluctuations in market conditions, weather, and other factors beyond the farmers' control. As a result, income was less risky in MIG operations than in confinement operations. These financial performance measures sug-

gest that MIG systems may offer a way for small farms to compete in dairy production.

Management-intensive grazing systems may also enhance the sustainability of small dairy operations by allowing entry of greater numbers of young farmers. Management-intensive grazing operations require less equipment for crop production and smaller freestall areas in barns (because cows spend more of their time grazing in pasture). Lower upfront investment costs make them easier to finance and thus more accessible to new entrants lacking capital.

Management-intensive grazing systems are still relatively new, suggesting that there is likely considerable room for improvement. Innovations will likely be site specific, as researchers and farmers adjust grazing practices to suit soils and climate; on-farm learning by doing and experimentation are likely to play important roles in this process. Breeding of animals and pastureage better adapted to intensive grazing can also help increase productivity in MIG systems. As these innovations are developed, the advantages of MIG systems over confinement operations are likely to grow.

Agricultural commodity prices have been becoming more volatile. Increased demand due to economic

Table 6. Average annual values (per farm) between 2 types of dairy farms, management-intensive grazing (MIG) versus confinement, based on Form 1040 Schedule F, 1995 to 2009

Form 1040 (Schedule F) item	Farms with ≤ 200 cows		
	MIG	Confinement	Difference
Milk production (cwt/farm)	11,908	19,727	7,819***
Milk sales (\$/farm)	227,789	362,088	134,299***
Crop sales (\$/farm)	795	5,054	4,259***
Cattle sales (\$/farm)	19,208	20,797	1,589
Income, other (\$/farm)	12,496	26,076	13,580***
Gross income (\$/farm)	260,298	414,048	153,750***
Car and truck (\$/farm)	552	589	37
Chemical expenses (\$/farm)	1,473	11,616	10,143***
Conservation expenses (\$/farm)	125	436	311
Custom hire (\$/farm)	4,573	12,060	7,487***
Depreciation (\$/farm)	28,628	35,224	6,596***
Purchased feed expenses (\$/farm)	67,938	107,649	39,711***
Fertilizer expenses (\$/farm)	5,384	11,863	6,479***
Freight and trucking (\$/farm)	7,627	14,738	7,111***
Fuel (\$/farm)	5,493	9,526	4,033***
Insurance, other than health (\$/farm)	2,875	6,431	3,556***
Interest (\$/farm)	10,769	15,024	4,255***
Labor (\$/farm)	5,529	23,977	18,448***
Rent or lease (\$/farm)	13,562	17,424	3,862**
Repairs and maintenance (\$/farm)	14,363	28,078	13,715***
Seed (\$/farm)	5,494	8,183	2,689***
Supplies (\$/farm)	12,779	16,071	3,292***
Taxes (\$/farm)	2,015	3,003	988***
Utilities (\$/farm)	6,216	9,230	3,014***
Veterinary, breeding, and medicine (\$/farm)	6,655	18,972	12,317***
Other expenses (\$/farm)	4,907	14,748	9,841***
Total expenses (\$/farm)	206,914	366,221	159,307***
Net profit (\$/farm)	53,383	47,826	-5,557
Milk production (metric; kg/farm)	540,138	894,802	354,664***

¹Income and expense numbers are expressed in consumer price index (CPI)-adjusted dollars.

, *Significant difference between MIG and confinement dairies at the 5 and 1% levels, respectively.

growth in developing countries and to the growth of biofuel uses has made commodity markets more susceptible to fluctuations in production. Decreased reliance on purchased feed and lower upfront expenditures make MIG systems less vulnerable to volatility in commodity prices. Lower risk is thus likely to become an increasingly important advantage of MIG systems.

Milk produced in MIG operations has several attributes that command higher prices today and seem likely to continue to do so in the future. As noted above, some MIG farmers have become organically certified. The transition to organic production is not as difficult when beginning from a MIG base. Some consumers are willing to pay more for livestock products from operations that provide greater animal welfare. Thus, MIG operations can be seen as a more natural, cow-friendly form of dairying. Lower veterinary expenses per cow, longer

milking lifespans (or fewer frequencies of culling), and higher values of cow for sale (e.g., higher quality bred heifers) all indicate that cows are healthier in MIG systems than in confinement systems. It may thus be possible to market milk from MIG producers as an enhanced animal welfare product with a premium price.

In many areas, environmental regulations are likely to target agricultural operations that have heretofore been largely exempt from them. For example, new water quality regulations affecting the Chesapeake Bay watershed, where the dairy operations in this study are located, are likely to require reductions in runoff of nitrogen and phosphorus from smaller agricultural operations similar to those that the current effluent discharge regulations impose on large confined animal feeding operations. Management-intensive grazing operations have lower nutrient runoff than confinement operations

Table 7. Riskiness of income: management-intensive grazing versus confinement operations, 1995 to 2009

Farm type	Average annual profit (\$)	SD	75% lower confidence limit ¹
Management-intensive grazing	54,901	32,055	36,405
Confinement	48,137	38,236	26,075

¹Indicates the profit attained in 3 out of every 4 yr.

Table 8. Comparison of milk production, gross income, total expenses, and net profit for different farm sizes and units: management-intensive grazing (MIG) versus confinement operations, 1995 to 2009

Farm 1040 (Schedule F) item	Farms with ≤ 200 cows			Full sample			Full sample, no organic		
	MIG	Confinement	Difference	MIG	Confinement	Difference	MIG	Confinement	Difference
Per hundredweight of milk									
Milk production (cwt)	—	—	—	—	—	—	—	—	—
Gross income (\$/cwt)	22.55	21.03	-1.52***	19.01	17.60	-1.42***	17.88	17.53	-0.36
Total expenses (\$/cwt)	17.8	18.58	0.78**	14.95	15.54	0.59**	14.35	15.50	1.15***
Net profit (\$/cwt)	4.75	2.45	-2.30***	4.06	2.06	-2.00***	3.53	2.03	-1.51***
Per cow									
Milk production (cwt/cow)	144	188	43***	144	190	46***	149	190	41***
Gross income (\$/cow)	3,147	3,920	774***	2,585	3,320	735***	2,599	3,320	721***
Total expenses (\$/cow)	2,511	3,456	946***	2,054	2,925	871***	2,096	2,927	830***
Net profit (\$/cow)	636	464	-172***	532	395	-137***	502	393	-110***
Per acre									
Milk production (cwt/acre)	47	68	21***	47	72	25***	49	72	24***
Gross income (\$/acre)	1,037	1,404	368***	860	1,270	411***	851	1,270	419***
Total expenses (\$/acre)	805	1,221	416***	665	1,106	441***	673	1,107	434***
Net profit (\$/acre)	232	183	-48***	195	164	-31	179	164	-15
Per farm									
Milk production (cwt/farm)	11,908	19,727	7,819***	11,545	22,952	11,407***	12,202	22,992	10,790***
Gross income (\$/farm)	260,298	414,048	153,750***	207,118	411,046	203,928***	212,600	411,294	198,694***
Total expenses (\$/farm)	206,914	366,221	159,307***	163,308	361,580	198,272***	171,348	362,023	190,675***
Net profit (\$/farm)	53,383	47,826	-5,557	43,811	49,467	5,656	41,251	49,270	8,019

, *Significant difference between MIG and confinement dairies at the 5 and 1% levels, respectively.

and will thus likely incur lower compliance costs if and when new, stricter regulations are implemented.

Land requirements likely impose the principal limitation on the size of intensive grazing operations. In the mid-Atlantic, for instance, grazing operations need 1.5 to 2.0 acres of pasture for every dairy cow/calf equivalent to provide sufficient grass to support a dairy operation. Pasture land for MIG operators must be contiguous to the milking parlor and located no farther than a cow can walk to and from twice a day. That requirement limits the maximum size of an intensive grazing operation. A lack of contiguous pasture land near their farms may create an absolute barrier to expanding the size of grazing operations to levels below that maximum as well. And in areas where land prices are high, as they are in much of the mid-Atlantic, expansion of grazing operations beyond the 200-cow limit in this study may not be economically justifiable.

CONCLUSIONS

This paper examines the comparative characteristics and relative performances of small (<200 cow) MIG and confinement dairy operators over a 15-yr period. The MIG operators were more profitable on per hundredweight, per cow, and per acre bases and were no less profitable on a whole-farm basis. Although confinement operators had higher gross income than MIG operators, their expenses tended to be greater than or equal to those of MIG operators. Profits of MIG operations were less variable as well, so that MIG operators faced less income risk. Increased reliance on grazing was associated with improved animal health, as reflected in lower veterinary, breeding, and medicine costs per cow and greater income from the sale of animals. The MIG operators were less labor intensive as well. Lower capital and labor requirements, lower variable expenses, and lower income risk make intensive grazing systems attractive for new entrants to the dairy business. Stricter environmental regulations may increase their attractiveness as well. Land requirements likely impose the principal limitation on the size of intensive grazing operations.

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