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Dairy farm management priorities and implications

RESEARCH ARTICLE

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Abstract

This analysis examines how dairy farmers prioritize critical management areas in their operations and derives implications for future growth. A questionnaire elicited preferences from seven dairy farm management areas: production/milking, calf/heifer, feed/crop, financial planning/analysis/management, risk, milk marketing, and employee/labor management. Significant heterogeneity was identified surrounding farmer prioritization across management areas. Dairy manager respondents allocated 52% of their management capacity and time, on average, to production/milking management. Investigating priorities via a latent class model, in one class, financial planning/analysis/management or employee/labor management become relatively more important, and potentially critical, to the growth of the operation. This analysis provides dairy operators and industry stakeholders insights to facilitate dairy farm success and growth. Larger farms already placing greater emphasis on employees and labor management indicated they were prioritizing financial management for their success whereas smaller farms with growth intentions largely lacked management focused on areas outside of production and milking management.

Keywords: farm management, best worst analysis, choice experiment, random parameter logit, latent class model
JEL code: Q12, Q13, Q14, Q19

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1. Introduction

The performance of dairy farms is attributable to a multitude of factors both within the control of the operator (e.g. managerial decisions) while other factors (e.g. macroeconomic or industry shifts) are not. Economic performance of different dairy farms can vary widely and has been attributed to differences in management (Boehlje and Eidman, 1984; Rougoor *et al.*, 1998). Success of dairy farm businesses depends on the quality of decisions made by management which relies on continuous evaluation of new information and technology (Bergevoet *et al.*, 2004; Joerger, 2016). With the farm manager's time often being the most limited resource (Holland *et al.*, 2014), it is important to examine which of the crucial areas of management that dairy farmers must focus greater attention. Of particular interest are prioritization of management areas for farms.

Managing facilities or equipment on a regular basis by livestock producers may be part of the recipe for economic success, but the fundamental aspects of management and decision making are still integrally important (Campe *et al.*, 2015). In addition to management decision making, farm size, milk production levels, and milking systems used are also identified as factors that influenced dairy farm profitability positively (Gloy and LaDue, 2003; Gloy *et al.*, 2002). Dis-adoption of recombinant bovine somatotrophin (rBST) by dairy farms in the U.S. illustrates an example of the removal of a technology by market forces (Cook-Mowery *et al.*, 2009), which was due to milk cooperative and milk retailers making decisions in response to market forces rather than regulatory or legal actions. The success of farms in dis-adopting rBST was highly dependent on managerial factors (Cook-Mowery *et al.*, 2009; Olynk *et al.*, 2012).

Individual characteristics of the farmer have been found to influence the farm operation's success. Specifically, farmers' attitudes, ambitions (Bigras-Poulin *et al.*, 1985), education, and other socio-psychological characteristics (Bigras-Poulin, 1985) have been shown to impact dairy farm outcomes. Similarly in another study which examines managerial traits, objective orientation, decision-making approaches, information preference profiles (Solano *et al.*, 2006), and management of firm resources (Mugera and Bitsch, 2005) impact performance of the farm operation. The analysis presented contributes to the understanding of how these measurable factors of firms and characteristics of farmers influence preferences for each functional area of dairy management.

The priorities of dairy farm managers likely comply, to at least some degree, with the traditional microeconomic theoretical framework of maximizing profit as illustrated in Figure 1. Coupling this framework with the functional view of organizational management (Menz, 2012), revenues and costs can be subdivided into each of the functional areas of management. The functions influence the organization's profitability through the manager's involvement in production, marketing, finance, human resources, and business environment. The management constructs for corporate firms are intertwined with the managerial responsibilities of dairy operations and, for some firms, may also form feedback loops. Each of the intertwined management areas can impact revenues and costs as the farmer makes tradeoffs in the allocation of their management time capacity. For example, the functional area of production has connections to 'production and milking management' as well as 'calf and heifer management'. In this framework, dairy farm managers focus their attention across these key interconnected areas in order to affect their dairy farm's revenues but the cost is that less attention is placed on other areas of farm management.

The primary objective of this analysis was to understand how dairy farmers make tradeoffs among the critical operational management areas of dairy operations to achieve success using a designed choice experiment with best-worst scaling (in this case, most important and least important is used in place of best and worst). The farm manager's priorities on these operational management areas could provide a glimpse as to how the farm manager has positioned their agribusiness operations over the past few years for the future through concentrations of management capacity. An improved understanding of dairy farmer prioritization, in particular across segments of farms with varying farm sizes, can help inform policy development and educational offerings for farmers.

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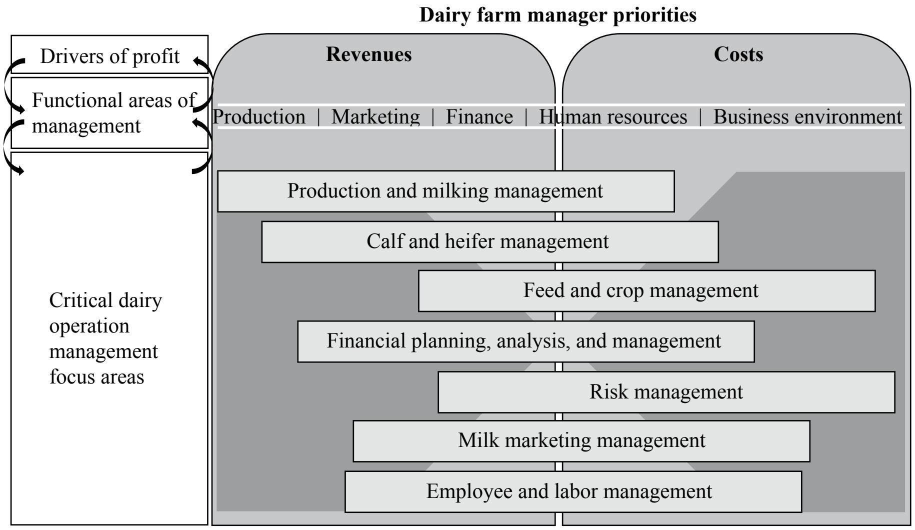

Figure 1. Dairy farm management framework.

2. Survey

The data used in this analysis were collected during the summer of 2015 using a questionnaire which was conducted primarily via U.S. mail, but with the option for respondents to reply online if they chose to do so. The questionnaire was mailed to dairy farmers in the U.S. including the states of Wisconsin, Minnesota, California, Vermont, Michigan, Indiana, and Florida, collecting information regarding general farm characteristics, calf and heifer information, reproduction information, dairy management and planning, and management capacity and prioritization. These selected states represented top producing dairy states across geographically diverse regions in the U.S. by milk production (measured in pounds) according to the USDA National Agricultural Statistics Service. The number of farms which received surveys in each state was selected proportionate to the total number of dairy farms for that particular state and respondents were not provided any monetary incentive to participate. Following the Dillman (1978) total design survey method, a questionnaire booklet, reminder postcard, and final questionnaire booklet were sent to each farmer with two weeks in between each mailing. The initial questionnaire booklet was sent on Monday, June 29 and a reminder postcard was sent two weeks later (on July 13th). Finally, after another two weeks passed, a second questionnaire booklet was mailed to each farmer. Both questionnaire mailings were accompanied by a postage paid return envelope.

The respondent pool consisted of 2,980 names and addresses of dairy farmers from the seven states obtained from the state registry of milk producers licensed to sell grade A milk, thereby including a broad group of farms to participate in the survey. There were 226 records returned as invalid addresses, reducing the total to 2,754 potential respondents. Of these potential respondents there were 798 total responses of which 422 were not currently actively involved in the operation of a dairy farm or declined to participate and 376 were actively involved in the operation of a dairy farm and participated in the survey (356 by U.S. mail and 20 by online response). The overall survey response rate was 29% with a 14% completion rate.

The questionnaire contained a designed choice experiment which was constructed to elicit information from dairy farmers regarding tradeoffs faced when forced to allocate managerial capacity and time. A number of methods can be employed to understand what factors are most influential within a given choice scenario, such as Likert-type rating scales and ranking. However, there are advantages and disadvantages to using such methods. Ranking and rating scales (e.g. a response takes place on a scale from 1 to 5 where 1 is not important and 5 is very important) are disadvantaged in that respondents are not faced with making tradeoffs among different issues and each of the issues may all be rated as being very important. Other weaknesses include central tendency bias where participants may avoid extreme response categories, acquiescence bias

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where participants may agree with statements as presented to appease the experimenter, social desirability bias where the participant portrays themselves more socially favorably rather than revealing their true behavior, lack of reproducibility, and difficulty in demonstrating validity in the measurement (Clason and Dormody, 1994; Komorita, 1963). The advantages in ranking and rating scales are found in their simplicity to construct by researchers and are easier to read and complete by participants (Laerhoven *et al.*, 2004).

To overcome the disadvantages of rating and ranking methods and understand the relative significances of management priorities among dairy producers, best-worst scaling can be employed. Best-worst scaling has, in recent years, gained popularity and been applied in a diverse array of problems such as health care research (Flynn *et al.*, 2007; McIntosh and Louviere, 2002; Szeinbach *et al.*, 1999), social and ethical issues in relation to products (Auger *et al.*, 2007), food product attributes (Louviere and Islam, 2008), food marketing (Cohen and Goodman, 2009), fast food social responsibility (Morgan *et al.*, 2016), and tourism (Lee *et al.*, 2007).

To determine the dairy farm manager's priorities and tradeoffs among seven tasks or areas of focus, an experiment using best-worst scaling, in this case most and least important, was employed. The seven tasks or areas of focus explored were: calf and heifer management; employee and labor management; feed and crop management; risk management; production and milking management; milk marketing; and financial planning, analysis, and management. Respondents were shown a set of four managerial focal areas and were asked to select which was the most and least important area of focus to their dairy farm's success when allocating their management effort. This selection task was repeated seven times by each respondent.

Figure 2 shows the choice experiment questions. The responses to these choice tasks by the farmers were then used to quantify the relative importance of each attribute. Among the 376 respondents who participated in the survey, 257 respondents fully completed the choice task question used in this analysis.

3. Methodology

The choice task presented to respondents involved tradeoffs among seven managerial areas, M, related to dairy operations. Respondents were given four operational managerial areas to decide among which was the most and least important task thus representing the maximum possible difference in importance.

Following Lusk and Briggeman (2009), l_m is assigned as the location of management area, m, on an underlying scale of importance and the latent unobserved level of importance for the individual dairy manager (or operator), O, is given by $O_{om}=l_m+\varepsilon_{om}$, where ε_{om} is a random error term. Among a choice set with M management areas, the dairy operator chooses management area m as most and h as least important which takes the same probability as the probability of the difference in O_{om} and O_{oh} and is greater than all other $M(M–1)–1$ possible differences in the choice set. Assuming the ε_{om} terms are distributed *i.i.d.* type I extreme value, then the probability takes the multinomial logit (MNL) form:

$$\text{Prob}(m\text{=most important} \cap h\text{=least important}) = \frac{e^{l_m-l_h}}{\sum_{a=1}^{M}\sum_{b=1}^{M} e^{l_a-l_b}-M} \quad (1)$$

Equation 1 is a binary probability statement taking on a value of 1 or 0; 1 for the chosen most and least important management area pair and 0 for all other possible pairs, $M(M–1)–1$. Effectively, l_m can be estimated by maximization of the log-likelihood function based on Equation 1 and represents the importance of m relative to a management area that was normalized to zero to prevent perfect multicollinearity.

One weakness of the MNL is that it imposes the assumption that all individuals in the sample treat each management area of focus equally in importance. There are two methods in which to relax this assumption and account for heterogeneity among the individuals: random parameter logit (RPL) and a latent class model (LCM).

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Management Time Allocation and Prioritization – Part E

Consider the tradeoffs faced when forced to allocate your management capacity and time – a situation where you must select which is the most and least important task or area of focus. From the options provided below, which area of management do you consider most important and least important to your dairy farm's success when allocating your management effort? *While you may feel that all of the areas presented are important to your operation, please select only one option for most important and option for least important.*

Question 1	Most Important		Least Important
	□	Calf/Heifer Management	□
	□	Employee/Labor Management	□
	□	Feed/Crop Management	□
	□	Risk Management	□

Question 2	Most Important		Least Important
	□	Feed/Crop Management	□
	□	Risk Management	□
	□	Production/Milking Management	□
	□	Milk Marketing	□

Question 3	Most Important		Least Important
	□	Risk Management	□
	□	Milk Marketing	□
	□	Financial Planning, Analysis, and Management	□
	□	Calf/Heifer Management	□

Question 4	Most Important		Least Important
	□	Production/Milking Management	□
	□	Financial Planning, Analysis, and Management	□
	□	Calf/Heifer Management	□
	□	Feed/Crop Management	□

Question 5	Most Important		Least Important
	□	Financial Planning, Analysis, and Management	□
	□	Feed/Crop Management	□
	□	Milk Marketing	□
	□	Employee/Labor Management	□

Question 6	Most Important		Least Important
	□	Employee/Labor Management	□
	□	Production/Milking Management	□
	□	Risk Management	□
	□	Financial Planning, Analysis, and Management	□

Question 7	Most Important		Least Important
	□	Milk Marketing	□
	□	Calf/Heifer Management	□
	□	Employee/Labor Management	□
	□	Production/Milking Management	□

Figure 2. Example of choice experiment with seven choice tasks each displaying four management areas.

The importance parameter is specified as $\tilde{l}_{om}=\tilde{l}_m+\sigma_m\mu_{om}$, where $\tilde{l}_m$ and σ_m are the mean and standard deviation of l_m in the population, and μ_o is a random term normally distributed with mean zero and unit standard deviation. This implies that the importance of m is assumed to be distributed according to a normal distribution with mean $\tilde{l}_m$ and standard deviation σ_m. Substituting $\tilde{l}_{om}=\tilde{l}_m+\sigma_m\mu_{om}$ into Equation 1 yields a probability statement that depends on the random term in μ_{om}. Rather than attempting to explicitly integrate over these random terms, following Train (2002), the model was estimated by maximizing a simulated log-likelihood

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function, evaluated at 50 pseudorandom Halton draws for μ_{om}. The random draws were individual specific, which takes into consideration the fact that each person answered seven most and least important questions.

While the RPL assumes the variance of $\varepsilon_{om}=1$, it is possible for the scale to differ by people or alternatives (Louviere, 2001). The RPL model outlined above accommodates possible differences in scale over alternatives because it allows for a separate management area specific variance (Train, 2002). Nevertheless, the mean estimates of l_m can still be confounded with scale differences, which necessitates recognition of estimated population parameters reflecting both mean and scale differences. Irrespective of some misspecification in the choice modeling, it has been shown that RPL can be utilized to approximate any underlying random utility model (McFadden and Train, 2000) and produce efficient estimates of predicted probabilities. This paves the way towards calculating a "share of preferences" (or priority share) for each management area, which sum to one and represents the predicted probability that each management area is chosen as the most important:

$$\text{share of preference for management area m} = \frac{e^{\tilde{l}_m}}{\sum_{h=1}^{M} e^{\tilde{l}_h}} \tag{2}$$

Importance of management area calculated from Equation 2 is based on a cardinal ratio scale where $\tilde{l}_m$ represents the estimated utility of management area m. Meaning that, for example, if one management area has a share outcome two times the outcome of another, then it indicates the management area was two times more important than the latter (Wolf and Tonsor, 2013). Note that the calculated priority share for a management area reflects true importance of the management area as well as relative uncertainty in importance placed by dairy operators.

Using observed choices and estimated parameters from the RPL as priors, posterior estimates can be attained at an individual specific level which can be compared to each operator's stated and revealed prioritization on management areas to uncover relationships among the variables (Huber and Train, 2001; Train, 2002). Here, the Bayesian calculations result in the means which are conditional on the operator's actual choice and not necessarily equivalent to the operator's actual coefficients (Train, 2002). However, Train (2002) provides evidence that differences among two statistics decline as operators face upwards of ten choice situations and these individual specific Bayesian estimates are better able to predict the operator's genuine decisions. Rather than individual specific values, the estimates are more appropriately interpreted as the mean of the parameter distribution conditional on each individual's actual choices (Lusk and Briggeman, 2009).

The LCM is another approach to analyze the heterogeneity of operation characteristics and operators' perception of importance of the seven areas of dairy management. Operation size, growth, or structure may be intrinsic to the particular operation – allowing for discrete segmentation based on homogeneous preferences within a segment or grouping (Boxall and Adamowicz, 2002). LCM estimation simultaneously achieves two functions: classifying individual operators into latent classes through probability and identifying the parameters for each of the latent classes (Swait, 1994). LCM differs from RPL in that the operator's choice occurs independently over management areas and it is assumed that the logit model generates the probability of choice (Greene and Hensher, 2003). Given a respondent classification into group, c, this can be represented by the conditional probability statement where the parameter l_{mc} is indexed by class (Ouma *et al.*, 2007) below:

$$\text{Prob}(m\text{=most important} \cap h\text{=least important} \mid c) = \frac{e^{l_{mc}-l_{hc}}}{\sum_{a=1}^{M}\sum_{b=1}^{M} e^{l_{ac}-l_{bc}} - M'} \tag{3}$$

Under the typical MNL form, the probability of the unobserved class membership is

$$Prob(c) = \frac{e\,(\theta_c Z_q)}{\sum_{c=1}^{C} e^{\theta_c Z_q}} \tag{4}$$

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Here, Z_q represents the model inputs of observable characteristics that drive classification of a respondent and θ_c is a vector of parameters which represent the magnitudes by which each driver affects respondent classification normalized to zero (Ouma *et al.*, 2007). The LCM is powerful in that it allows the ability to develop a statistical model based on maximum likelihood which accounts for both the similarities and differences between firms. It also groups subtypes of related cases based on unobserved (latent) heterogeneity and includes exogenous variables to allow concurrent class assignment and characterization (Coltman *et al.*, 2011).

4. Results and discussion

4.1 Dairy farmer demographics

Table 1 displays summary statistics of respondent demographics. The average total number of milk cows was 417 ranging from 8 to 9,675 cows with a standard deviation of 1,049 cows. The sample is similar in composition of farms responding with regard to farm size to other recent national dairy studies (Wolf and Tonsor, 2015).

Table 1. Respondent demographics.

Demographic variable			% of respondents
Total milk cows	<50 cows	119 farms	32
	50-99 cows	98 farms	26
	100-999 cows	121 farms	33
	1000-2,499 cows	10 farms	3
	2,500+	23 farms	6
	Average	417 milk cows	
	Median	70 milk cows	
	Range	8-9,675 milk cows	
	Standard deviation	1,049 milk cows	
Other enterprises	None	196 farms	50
	Custom heifer raising	5 farms	1
	Cash crop (corn, soybeans, etc.)	95 farms	24
	Other livestock	45 farms	11
	Other	54 farms	14
Ownership	Individual owner	248 farms	67
	Partnership	42 farms	11
	Limited partnership	27 farms	7
	Corporation, family	50 farms	14
	Corporation, non-family	4 farms	1
Pounds of milk sold	Average	12,809,773 lbs	
	Median	1,302,723 lbs	
Grow by 2020	Yes	54%	
	No	46%	
Operator retiring in next 10 years	Yes	48%	
	No	52%	
Farm transfer plan to next generation	Yes	64%	
	No (no next generation)	11%	
	No (next generation not interested)	17%	
	No (farming our assets)	8%	

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The average pounds of milk sold per respondent in the sample in 2014 was 12.8 million while the median is about 1.3 million. According to the 2012 Census of Agriculture, smaller operations (defined as 99 cows or less) accounted for a smaller proportion (17%) of total number of operations in comparison to data collected for this analysis.[1] In effect, the results from this analysis may be more representative of larger dairy herds.

When asked about future farm size, 54% of respondents wish to grow their operations in total number of milking and dry cows by 2020. Likewise, about half of the dairy operators planned to retire within the next 10 years. A majority of respondents also had made plans to transfer the farm to the next generation (64%) while the remaining either did not have a plan (11%), indicated the next generation was not interested (17%), or were "farming their assets" (8%) and knowingly using their existing assets to generate income without intent to replace or reinvest in those assets.

Among those who planned to retire in the next 10 years, 55% still intended to grow herd size. For those who plan to continue operations over the next 10 years, 60% planned to grow their herd. Conditional on operations that plan to grow their total number of cows by 2020, 78% of operations had made farm transfer plans to the next generation. While 50% of non-growing operations had transfer plans to the next generation, 25% of operations which did not expect to grow by 2020 did not have transfer plans to the next generation because the next generation was not interested.

When considering ownership types, a majority of partnerships (24%) and corporations (21%) tend to have transfer plans in place. While 55% of sole proprietorships also had transfer plans to the next generation, 45% of operations did not have transfer plans compared to 17% for partnerships, 29% for limited partnerships, and 23% for family corporations.

4.2 Dairy farmer management effort prioritization

Estimations for the most-least important scaling analysis using the choice experiment data were performed in NLOGIT 5.0 (Econometric Software Inc., Plainview, NY, USA) (Greene, 2007). Table 2 presents estimated coefficients and calculated shares of priority results of the MNL, RPL, and LCM. Each priority share calculated using the estimated coefficients, represents prioritization of the management area relative to the other operational management areas and not necessarily an allocation of time devoted in the particular area.

Initially, the MNL was used to analyze the most-least important responses to generate a base model used in further analysis incorporating the potential for heterogeneous preferences by respondents, specifically using both the RPL and LCM. The LCM was examined with consideration of two to seven classes. To evaluate the fit of the LCM models, the Akaike information criterion and Bayesian information criterion were used which led to selecting a four-class model (Boxall and Adamowicz, 2002).

The RPL model revealed that, dairy managers, on average, allocated about 52% of their priority shares towards production and milking management. Calf and heifer management, feed and crop management, and financial planning, analysis, and management were estimated to have a lower priority. The remaining managerial areas – risk, milk, and employee and labor management – were allocated the least amount of the share. This primary management focus towards production and milking management was also present in a 1998 analysis (Harsh *et al.*, 2001).

Finding production and milking management to be among the highest priority overall among dairy farmers is not surprising. History shows that those who carefully manage production tend to have more stable economic performance and reach higher levels of profit (Grisley and Mascarenhas, 1985; Haden and Johnson, 1989; Kauffman and Tauer, 1986; Warren, 1914). The second most important management area was calf and

[1] This sample contained a larger proportion of smaller dairy farms (58% of farms had 0 to 99 cows) than the most recent Census of Agriculture (USDA, 2012).

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Table 2. Estimation results are shown for the multinomial logit, random parameter logit, and the latent class model. Preference heterogeneity was shown to be present for the operational management areas by the statistically significant standard deviations for the parameter distributions. Thus, priority shares are calculated for the random parameter logit and the latent class model which provided flexibility to better understand the level of preference heterogeneity present among this sample of dairy farmers.[1]

Operational management areas	**MNL**	**RPL**			**LCM**							
	Coefficient (std. error)	**Coefficient (std. error)**	**Std. dev. (std. error)**	**Share of preferences**	**Coefficients (std. err.)**				**Share of preferences**			
					Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 1**	**Class 2**	**Class 3**	**Class 4**
Production/milking management	1.9961 (0.0783)	2.9014 (0.1343)	1.4872 (0.1557)	52%	4.4443 (0.2653)	5.3035 (1.0304)	1.2524 (0.3773)	0.3908 (0.1659)	38%	93%	24%	29%
Calf/heifer management	1.0872 (0.0726)	1.6698 (0.1171)	1.3839 (0.123)	15%	3.7678 (0.2686)	1.7040 (0.404)	1.6198 (0.3365)	-1.0786 (0.1731)	19%	3%	35%	7%
Feed/crop management	1.1024 (0.072)	1.6003 (0.1119)	1.2564 (0.1078)	14%	3.8202 (0.282)	1.7121 (0.397)	1.4023 (0.2931)	-0.9575 (0.1774)	20%	3%	28%	8%
Financial planning, analysis, and management	0.9674 (0.072)	1.5162 (0.1268)	1.6689 (0.121)	13%	3.4536 (0.2825)	0.6273 (0.3657)	-0.5512 (0.3176)	0.4823 (0.1599)	14%	1%	4%	32%
Risk management	-0.3095 (0.0654)	-0.4755 (0.1086)	1.4043 (0.1132)	2%	2.3814 (0.2884)	-1.5295 (0.3443)	-1.6575 (0.32)	-1.6433 (0.1816)	5%	0%	1%	4%
Milk marketing	-0.5724 (0.0666)	-0.6486 (0.1254)	1.7307 (0.1304)	1%	2.2025 (0.2607)	-1.6850 (0.4221)	-1.9152 (0.328)	-2.3159 (0.1905)	4%	0%	1%	2%
Employee/labor	0.0000	0.0000		3%	0.0000	0.0000	0.0000	0.0000	0%	0%	7%	20%
Class probability					0.345	0.218	0.154	0.283				

[1] MNL = multinomial logit; RPL = random parameter logit; LCM = latent class model.

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heifer management, which is commonly regarded as a key driver of farm success and profitability. Focusing greater attention towards dairy activities, such as improving calving rates, reducing mortality, or improving animal heath, rather than towards crop production activities can promote farm financial success and increase economic efficiency (Ford and Shonkwiler, 1994; Heinrichs *et al.*, 1987).

The third most important area was feed and crop management with 14% priority share. Since feed costs are the largest single cost on a dairy operation, it was expected that significant effort and attention would be placed on this area of management. Managing the supply of quality feedstuffs and controlling the costs of feed have been found to have an influence on the profitability and success of an operation (Haden and Johnson, 1989; Matulich, 1978).

Financial planning, analysis, and management was the fourth most important management area, on average. Ford and Shonkwiler (1994) also found that financial management is highly significant to the profitability of a dairy operation. The activities clustered in this management area are so heavily intertwined among other areas such as technology adoption, herd size, and record keeping (El-Osta and Morehart, 1999) that it could have a dampening effect on the level of importance rated by participants.

The remaining management areas (milk marketing; risk management; and employee and labor management) were considered relatively less important by the dairy farm operators and made up approximately 6% of the priority share in total. Milk marketing is a burden often borne by the cooperative (Brown, 2011; Brown *et al.*, 2010) which could explain its lower priority share as the dairy operator simply does not necessarily allocate a greater level of focus towards the area. With respect to risk management, dairy operators may consider it similar to milk marketing if they are primarily considering milk price risk. Further, there are federal programs that attempt to insulate farmers from some market volatility. Dairy operators, however, can still mitigate other risks through the adoption of forward contracting of inputs (Haydu *et al.*, 1992; Mishra and Perry, 1999; Wolf and Widmar, 2014). Employee and labor management was also ranked as being of relatively lessor importance. Dairy operations typically, at least historically, rely heavily on higher quality family labor incentivized by the dairy operation's success (Grisley and Mascarenhas, 1985). Furthermore, many operations have become more mechanized thus relying less on highly skilled labor (Schmitz and Moss, 2016).

Exploring further the heterogeneity in producers' relative prioritization among management areas, an LCM model was used. In the latent class model, probabilities of class membership were calculated for each respondent. In this model, priorities vary heterogeneously across the classes and homogenously within a class. Class 1, placed more emphasis across more areas of management and is thus dubbed a more 'balanced' group (Table 3). Production and milking management received the greatest amount of attention at almost two times the importance of the next most important task (feed and crop management). Calf and heifer management ranked third most important for this class of dairy operators followed by financial planning, analysis, and management. Dairy operators allocated a 91% share of priority to the top four management tasks in total, with the remaining managerial tasks each had less than a 5% priority share. Among the approximately 35% of farmers falling within this class (Class 1), dairy farm operations were more likely to be operations that consisted of less than 999 total milk cows. Figure 3 shows each class delineated by operation size.

Table 3. Summary class size and top management priority.

Class (size)	Summary descriptor	Top management priority
Class 1 (35%)	Balanced status quo group	Production/milking management (38% share)
Class 2 (22%)	Production focused	Production/milking management (93% share)
Class 3 (15%)	Calf/heifer and feed/crop managers	Calf/heifer management (35% share)
Class 4 (28%)	Production through finance labor concentration	Financial planning, analysis, and management (32% share)

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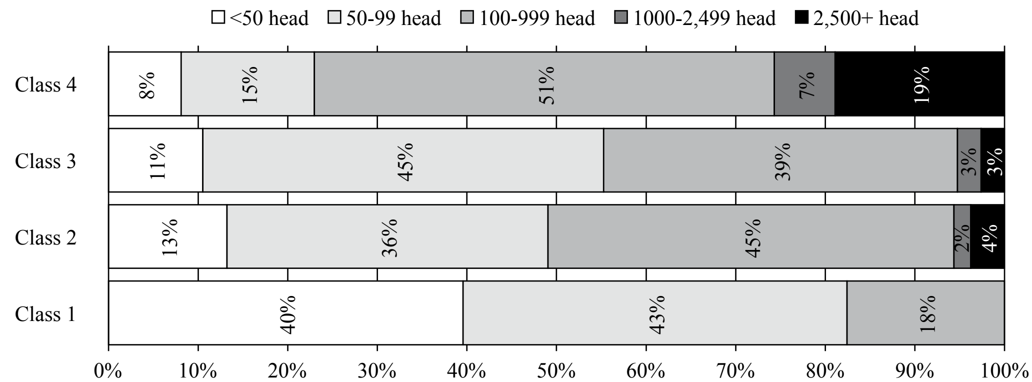

Figure 3. Percent of sample of each operation's size classification (in terms of number of heads) by each latent class segment. Class 1 consists of smaller farms with 40% of operations that have less than 50 heads. Class 3-4 consist of larger operations. Class 4 has the largest proportion of firms with over 2,500 heads (19%).

Class 2 focused primarily on production and milking management at 93% priority share. This group dedicated only 1-3% of their priority shares on management towards areas such as calf and heifer management, feed and crop management, and financial planning, analysis, and management. No measurable priority share was allocated towards risk management, milk marketing, or employee and labor. Larger farmers were more likely to be found in this class than those in Class 1. The striking difference, however, is that 60% of this group of dairy farmers intended to grow their herd size by 2020.

With regards to Class 3, this group of respondents divided the majority of their priority shares among three management areas: calf and heifer management (35%), feed and crop management (28%), and production and milking management (24%). Similar to Class 1, the remaining areas received little attention. This class of dairy operators had the highest priority share for calf and heifer management at 35%. With this class, the model also predicts managers placing about 7% of priority share for employee and labor management, which ranks as the fourth most important management area.

Class 4 was similar to the other groups of dairy operators in that they also focused greatly on production and milking management. However, this group differed in that they showed the greatest priority towards financial planning, analysis, and management. Also, employee and labor management had the highest priority share at 20% among all the different classes of farmers predicted. These top three management tasks were allocated approximately 80% of the priority share.

4.3 Implications for dairy farms and agribusiness management

Dairy farmers likely to prioritize farm management areas, as depicted by Class 1 in the LCM, were generally smaller than the average in the sample but expected to grow their farm operations by more than the average in the sample. Class 1 was similar to the RPL model in terms of the top ranking management areas. Class 3 allocated 94% of priority share to four management areas which mirrored those of Class 1 with the exception of replacing financial planning, analysis, and management with employee and labor management. In both Classes 1 and 3 less than 50% of respondents likely to display these priorities indicated they wished to grow their dairy farms.

Over 60% of the farmers likely to belong to Classes 2 and 4 stated that they intended to grow their dairy operations by 2020. With regard to management strategies for pursuing the intended growth, farm managers and agribusinesses working with dairy farms may consider whether managerial efforts need to shift towards employee/labor management or if growth can be obtained through the use of robotics or other mechanization. There are significant implications for dairy farms and dairy industry service providers surrounding how

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these farms intend to – and ultimately pursue – growth given they currently indicate that they do not allocate (much) importance to labor management. Agribusinesses focusing on input supply for dairy farms should be particularly attuned to how their customers intend to pursue growth with respect to the labor needs on farms. Based on stated level of importance for other management areas over labor management there may be opportunities to provide support for human resource needs, in particular if farms are underprepared to tackle such challenges associated with their intended growth. There may be opportunities for aiding farm operations seeking growth through educational programming, agribusiness support services, and/or outsourcing human resource management activities.

Class 4 is unique due to the nearly 3 times higher priority allocation to employee and labor management than any other class in the LCM and Class 4 is also nearly 7 times greater than the mean from the RPL model for the same managerial area. Class 4 consists of larger farmers who are most likely to fall among herd sizes of 100-999 cows or more than 2,500 cows. Likewise, this group of dairy farm managers places great emphasis on employee and labor management which is likely the result of operating larger farms, thus with greater labor needs, at the time of survey completion. For farms already prioritizing human resource management, growth appears likely to be centered on more traditional business management activities, including financial planning and business analysis. Class 4 stands out amongst other classes for prioritization of human resource management along with having the highest ranking of importance towards financial planning, analysis, and management.

5. Conclusions

Facing tremendous volatility, U.S. dairy farmers must remain vigilant in actively pursuing opportunities to further the long-term success in their operations. Dairy input suppliers and service providers must also remain attune to the changing marketplace in order to ensure that they're generating value for their changing customers through the products and services provided. This study examined how managers made tradeoffs in their managerial efforts among critical dairy farm management areas and investigated relationships in management area prioritization with key dairy farm characteristics.

Dairy farm managers were asked to complete a choice experiment which involved making tradeoffs between what they believed was the most and the least important area of management (production/milking, calf/heifer, feed/crop, financial planning/analysis/management, risk, milk marketing, and employee/labor management) in relation to the success of their operations. Each of these operational management areas are critical to the success of dairy farms and are within the control of dairy operators through quality managerial decisions and affect the success of dairy farm businesses regardless of whether success is defined as the ability to provide for the farmer's family and future generations, maintain the operation's current viability, or growth in terms of expansion going forward.

The random parameter logit model was used to examine statistically significant preference heterogeneity over the operational management areas. Overall, production and milking management was found to be approximately 3.5 times more important than the next highest management priority area of calf and heifer management. However, a LCM model reveals additional insights into the prioritizations of four distinct classes of farm managers. From this analysis, four classes of dairy producers with distinctly different agribusiness management strategies and priorities could be further studied. These results show how operations have prioritized their time allocated across managerial areas through volatility in the industry experienced over the past several years. One group of farmers has maintained a relatively balanced prioritization while other groups prioritized strongly production and milking in order to maintain the success of their operations. Both groups could be relying heavily upon their core competencies. In contrast, a third group could be taking a specialization or differentiating approach to the management of their operations beyond the core competencies of the traditional farmer.

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This analysis provides dairy operators and industry stakeholders insights to facilitate dairy farm success and growth. For example, larger farms already placing greater emphasis on employees and labor management indicated they were prioritizing financial management for their success. In contrast, smaller farms stating growth intentions largely lacked strong emphasis, relatively, on management areas aside from production and milking management; thus highlighting opportunities to facilitate business success through a more holistic management approach, especially the development of human capital. The evidence provided by the analysis could highlight needs for agribusiness support structures that enable dairy farm managers to either outsource management areas to specialized consultants or the need for human capital development opportunities as farmers pivot their operations given the prevailing agribusiness industry conditions.

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