Factors Affecting the Decision to Exit Dairy Farming: A Two-Stage Regression Analysis

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ABSTRACT

Substantial attention has focused on the dairy industry because of a concern that many producers are getting out of dairying. Although low milk prices are postulated as a primary reason for exits from dairying, other factors may be important as well. Data from a representative 64-farm subset of a 2002 survey of dairy producers in Maine were used in the current study. Of the 64 farms, 15 indicated an imminent exit from dairying, whereas 49 dairy farms expected to remain in business for ≥ 5 yr. A binary choice logit regression model, based upon the dependent variable decision to exit or remain in the industry, was used as part of a 2-stage regression process to ascertain why dairy producers are choosing to leave the industry. The hypothesis states that the decision is a function of 3 independent variable categories: demographic, efficiency, and opportunity costs. Four variables were revealed that significantly influence the exit decision. Older producers, higher off-farm income, lower returns over variable cost, and greater diversification of farm income were more likely associated with a decision to leave dairy farming. Because factors other than milk price are involved in exit decisions, perhaps national or regional dairy programs should consider strategies beyond price supports to provide for a stable dairy industry and a reduction in the rate of dairy farm exits.

(**Key words:** logit, exit, demographic, economic factor)

Abbreviation key: ROVC = return over variable costs.

INTRODUCTION

Over the past 25 yr, national milk production has shifted from the East and Midwest to the West. In 1975, 71% of national milk production was produced in the Northeast, Lake States, Corn Belt, and Plains, and just

17% was produced in the Mountain and Pacific states. Although traditional dairy regions still produce the most milk in the nation, the aggregate production of the Mountain and Pacific states is rapidly approaching the level of the Northeast and the Lake States (Figure 1).

Paralleling this shift in dairy production is a decline in overall farm numbers through firm exit and consolidation in search of scale economies and production efficiencies (Rahelizatovo and Gillespie, 1999). Concern in many traditional dairying states arises because the loss adversely affects agribusiness firms supporting the dairy industry as well as the economic activity of farming-dependent areas (Stam et al., 1991). In particular, many traditional dairy states are concerned farm numbers are reaching the lower limit of critical mass where feed companies, bovine veterinarians, other specialized services and dairy processors can find sufficient business volume to justify operation.

Technological advances leading to increases in milk production per cow have contributed to industry contraction since 1970. Additionally, recent low milk prices from 2001 through the middle of 2003 are cited as the cause of a 3.7% decline in national dairy farm numbers (Olsen, 2002). Low milk prices and resulting low on-farm income may influence the decision to exit dairying. Research on other segments of the agricultural economy has found different factors influencing a producer's decision to exit farming (Ehrensaft et al., 1984; Bentley and Saupe, 1990; Gale, 1994; Rahelizatovo and Gillespie, 1999; Goetz and Debertin, 2001). For example, research on farm exits located in southwestern Wisconsin identified age as an important factor (Bentley and Saupe, 1990).

The purpose of this paper is to derive the determinants influencing the decision to exit dairy farming in a traditional dairying state using a 2-stage regression model. Defining which factors, beyond product price, that impact a producer's decision to exit dairying provides both government and dairy industry organizations with powerful policy information on the exit decision. This information can be used to focus resources on maintaining a balanced flow of producer entrants and exits, and to maintain a healthy dairy industry in

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Figure 1. Historical trend in milk production by region from 1975 to 2000 (USDA/NASS, 2004).

states where dairy is an important component of the agricultural economy.

Primary data on the decision to exit dairy farming will be analyzed using a 2-stage approach. The first stage identifies factors affecting firm profitability. The resulting predicted profitability variable is used in a second-stage binary logit model with 2 options: exit or remain in the industry. The 2-stage approach is necessary to control for regressor endogeneity in the exit decision model. Independent explanatory variables hypothesized to influence the exit decision will focus on individual farm and farmer characteristics in addition to economic performance. The variables for both stages are broadly categorized into demographic, production and economic efficiency, and opportunity cost factors. These models will be useful in predicting whether a farm is more or less likely to exit dairy farming and in determining the impact of alternative public policies on the likelihood of an exit decision.

The remainder of the paper is organized as follows. The second section provides a review of previous studies that have examined the decision to exit farming to justify the set of selected explanatory variables. The third section will describe the data and method used in the analysis. The final section will conclude the paper and provide insight into the effectiveness of alternative public policies targeted to reduce farm exit from dairy production.

Literature Review

The perfectly competitive market model defines the exit or shut-down decision rule as based upon the comparison of a product's market price relative to an individual producer's short-run average variable costs given certain assumptions, most notably perfect knowl-

edge and no barriers to exit. Although the perfectly competitive market model applies to many industries, dairy producers may not follow the narrowly defined economic shut-down rule because of the nature of capital used, biological lags between breeding and milking, as well as imperfect information, *inter alia*, about future milk prices.

Milk production is highly capital-intensive and requires production inputs that are specialized in nature. Additionally, liquidation of these capital inputs may yield salvage values comparatively lower than what could be achievable through discounted future streams of revenue. Relaxing the assumption of perfect information, milk prices exhibit monthly and seasonal fluctuations caused by market clearing conditions and the Federal price-setting procedure. As a result, production decisions are based upon price expectations as well as the current market price (Foltz, accepted). If the expected long-run price is higher than the cost of production, a producer may continue to milk despite a "temporary" price below the minimum of the average variable cost curve. For these reasons, a more appropriate rule can be based upon long-run profitability, including an expected return on capital and the opportunity cost of labor. Prolonged negative profitability, measured as the difference between the long-run average total cost curve, including capital costs and the opportunity cost of labor used in another activity, and the price received by producers may drive the exit decision.

Factors affecting structural change (that is exit, entry, and firm composition) in agriculture include many dimensions (Boehlje, 1992). Boehlje argues that 5 different groups of factors influence change in the structure of agriculture: technology, human capital, finances, institutions, and sociology.

Firm productivity and technology used has been determined to influence financial performance and hence the shut-down decision. New York dairy farms were analyzed to determine the relationships among technology, finances, human resource factors, and profitability (Gloy et al., 2002). Number of cows, production per cow, and milking system defined the production factor variables, and return on assets defined the profitability variable. Regression analysis identified all production factors as significantly influencing the return on assets ratio.

Several studies argue that a farm owner or operator's decision to exit is largely posited upon age. Gale (1994) found evidence, using Boehlje's life-cycle model, that the probability of an exit decision follows a pattern similar to a firm's business cycle. Exit is more likely at the consolidation period than at start-up or maturity. Broader analysis of entry and exit decisions provides support for the disinvestment stage of the life-cycle

model by finding farmland contraction in older age cohorts and greater participation in dairy termination programs (Ehrensaft et al., 1984; Gale, 1990).

Off-farm income can provide support during a time of instability or lessen transition costs from farming when moving to alternative employment. Goetz and Debertin (2001) show that off-farm employment leads to higher levels of farm exits; most notably in counties that were already experiencing farm losses. Boehlje identified this component as a sociological response to the risk associated with farm income.

Defining the exit decision based upon the long-run rule is complicated by the fact that a number of opportunity cost variables are not easily measured. This study defines instruments correlated with factors affecting the long-run decision to exit, supported by structural change models, in addition to a measure of short-run profitability. We investigate the relative impact of 3 categories of variables: demographic, production and economic efficiency, and opportunity cost factors on the decision to exit dairy farming.

MATERIALS AND METHODS

The exit decision was analyzed in a traditional dairy-farming state. In January 2002, a cost of production survey was sent to all dairy farmers in the state of Maine. The survey contained 93 questions broken into 8 sections: 1) operator/owner profile, 2) farm business and technology usage, 3) milk production systems and buildings, 4) livestock holdings and husbandry practices, 5) crop production and feeding practices, 6) labor use and employment, 7) miscellaneous costs, and 8) future outlook, production strategies, and closure. Responses were based upon 2001 records. Twenty-seven percent of the surveys (115 of 417) were returned either fully or partially completed. Results of the survey and the enumeration process are presented in Dalton and Bragg (2003).

All returned surveys completed the section on future outlook, and 26% of the producers indicated that they plan to exit dairy farming within the next 5 yr (Dalton and Bragg, 2003). Because this analysis combines information from several parts of the survey and because many producers were reluctant to divulge information in one or more of the cost categories, several responses were removed from the analysis. Of the 64 observations used in this study, 15 (23.4%) indicated that they were exiting dairy farming, and 49 (76.6%) indicated that they intended to continue dairy farming for ≥ 5 yr. The distribution of responses in the subset of surveys used in this analysis is not statistically different from the respondents omitted from the study (χ^2 [1 df] = 0.525).

In addition, the respondent population used in the regression analysis was compared against the full state-

wide population of producers to determine whether the sample was representative of those producers who chose not to respond to the survey. Two variables were selected for analysis: herd size and milking technology. The distribution of herd size of the sample respondents was compared against nonrespondents. Both Mann-Whitney and Kolmogorov-Smirnoff tests failed to reject the hypothesis that the distributions of the 2 groups came from the same population at the 10% significance level (Steel et al., 1997). In addition, a test of the mean herd size between the 2 groups were not significantly different at $\alpha = 0.05$. A second test was used employing a nonparametric Pearson χ^2 test to determine whether the milking technology used by respondents (stanchion or parlor) was different from nonrespondents (Steel et al., 1997). This statistic, distributed χ^2 (1 df) = 0.027, was not significant at the 10% significance level. Overall, these 3 tests indicate that the respondent population was not significantly different from the nonrespondent population on these 2 important characteristics.

To derive the impact of firm profitability on the exit decision, a 2-stage approach was used to control for the interdependence of the factors affecting profitability and, subsequently, the exit decision. The first stage of the analysis calculates the estimated return over variable costs (ROVC) by modeling ROVC as a function of technological, managerial, and financial factors.

Return over variable costs is defined as total farm revenue from milk receipts and livestock sources net of variable expense. Variable expense is defined according to the procedure used by the USDA to calculate the costs and returns to dairy farming (USDA, 2004). Costs accrue over 5 different expense categories: marketing, herd health management, crop and feed, farm maintenance, and other expenses. Consistent with USDA's commodity costs and returns report, all farm labor, family and hired, is treated as an overhead expense and is omitted from the variable cost calculation. Based on the economic shut-down rule, it is hypothesized that those producers earning lower returns over variable costs will exit the industry.

Eleven variables, reflecting technology, management, and efficiency characteristics of individual farms, were selected as explanatory variables in the first-stage regression. Variables describing the state of production and milking technology include dummy variables for whether the farm used AI, a personal computer to manage production or finance information, TMR machinery, scheduled veterinary visits, grazed pasture as the primary source of forage, or milking parlor or stanchion system. All variables take a value of 1 if the technology is used. It is hypothesized each will have a positive influence on ROVC.

The efficiency category is divided into 2 subcategories: production and economy. Milking herd size and milking herd productivity delineate the technical efficiency category. A farm's milking herd size reflects overall farm size and the structure of the average cost curve. Tauer (2001) indicated that smaller farms are more likely to be cost inefficient and that cost per hundred-weight (45.4 kg) decreases with herd size. As such, it is hypothesized that producers on smaller farms are more likely to have lower ROVC.

The milking herd productivity variable implicitly captures all milk yield maximizing management practices used to improve or maintain herd productivity. It is hypothesized that producers not employing herd management techniques are not maximizing economic herd output. Subsequently, lower ROVC may be realized.

Total asset turnover ratio, feed cost efficiency, and legal structure make up the financial efficiency category. The total asset turnover ratio is a measure of the producer's ability to use farm capital to generate revenues. It is hypothesized that producers with higher ratios will earn higher ROVC. The feed efficiency variable measures the cost of produced and purchased feed per cow. Those producers with higher purchased and produced feed costs per cow are hypothesized to earn lower returns. Managerial organization is captured through the legal structure of the farm. This variable is defined as a dummy variable with the value of 1 if the operation is a sole proprietorship and 0 otherwise.

The second stage, modeling the decision to exit dairy farming (or remain in the industry), was estimated through logit regression to derive the determinants that account for why dairy producers are choosing to leave the industry. Following Pindyck and Rubinfeld (1991), the logit model can be estimated according to Equation 1:

$$P_i = F(Z_i) = \frac{1}{1 + e^{(-Z_i)}}, \quad [1]$$

where the dependent variable, P_i , represents the probability of the exit decision occurring for firm i . The assigned value is 1 if the producer expects to stop milking within the next 5 yr and is 0 if otherwise. This decision is explained by Z_i , a vector of unknown coefficients defining a utility index, and e represents the base of natural logarithms (Griffiths et al., 1993).

This study hypothesizes that the exit decision is a function of explanatory variables that can be grouped into 3 categories: demographic characteristics of the producer, economic efficiency, and the opportunity cost of remaining in dairying. The index modeled in this

analysis is specified in Equation 2 and is estimated using the maximum likelihood procedure:

$$Z_i = \alpha + \beta_1 age_i + \beta_2 education_i + \beta_3 predictedROVC_i + \beta_4 income(off-farm)_i + \beta_5 herfindahl_i + \varepsilon_i, \quad [2]$$

where α is a scalar, β is a $j \times 1$ vector of parameters to be estimated, and the error term is defined as ε_i . The coefficients on the first two variables, β_1 and β_2 , summarize the impact of demographic characteristics on the exit decision, age, and education. The life-cycle model of investment, expansion, and disinvestment, and hence the influence of a producer's life-cycle stage on the exit decision, is captured by the age variable.

Consistent with Gale (1994), who suggests that because producers of retirement age or older "may reduce farm size to reduce work effort as their health declines or to accommodate reduced income needs," it is hypothesized that the probability of disinvestment behavior, reflected as the exit decision, should increase with age (Gale, 2003). Human capital and managerial ability is represented as the producer's highest year of formal education. Higher levels of education can be positively or negatively correlated to the probability of the exit decision by either creating the opportunity to access off-farm employment or by increasing the willingness to adopt management intensive systems in an effort to improve efficiency, respectively.

The economic efficiency category is comprised solely of the predicted value of the ROVC variable. The predicted value of ROVC for firm i is calculated in the first stage of analysis, and β_3 summarizes its impact on the exit decision. It is hypothesized that lower ROVC will increase the likelihood of exit.

The opportunity cost category is comprised of the final 2 variables: β_4 measures the importance of off-farm income relative to farm income, and β_5 summarizes the impact of diversification of farm income among milk, crop, and livestock sources. Producers are predicted to perceive lower transaction costs when transitioning out of the industry to alternative employment when the producer, or another family member, is currently employed off the farm. As a result, it is hypothesized that the likelihood of exit increases when 50% or more of total household income is earned off-farm. How diversified or concentrated is a farm's income in milk, crop, and livestock is measured with a Herfindahl index (Schmalensee, 1977). The index is calculated as the sum of the squared income shares. A higher number indicates concentration, and a lower number indicates diversification. This index can be positively or negatively correlated to the exit decision by either lowering the transition costs of moving into a different agricultural activity or by reducing volatility of farm income

during a period when the milk price falls below the average variable cost of production.

A transformation of the probability formula is conducted to determine the marginal impact of a change in each of the values of the independent variables on the exit decision (Griffiths et al., 1993). The goal is to isolate a variable to determine the impact of a change in underlying determinants on a producer's probability of exit. These marginal changes are useful in identifying variables that can be linked to extension and public policy strategies to reduce firm exit. The marginal impact of that change is determined by Equation 3:

$$\frac{\partial \hat{P}_i}{\partial X_i} = \frac{\partial F(X_i B_j)}{\partial X_i} = f\left(\frac{e^{-\hat{z}}}{(1 + e^{-\hat{z}})^2}\right) * \hat{\beta}_j. \quad [3]$$

This will produce an estimate of the percentage change in the probability a producer will choose to exit the industry given a 1-unit change in the selected variable. The coefficient, β_j , is used to denote the estimate for predictor j from the full set of explanatory variables described in Equation 2. The estimated value for Z_i was computed at the median of the explanatory variables, creating a profile dairy producer who is 52 yr old with a high school education who does not earn off-farm income, is highly specialized toward only milk production, and earns a net cash profit of \$1.30/hundredweight (45.5 kg) from milk sales.

RESULTS AND DISCUSSION

Summary statistics of the variables used in the first- and second-stage regressions are presented in Table 1. The descriptive statistics were analyzed in a split-file format to illustrate differences between producers exiting or not exiting. Results of the corrected OLS regression are presented in Table 3, and the results from the second-stage regression, the focus of this study, are presented in Table 2. Both equations were estimated using Shazam.

Heteroskedasticity was diagnosed in the first-stage regression, and White's heteroskedastic-consistent covariance matrix was applied to correct the problem (White, 1980). The return of variable cost was positively related to whether a producer used AI and the size of their herd and was negatively related to whether they relied on pasture as the primary source of forage during the grazing season and the total cost of purchased forage and feed per cow. The predicted ROVC value from this regression is integrated into the second-stage logit regression model.

The logit regression model predicts 84% of the exit decisions correctly indicating a strong model fit. The model found 4 variables that were significant in de-

termining the decision to exit dairying: the producer's age, the predicted value of the ROVC, the importance of off-farm income, and the diversity of on-farm income as measured through the Herfindahl index.

The positive signs on the variables for age and off-farm income importance indicate the likelihood of exit are reduced if a producer is younger or if off-farm income is less important than on-farm income to total farm income. Results from the age variable support the life-cycle model and indicate that older producers are more likely to exit. For each year that a producer ages beyond the average of the data, the probability of the decision to exit occurring increases by 1.14%. Off-farm income provides a pulling force on the exit decision when it contributes a greater proportion to total farm income than on-farm income. The marginal impact of this variable on the probability of exiting is extremely high, and interpretation is cautioned because this variable is measured as a binary variable and must be interpreted at the point where off-farm income becomes more important than on-farm income. When off-farm income begins to dominate on-farm income, the probability that the producer will exit increases by nearly 5 times.

Negative signs on the Herfindahl index and estimated ROVC variables are consistent with hypothesized results. Diversification of on-farm income contributes to an increased likelihood of exit by reducing the transaction costs of exiting dairying to another type of farming. Conversely, those producers who are specialized in milk production are less likely to exit the industry. The difference in the Herfindahl index between farmers exiting and not exiting, multiplied by the marginal impact, resulted in a 0.91% decrease in the probability of exiting.

Consistent with theory, higher ROVC reduce the likelihood of exit. Producers who are, in a sense, better able to reduce per unit costs or manage herd health to provide a higher value milk product, based upon the ratio of components, are less likely to exit. For each additional \$0.13 increase in the ROVC, the probability of an exit decision decreases by 2.16%. According to results from the first-stage regression, herd size, feed costs per cow, whether one used AI or not, and whether one used pasture as the primary source of forage are significantly correlated with ROVC. Strategies to increase ROVC, and hence reduce the probability of an exit, should focus on these factors affecting cost structure. However, care should be taken in interpreting the results of the first-stage regression, as only a small portion of variability is explained.

CONCLUSIONS

Many argue that historically low milk prices are driving many producers out of dairying and that price inter-

Table 1. Mean and standard deviation of the determinants selected for least squares and logit regression.

	Description	Not exiting	Exiting	Total
ROVC	Return over variable cost (\$/cwt [45.4 kg])	1.70 (10.01) ¹	0.01 (6.99)	1.30 (9.37)
AI	AI services used (0 = no; 1 = yes)	0.94 (0.24)	0.93 (0.26)	0.94 (0.24)
PC	Use of computer-based herd management software (0 = no; 1 = yes)	0.24 (0.43)	0.20 (0.41)	0.23 (0.43)
TMR	Use of TMR machinery (0 = no; 1 = yes)	0.47 (0.50)	0.20 (0.41)	0.41 (0.50)
Vetsched	Use of regularly scheduled veterinary visits (0 = no; 1 = yes)	0.65 (0.48)	0.60 (0.51)	0.64 (0.48)
Pasture	Pasture use as forage ration (0 = no; 1 = yes)	0.49 (0.51)	0.80 (0.41)	0.56 (0.50)
Milking system	Milking technology (0 = stanchion or tie stall; 1 = parlor)	0.57 (0.50)	0.07 (0.26)	0.45** (0.50)
Herd	Milking herd size (no. of cows)	204 (289)	71 (30)	173** (259)
RHA	Rolling herd average (cwt [45.4 kg]/milk cow)	166.76 (43.31)	149.80 (39.93)	162.78 (42.85)
ATR	Total asset turnover (farm revenue [\$]/ending capital assets [\$])	0.78 (0.62)	0.61 (0.57)	0.74 (0.61)
Feed	Total feed costs per cow (\$/cow)	596 (307)	622 (324)	602 (308)
Legal structure	Business legal structure (0 = partnership or corporation; 1 = sole proprietorship)	0.45 (0.50)	0.53 (0.52)	0.47 (0.50)
Age	Producer's age (yr)	51 (12)	58 (11)	53† (12)
Education	Producer's highest level of formal education (yr)	13 (2)	14 (3)	13 (2)
Off-farm	Off-farm income importance (0 = <50% of total income; 1 = ≥50% of total income)	0.18 (0.39)	0.33 (0.49)	0.22 (0.42)
Herfindahl	Diversity of on-farm income as measured by a Herfindahl index	9063 (771)	8364 (1257)	8899† (945)
N	Sample size	49	15	64

¹Standard deviation of the mean is listed in parentheses.

**, *, †Means of the 2 subsets are statistically different at 1, 5, and 10% levels, respectively.

vention will slow the number of producers choosing to exit the industry. This research identified additional factors that affect the decision to exit dairy farming. A 2-stage regression model was used to derive the determinants that play a role in the exit decision for a sample

of dairy farmers from a traditional dairying state. Results from the second-stage logit model indicate there are several factors, in addition to ROVC, which influence an individual's exit decision. These additional factors include the producer's age, the importance of off-farm income, and the diversity of on-farm income. Regression analysis returned expected signs on all of these significant variables. The likelihood of exit increases as the producer ages and as the importance of off-farm income to total income grows. The likelihood of exit is lowered as a firm specializes toward milk production and as the ROVC increase.

Based on these results, courses of action are recommended to provide long-run industry support options. Linking exiting producers, wishing to transfer the farm outside of the family, to younger potential entrants is one manner to reduce the barriers to entry and to address the predictable component of producer retirement. As off-farm employment opportunities grow in rural areas, this may impact the division of family time between farm and non-farm employment. If farms shift time allocation to non-farm employment activities, and

Table 2. Logit model estimates for the probability of an exit decision (n = 64).¹

Variable	Coefficient	SE	Marginal probability (%) ²
Age	0.097**	0.039	1.14
Education	0.213	0.174	2.49
Predicted ROVC ³	-0.185**	0.086	-2.16
Off-farm	1.822**	0.931	43.1
Herfindahl index	-0.0006†	0.0004	-0.007
Constant	-4.429	4.905	

¹Log of the likelihood function = -28.9; likelihood ratio test = 19.9**;
percentage of correct predictions = 84%.

²Evaluated at the median value of each variable.

³ROVC = return over variable costs.

**, *, †Coefficients are statistically different from 0 at the 1, 5, and 10% probability levels, respectively.

Table 3. Least squares regression estimates of ROVC (return over variable costs) using White's heteroskedasticity consistent covariance matrix ($n = 64$; adjusted $R^2 = 0.09$).

Variable	Coefficient	SE
AI	7.172**	2.499
Personal computer	-3.732	3.084
TMR machinery	-2.908	2.209
Scheduled veterinary visits	3.221	2.446
Pasture usage	-5.785*	2.605
Technology	2.647	2.679
Herd size (milking herd size)	0.007*	0.003
Herd average (cwt [45.4 kg]/milk cow)	-0.028	0.037
ATR (total asset turnover ratio)	-1.357	1.676
Feed cost (\$/milk cow)	-0.007**	0.003
Legal structure	-1.971	2.355
Constant	6.158	8.570

**, *, †Indicates that the coefficients are statistically different from 0 at the 1, 5, and 10% levels, respectively.

the importance of this income source becomes greater than farm income, the likelihood of exit increases.

This and the remaining determinants have important implications for the structure of dairy farming in a traditional dairying state. The likelihood of exit increases as the importance of off-farm income increases and as farm production becomes more diversified. Farms continuing to produce in the future will be more specialized in producing low cost milk, and these revenues will be the primary source of farm income. Farms with larger herd sizes, better able to control feed costs, not relying upon pasture, and using AI will be earning higher returns over variable cost and will be less likely to exit.

The goal of Maine dairy policy, and many traditional dairying states, is to foster both a healthy and diverse industry. Findings from this research confirm the need for a broader focus of dairy support programs beyond the scope of price supports to reduce farm exit. Results from this study are generalizable to the population of Maine farmers not responding to the survey and can be used as a point of reflection for a geographically broader survey on farm exit decisions. In addition, future research should explore the relationship of the exit decision to alternative land-use opportunities to determine whether urban and residential development increases the probability of exiting dairy production.

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