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Dairy Farm Size, Entry, and Exit in a Declining Production Region

Noro C. Rahelizatovo and Jeffrey M. Gillespie

ABSTRACT

As with most agricultural industries, the U.S. dairy industry has evolved into a structure including fewer yet larger firms. In Louisiana, total milk production has declined along with dairy farm numbers since 1972. This study addresses the impact of alternative policies, macroeconomic factors, and technology on the structure of the Louisiana dairy industry using a micro-data non-stationary Markov chain analysis. Results indicate that a number of factors have affected the structure of the industry in Louisiana, including but not limited to prices, milk supply reduction programs, technology and interest rates.

Key Words: dairy farms, Markov chain analysis, seemingly unrelated regression.

Throughout recent history, technological developments have led to larger farms able to benefit from associated increased-size economies. The U.S. milk production industry has been no exception, with increased consolidation and accompanying exit of firms as greater production efficiency has been sought. Over time, fewer U.S. farms have produced more milk: for instance, from 1993 to 1997, the number of U.S. milk production firms dropped from over 159 thousand to under 117 thousand, while total milk production increased. The percentage of farms with over 100 cows increased from 13.7 to 19 percent over that period.

While firm exit and consolidation may be a concern in any region due to the reduction of employment in the industry, it can be especially troubling in a region where reduction of firm numbers occurs along with a decrease in total production. Such a situation may lead to massive out-migration of labor, leaving fewer opportunities for those who wish to remain in the industry and/or region. This situation has been common in several regions with respect to dairy farming. For instance, in the Southeastern U.S.[1] from 1981 to 1995, nine of the 11 states experienced decreases in dairy farms and total milk production. Over the period, while total U.S. milk marketed increased by 17 percent, milk marketed in the Southeast decreased by seven percent, decreasing the Southeast's share of milk marketed from 11.6 to 9.2 percent.

The reduction in dairy production in marginal regions of production is leaving milk producers, input suppliers, milk processors, researchers, and extension personnel asking which factors have exacerbated the rapid exit of milk production firms in their regions. It is

Noro Rahelizatovo is a graduate research assistant and Jeffrey Gillespie is an assistant professor, Department of Agricultural Economics and Agribusiness, Louisiana State University Agricultural Center, Baton Rouge, Louisiana 70803.

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[1] States in the Southeastern U.S. are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

expected that some movement of production firms will occur as new regions develop comparative and/or competitive advantages with new technology (Reimund *et al.*). However, given the natural movement of firms due to technology, are there exogenous macroeconomic and policy factors that have acted to accelerate or decelerate the evolutionary process? Understanding the effects of these factors has become critical in regions where dairy production has decreased to levels where few milk processors remain to buy milk from the remaining producers and short-term viability is in question. Many of these regions are searching for policy initiatives, such as the Northeast regional compact, that could potentially slow the trend of farm loss.

This paper examines the survival tendencies and growth patterns of dairy farms in a marginal production, dairy-deficit region, Louisiana. Factors that have led to the continued decline in farm numbers and increases in farm size are identified and analyzed. While the results apply specifically to the Louisiana dairy industry, implications may be drawn for other marginal milk production regions across the U.S., especially dairy deficit regions in the Southeast.

The objectives of this study are to (i) determine the growth patterns and survival tendencies of dairy farms in a marginal milk production region over the period 1981–1995, specifically the size distribution of dairy farms, and (ii) determine the effects of macroeconomic factors, agricultural policies, and technological changes on dairy farm structure in the region. Markov chain analysis is used to model the effects of factors influencing the numbers and sizes of dairy farms and implications are drawn as to the future of the industry in marginal production, dairy-deficit regions. Louisiana provides an interesting example of a rapidly decreasing milk production region: from 1993 to 1997, the number of dairy farms decreased from 696 to 557, while the total pounds of milk produced decreased from 923 million to 795 million.

Literature Review

Among the early cited applications of Markov chain analysis in agricultural economics research was Williams and Alexander (1963), in which structural changes in the Louisiana dairy industry were examined. The economic environment of milk production was rapidly changing; from 1952 to 1962, the number of dairy farms in Louisiana decreased from 4461 to 3453. Williams and Alexander predicted that the number and size of dairy farms would reach an equilibrium by 1972 in which 3218 farms, which produced 1500 pounds of milk per day, would be sustained. History has proven that the industry did not reach the predicted equilibrium.

Markov chain analysis has been applied in numerous other studies, where researchers have estimated the probability of movement from one state of nature to another over time. In most industry structure Markov chain analyses, *state of nature* refers to size category. A Markov chain model uses micro-data when data reflecting movements of individual firms among the states of nature over time are available. Examples of such studies include Williams and Alexander, Hallberg, Stavins and Stanton, and Chatzopoulou. Alternatively, when individual firm movements among states of nature through time are unknown and only aggregate data indicating the number of firms in each size category for each period are available, a macro-data model may be used. Examples include Disney, Duffy, and Hardy; von Massow, Weersink, and Turvey; and Zepeda. When available, micro-data is preferred since it provides more detailed information.

Early researchers applying Markov chain models in firm analysis assumed stationarity, that the probability law relating the next period's state to the current state did not change over time (e.g., Adelman; Williams and Alexander). Later, as test results showed that stationarity did not adequately reflect reality in many cases, analyses were conducted assuming non-stationary transition probabilities. This recognized that the probability of a firm moving from one size category to another was not constant over time and depended upon exogenous variables (e.g., Hallberg; Stavins and Stanton; Chatzopoulou). In this study, nonstationarity is assumed.

Since the Williams and Alexander study,

several researchers have examined dairy industry structure using Markov chain analysis. Among the studies, Stavins and Stanton examined the New York dairy industry during the 1970s. They compared results and implications using several models, including stationary, non-stationary, and micro- and macro-data models. Chavas and Magand (1988) examined four U.S. regions of dairy production with a non-stationary macro-data model. They showed that dairy farm movements in the southern U.S. appeared to be more highly influenced by profitability than the more traditional production regions, such as the Northeast and Lake States. Zepeda examined structural change in the Wisconsin dairy industry using a non-stationary macro-data model. She found that the milk-feed price ratio, farm debt, interest rate, and the dairy termination program affected farm entry and exit. Our study differs from these studies in that we (i) utilize micro-data, including the full population of firms in a particular state, (ii) closely examine a dairy deficit milk production region, (iii) include a wider set of explanatory variables to examine the changing structure, and (iv) include more than one independent variable to explain the changes in transition probabilities among size categories.

Theory

Markov Chain Models

Three basic quantities are considered in a Markov chain process: (i) a finite set of states of nature, (ii) the initial distribution of components in those states of nature, and (iii) the stochastic transition probability matrix that shows the probabilities of moving among the states of nature. A process involving an initial distribution matrix N^0 with n states of nature, transition probability matrices P^t over time, and a final time period T may be represented in matrix form as follows:

$$\text{(1)} \quad N^0_{(1\times n)} \times P^1_{(n\times n)} \times P^2_{(n\times n)} \times \ldots \times P^T_{(n\times n)} = N^T_{(1\times n)}$$

where the superscripts represent the time period, t = 1, . . . , T; the subscript indicates matrix dimensions; and $N^T_{(1\times n)}$ represents the matrix of the distribution at time period T. Each transition probability matrix $P^t_{(n\times n)}$ has the following characteristics:

(i) each element represents a specific transition probability p_{ijt}, which is the probability of moving from state i in year t − 1 to state j in year t;
(ii) $0 \le p_{ijt} \le 1$ for i = 1, 2, . . . , n, j = 1, 2, . . . , n, and t = 1, 2, . . . , T; and
(iii) for any given state i,

$$\sum_{j=1}^{n} p_{ij} = 1.$$

Factors Influencing the Trend Toward Increased Concentration

A number of factors are hypothesized to have influenced the entry, exit, expansion, and contraction of dairy farms over the period 1981–1995. These factors include prices, agricultural policies, and macroeconomic factors. In this study, the following factors are examined to determine their effects on dairy farm entry, exit, expansion, and contraction: the milk price, feed price, milk diversion program, dairy termination program, prime interest rate, farmers' average debt-equity ratio, and average milk produced per cow.

The effects of the above factors are discussed in the context of three milk producer types—turnkey, established, and debt-free farmers—as identified by Klemme.[2] Turnkey farms are typically relatively new farms characterized by a long planning horizon, high level of investment, and high debt. Established farms have been producing for an intermediate time period. Debt load is average and occasional expansion may occur with these firms.

[2] The producer types listed—turnkey, established, and debt-free producers—are akin to the entry or establishment, growth and survival, and exit or disinvestment stages, respectively, as discussed by Boehlje in the context of the family farm life cycle.

Debt-free farms are typically owned by producers nearing the end of their careers, and are likely to exit under conditions favorable for exit. Each of these producers uniquely reacts to factors impacting net returns (2),

$$(2) \quad \pi_m = (P - AVC) \cdot Q - TFC$$

where π_m represents the firm's net returns associated with milk production, P is the price of milk, AVC is the firm's average variable cost of production, Q is the firm's quantity of milk produced, and TFC is the firm's total fixed cost associated with milk production.

U.S. milk prices have varied over time, likely influencing producers' expansion and/or contraction decisions. In years of lower milk prices, more producers are likely to reduce milk production through accelerated culling of marginal cows, especially established and debt-free producers. Feed ration changes may occur, as well, under price changes. These producers would be attempting to reduce average variable costs of production. In some cases, producers might even exit the industry under low prices, especially if they were debt-free and close to retirement. Alternatively, it is possible that lower milk prices lead some turnkey and established producers to expand. These would be producers who plan to remain in business, expanding in order to reduce average fixed costs and benefit from greater size economies.

Feed accounts for a large proportion of the total specified expenses in milk production and is the largest variable cost associated with dairy production.[3] It is, thus, a major factor affecting expansion and contraction decisions. It is expected that in years of high feed prices more producers exit due to lower profits associated with higher average variable costs. Many of these producers are likely debt-free producers who are retiring from dairying; however, some may also be high-debt turnkey producers who declare bankruptcy. Few producers are likely to expand under conditions of higher feed costs, though in limited cases, turnkey and established producers may expand in order to lower average fixed costs and benefit from increased economies of size.

Two voluntary participation dairy programs—the milk diversion program and the dairy termination program—were enacted by the U.S. Congress in the mid-1980s. In a region including a large number of marginal producers, these programs were probably especially attractive. The milk diversion program lasted from January, 1984 to March, 1985. Participants decreased milk production from five to 30 percent from the 1981–1982 base period and, in return, received \$10 per hundredweight for all milk marketings reduced below the base period. This program likely influenced the contractions of dairy farm size that occurred in those years. The program likely affected net returns in Year 1 of the program as in (3)

$$(3) \quad \pi_{md} = (P - AVC) \cdot (Q - dQ) + S + C - TFC$$

where Q was reduced by dQ and S subsidized the reduction, dQ. Profit under the milk diversion program in Year 1 is represented as π_{md} and returns from cull cow sales are represented by C. If condition (4) held, producers likely entered the program and decreased production.

$$(4) \quad S + C > (P - AVC) \cdot dQ + R$$

where R is the cost incurred in replacing heifers for any anticipated increase in milk production upon termination of the Milk Diversion Program in March, 1985. Higher average variable cost producers with lower quality cows probably entered the program and culled marginal cows. This culling activity would have allowed producers to reduce AVC while collecting the subsidy, S, and the value of the culled animals, C.

Dairy termination program sign-ups occurred in 1986 and 1987. Program participants agreed to (i) cease milk production, (ii) slaughter and/or export their herds, (iii) not engage in dairy activity during the subsequent five-year period, and (iv) not lease the farm to

[3] Boucher and Gillespie estimate that feed accounts for approximately 40 percent of the total specified expenses in milk production in Louisiana.

another producer for milk production during the period. In return, milk producers were paid various bid prices to a maximum of $22.50 per hundredweight of their 1985 milk production. The program probably influenced the exit of dairy farms in 1986–1987, especially in cases where (5) existed:

$$D(Q_{85}, B) - \sum_{h=1}^{5} \gamma^{h-1}\pi_{mi} > 0 \tag{5}$$

where h represents Years 1 through 5 of the program, D is the total program payment as a function of quantity of milk produced in 1985, Q_{85}, and bid price, B. γ is the discount factor. The economic question is whether the lump-sum buyout payment was greater than the rent returns that could be expected over the time expected to remain in dairying. The dairy termination program was particularly attractive to producers nearing retirement.

Another factor that may have influenced dairy farmers' decisions to expand or contract is the producer's debt-equity ratio. High debt can be a barrier to entry or expansion for producers. Also, increases in bankruptcy are likely to occur with high debt, thus forcing increased farm exits. The debt-equity ratio affects all producer types. However, turnkey producers are likely to carry the highest debt relative to equity.

The cost of capital likely influences dairy farm size. As new technology is required, larger capital investments are needed for expansion. Mainly fixed costs are affected by the prime interest rate. Lower prime interest rates encourage while higher rates discourage investment. Thus, it is hypothesized that a lower prime interest rate encourages expansion of dairy farms. It is likely that the prime interest rate affects turnkey and established producers' expansion decisions the most; these are the producers who are most likely to expand production under favorable economic conditions. Alternatively, if the prime interest rate is high, more exits by debt-free producers nearing retirement might be expected if the interest earnings on liquidated assets promise to be greater than the rent returns to specialized assets if milk production is continued.

The average milk production per cow affects dairy farm size.[4] As milk production per cow increases, milk production per farm increases, even when the number of cows per herd remains fixed. Over time, the average milk production per cow might serve as a proxy for technological and managerial change. All farmer types are likely affected by average milk production per cow.

Methods

Estimating the Effects of Exogenous Factors on Transition Probabilities

Transition probabilities p_{ijt} in a non-stationary transition probability model are derived as (6)

$$p_{ijt} = \frac{m_{ijt}}{\sum_{j=1}^{n} m_{ijt}} \qquad \begin{array}{l} i = 1, \ldots, n, \\ j = 1, \ldots, n, \\ t = 1, \ldots, T. \end{array} \tag{6}$$

Term m_{ijt} represents the number of firms in Size Category i in year t − 1 that moved to Size Category j in year t. Individual dairy farm data are needed to determine the m_{ijt}'s. By dividing the number of farms moving from one size category to another category by the total number of farms in the initial size category, the transition probability for a particular year can be estimated. These data were compiled from reports of the Louisiana State Department of Health and Human Resources, which included the pounds of daily milk production of all commercial dairy farms in Louisiana from 1981 through 1995. Each commercial dairy farm state was traced over the period of study. Five size categories were identified for the analysis: the entry-exit (E) category, including non-producing farms with the potential to enter milk production and serving as a depository for firms that had exited milk production; the small (S) size category, including farms producing less than 2,000 pounds of milk per day; the medium

[4] Data from the National Agricultural Statistics Service indicate that Louisiana has had among the lowest milk production per cow in the U.S. in recent years.

(M) category (2,000 to 3,999 lbs); the large (L) category (4,000 to 5,999 lbs); and the extra-large (X) category (6,000 lbs and over). Each dairy farm was assigned to a specific category each year based upon the pounds of milk produced.

The matrix of transition probabilities $P(p_{ijt})$ estimated in this study is shown in (7).

$$(7) \quad P[p_{ijt}] = \begin{bmatrix} p_{EEt} & p_{ESt} & p_{E5t} & 0 & 0 \\ p_{SEt} & p_{SSt} & p_{S5t} & 0 & 0 \\ p_{MEt} & p_{MSt} & p_{MMt} & p_{M5t} & 0 \\ p_{LEt} & 0 & p_{L5t} & p_{LLt} & p_{LXt} \\ p_{XEt} & 0 & 0 & p_{X5t} & p_{XXt} \end{bmatrix}$$

Some transition probabilities were consistently small (≤ 0.001). In these cases, size categories were aggregated. This technique is commonly used in cases where some of the transition probabilities are very small (e.g., Chatzopoulou). Transition probabilities which were aggregated include EM, EL, and EX into E5 (where "5" represents the aggregation); SM, SL, and SX into S5; ML and MX into M5; LS and LM into L5; and XS, XM, and XL into X5. The seemingly unrelated regression (SUR) technique is useful in estimating the effect of the independent variables on transition probabilities p_{ijt}. Each row of (7) is a system of n linear equations (8).

$$(8) \quad \begin{aligned} p_{i1} &= \alpha_1 + \beta_{11}X_1 + \beta_{12}X_2 + \ldots + \beta_{1K}X_K + e_1 \\ p_{i2} &= \alpha_2 + \beta_{21}X_1 + \beta_{22}X_2 + \ldots + \beta_{2K}X_K + e_2 \\ p_{in} &= \alpha_n + \beta_{n1}X_1 + \beta_{n2}X_2 + \ldots + \beta_{nK}X_K + e_n \end{aligned}$$

where there are K independent variables, α_j and β_{jk} represent the parameters to be estimated, X_k represents the independent variables, and e_j represents the error term. It is expected that the errors associated with the equations are correlated; the transition probabilities that constitute the dependent variable p_{ijt} of each equation sum to one. The estimation should include specific restrictions (Hallberg) so as to satisfy conditions (9) and (10) in a Markov chain model:

$$(9) \quad 0 \leq p_{ijt} \leq 1, \qquad i = 1, 2, \ldots, n, \quad j = 1, 2, \ldots, n, \quad \text{and} \quad t = 1, 2, \ldots, T$$

$$(10) \quad \sum_j p_{ij} = 1, \qquad \forall\, j = 1, \ldots, n.$$

Unfortunately, enforcement of (9) for all estimates is not feasible in our SUR model. An alternative model is a multinomial logit model; however, the large number of observations needed for sufficient degrees of freedom with numerous choices and independent variables prevents use of the model in our case. Restrictions (11) and (12) ensure satisfaction of (10).

$$(11) \quad \sum_{j=1}^{n} \alpha_j = 1, \qquad j = 1, \ldots, n$$

$$(12) \quad \sum_{j=1}^{n} \beta_{jk} = 0, \qquad \forall\, X_k.$$

Restriction (12) ensures that the effect of the change of any explanatory variable in one equation of the system offsets the cumulative effect of that explanatory variable in the other equations.

In view of the restrictions, the method used by Barten to estimate a complete demand system is useful. A total of $(n - 1)$ equations for each size category is estimated using SUR. The constant term α_n for the remaining "holdout" equation n is derived using (13).

$$(13) \quad \alpha_n = 1 - \sum_{j=1}^{n-1} \alpha_j.$$

The remaining coefficient β_{nk} is derived simultaneously as in (14).

$$(14) \quad \beta_{nk} = -\sum_{j=1}^{n-1} \beta_{jk}.$$

Variances of the coefficients of the remaining equation are derived using (15).

$$(15) \quad \operatorname{var} \beta_{nk} = \sum_{j=1}^{n-1} \operatorname{var} \beta_{jk} - 2 \sum_{j=1}^{n-1} \sum_{l=1}^{n-1} \operatorname{cov}(\beta_{jk}, \beta_{lk}) \qquad j \neq l, \quad j < l.$$

The asymptotic t-ratios t_n are computed using (16).

$$(16) \quad t_n = \frac{\beta_{nk}}{\sqrt{\text{var } \beta_{nk}}}.$$

In each of the systems of equations all equations do not contain the same set of explanatory variables. Milk diversion program and dairy termination program variables are excluded from the equations that express the expansion movement. Dairy termination program variables are excluded from the equations that express the contraction in size since the program allows only for exit. Milk diversion program variables are excluded from the equations that express exit since the program was designed to encourage contraction of production, not exit.

To create a "closed" system whereby decisions of all dairy production firms could be modeled throughout the assessed time period, an entry category was needed. Identification of the initial pool of potential entrants in 1981 presented a challenge, as discussed by Adelman, and Stavins and Stanton. This model considers the total new entries over the period 1981–1995 as the initial number of non-producing firms N_0 in 1981. That initial pool comprises the total set of producers who entered production at some point during the period, 1981–1995. In the case where a producer's offspring took over management of the dairy farm, a new entry is not assumed.

Time series and cross-sectional data for 15 years and three milk production regions of Louisiana were pooled for the analysis. Data for milk and feed prices are those experienced by Louisiana producers (USDA, 1996). These prices are adjusted for inflation by the consumer price index. The prime interest rate (*Economic Report to the President*) is the average for the U.S., as is the debt/equity ratio for United States farmers. The average milk production per cow for each region is calculated using the daily average milk production per farm (Louisiana State Department of Health and Human Resources), and the number of cows reported in Fielder and Nelson, Fielder *et al.*, Zapata *et al.*, and Zapata and Frank (1990 and 1995). The effects of the milk diversion and dairy termination programs are estimated using two discrete variables for each program (MDP84, MDP85, DTP86, DTP87), modeling the differences in the effects of the programs during the two years when each was in effect. Two discrete variables are included for the three dairy production regions in Louisiana, the Northwest (N) and Other (O). The Southeast region of Louisiana is designated as the base region.

Table 1. Numbers of Dairy Farms in Four Size Categories, Louisiana, 1981, 1988, and 1995

Size Category	1981	1988	1995
Small (<2000 lbs/day)	460	275	182
Medium (2,000–3,999 lbs/day)	383	310	259
Large (4,000–5,999 lbs/day)	70	90	104
Extra Large (≥6,000 lbs/day)	39	55	60
Total Number of Farms	952	730	605

Results

Four initial tests were performed on the data: (i) Variance proportions indicate that multicollinearity is not problematic for the set of explanatory variables, (ii) Use of the likelihood ratio test proposed by Hallberg indicates that the transition probabilities p_{ijt} are non-stationary, (iii) Box-Cox test results do not lead to rejection of the linear-linear functional form in the estimation of the p_{ij}, and (iv) Breusch-Pagan test results indicate that the error terms between the equations are correlated at a given point of time, indicating the appropriateness of SUR.

Initial examination of the data indicates that the numbers of small- and medium-sized dairy farms declined from 1981 to 1995 (Table 1), with the small category declining the most. The numbers of large and extra-large dairy farms increased. The total number of dairy farms in Louisiana declined; the magnitude of expansion of the large and extra large size categories was much less than the magnitude of contraction in the small and medium-size categories.

Based on the system-R^2s (Table 2), the best fit of the five systems of equations was with the large-size system. As expected, the fit with the entry system was not as good as with the

Table 2. Results of the Seemingly Unrelated Regression, Markov Chain Analysis

Equation	Real Milk Price ($/lb)	Real Feed Price ($/ton)	Avg Milk/ Cow (ratio)	Prime Interest Rate (%/100)	Debt/ Equity Ratio (ratio)	Dairy Termin. 1986 (0–1)
			Entry			
Entry-Entry	−0.333 (0.783)	−0.035 (0.052)		−0.002 (0.005)	−0.001 (0.002)	
Entry-Small	−0.266 (0.432)	0.070** (0.029)		−0.002 (0.003)	0.001 (0.001)	
Entry-Med-Ext Lg	0.599 (1.134)	−0.034 (0.080)		0.005 (0.007)	−0.000 (0.004)	
			Small			
Small-Exit	−2.630 (3.456)	−0.031 (0.274)	−0.007 (0.021)	0.019 (0.019)	0.002 (0.010)	0.136** (0.040)
Small-Small	4.946** (2.251)	0.137 (0.149)	−0.009 (0.012)	−0.041** (0.011)	−0.014** (0.006)	−0.136** (0.040)
Small-Expand	−2.317 (1.539)	−0.106 (0.103)	0.017 (0.010)	0.021** (0.009)	0.012** (0.005)	
			Medium			
Medium-Exit	−2.378* (1.347)	0.066 (0.089)	−0.005 (0.006)	−0.002 (0.005)	0.001 (0.003)	0.053* (0.031)
Medium-Small	0.856 (1.669)	0.078 (0.093)	−0.022** (0.009)	−0.009 (0.008)	−0.001 (0.007)	
Medium-Medium	0.369 (3.154)	−0.031 (0.197)	0.002 (0.017)	0.006 (0.018)	−0.005 (0.010)	−0.053* (0.031)
Medium-Expand	1.153 (1.511)	−0.113 (0.101)	0.026** (0.010)	0.004 (0.009)	0.006 (0.005)	
			Large			
Large-Exit	0.963 (1.128)	−0.047 (0.074)	0.011** (0.005)	0.004 (0.004)	0.001 (0.003)	0.091** (0.027)
Large-Contract	0.840 (2.873)	−0.111 (0.162)	−0.057** (0.016)	0.005 (0.014)	0.006 (0.011)	
Large-Large	−1.384 (4.629)	0.271 (0.292)	0.040 (0.028)	−0.008 (0.026)	−0.022 (0.017)	−0.918** (0.266)
Large-Extra Large	−0.420 (2.546)	−0.113 (0.170)	0.005 (0.017)	−0.001 (0.015)	0.014* (0.008)	
			Extra Large			
Extra Large-Exit	−2.482 (1.977)	0.152 (0.130)	−0.011 (0.009)	−0.003 (0.008)	−0.005 (0.005)	0.074 (0.049)
Extra Large-Contract	−7.033* (3.912)	0.424** (0.214)	−0.059** (0.021)	0.011 (0.018)	−0.004 (0.016)	
Extra Large-Extra Large	9.515* (4.990)	−0.576** (0.282)	0.070** (0.026)	−0.008 (0.024)	0.009 (0.018)	−0.737 (0.485)

** and * indicate significance at the 0.05 and 0.10 levels, respectively.

Size Category	Entry/Exit	Small	Medium	Large	Extra Large
System R-Squares	0.63	0.70	0.72	0.80	0.72

Table 2. Extended

Dairy Termin. 1987 (0–1)	Milk Diversion 1984 (0–1)	Milk Diversion 1985 (0–1)	North East Region (0–1)	Other Regions (0–1)	Constant
			Entry		
			0.015	0.022*	1.055**
			(0.014)	(0.014)	(0.040)
			−0.028**	−0.028**	−0.020
			(0.007)	(0.007)	(0.022)
			0.012	0.006	−0.034
			(0.019)	(0.020)	(0.058)
			Small		
0.059			0.223	0.033	0.292
(0.050)			(0.560)	(0.695)	(0.327)
−0.059			−0.152**	−0.092**	0.729**
(0.051)			(0.032)	(0.039)	(0.187)
			0.129**	0.059*	−0.021
			(0.027)	(0.033)	(−0.157)
			Medium		
0.043			0.032**	0.031*	0.258**
(0.038)			(0.016)	(0.019)	(0.094)
	−0.196	−0.041	−0.028	−0.049*	0.234*
	(0.050)	(0.054)	(0.023)	(0.028)	(0.137)
−0.043	0.196	0.041	−0.081*	−0.046	0.783**
(0.038)	(0.500)	(0.101)	(0.048)	(0.006)	(0.283)
			0.077**	0.064**	−0.274*
			(0.027)	(0.033)	(0.154)
			Large		
−0.012			0.022*	0.067**	−0.208**
(0.033)			(0.012)	(0.015)	(0.074)
	−0.018	−0.158*	−0.064	−0.062	0.712**
	(0.084)	(0.089)	(0.040)	(0.050)	(0.240)
0.012	0.018	0.158*	−0.045	0.013	0.507
(0.034)	(0.087)	(0.089)	(0.073)	(0.088)	(0.434)
			0.087*	−0.018	−0.011
			(0.045)	(0.055)	(0.260)
			Extra large		
0.179**			0.028	0.060**	0.295**
(0.056)			(0.022)	(0.027)	(0.135)
	−0.081	0.024	−0.138**	−0.179**	1.040**
	(0.116)	(0.133)	(0.053)	(0.065)	(0.318)
−0.179**	0.081	−0.024	0.109	0.119	−0.334
(0.056)	(0.116)	(0.131)	(0.067)	(0.083)	(0.397)

other systems. This is due to the few entries that occurred over the period and resulting difficulty in predicting expected firm behavior with a small number of firms. In the entry/exit, small, and medium-size categories, all predicted transition probabilities were in the interval [0,1]. In the large category, only five of the 168 (42 observations × 4 equations) were slightly negative; none was greater than one. In the extra-large category, only five of the 126 transition probabilities were slightly negative; none was greater than one. Thus, (9) was violated in just over one percent of the cases. Estimated coefficients may be interpreted as changes in probabilities. For instance, the coefficient, 0.136 for the Dairy Termination Program for the small to exit category indicates that with the program the probability of a small dairy farm exiting increased by 0.136.

SUR results (Table 2) show that an increased milk price significantly increases the probability of small and extra-large farms remaining their respective sizes. On the other hand, as expected an increased milk price reduces the probability of medium-sized farms exiting and extra-large farms decreasing in size. These results support the hypothesis that higher milk prices lead to fewer dairy farm exits and greater firm stability.

An increased feed price increases the probability of an extra-large dairy farm contracting in size and decreases the probability of an extra-large farm remaining extra large. Unexpectedly, an increased feed price increased the probability of entrance into the small category. During eras of high feed prices, one expects fewer farms to enter the larger categories, especially given that those categories are less likely to be forage-based and more likely to be confined and more concentrate-dependent. Perhaps smaller, more forage-intensive operations are the more likely farms to arise under higher feed prices. Alternatively, significance of feed price in the equation may be due to the small number of producers who entered during the period, resulting in a poor fit of the entry system.

Results of the prime interest rate variable suggest that higher interest rates are likely to cause small-sized operations to either exit or increase in size. This is consistent with results of von Massow, Weersink, and Turvey, who found that, under higher interest rates, surviving smaller classes of hog farms were likely to either exit or expand. They suggest this is not unreasonable if the smaller size categories are highly volatile transition sizes. Alternatively, Zepeda found that smaller dairy farmers were less likely to exit under higher interest rates. Our results, along with others, suggest that smaller farms may be somewhat volatile with respect to interest rates.

As expected, higher debt-equity ratios appear to be correlated with the movement of farms among size categories. With both the small- and large-sized units, increases in the debt-equity ratio were associated with expansion. The coefficient associated with remaining the same size was negative for all size categories, though not always statistically significant. This may reflect the increased debt that these farms must incur in order to expand. Alternatively, it may reflect the idea that the higher the debt-equity ratio, the greater the fixed costs component of the farm's cost structure since the debt carries interest costs. The only way to spread these fixed costs is to spread them over more units of output. One must, however, use caution in utilizing a national farm debt-equity ratio as a proxy for dairy producers' debt-equity ratios in a particular region.

As expected, a higher average milk production per cow increases the probability of expansion of medium-sized dairy farms to larger size categories and decreases the probability of moving to a smaller size category. Results indicate that an increased average milk production per cow significantly increases the exit movement of large farms. A possible explanation is that as cows produce more milk some producers are forced to expand milk tank capacities and facilities. Thus, they face the decision of (i) investing in equipment versus (ii) reducing herd size versus (iii) exiting. Exiting may be the chosen option for some producers, especially debt-free producers who retire early. However, this is hard to accept, given that better producers are likely to be more profitable, and thus more able to stay in business. As expected, an increase in the average milk production per cow negatively influences the probability of extra-large sized farms contracting in size, but reinforces the probability of remaining extra large.

The 1984 milk diversion program does not appear to have significantly caused farms to move among the assigned size categories. This should not be interpreted as suggesting that the program had no influence on dairy production—Carley suggests that it did. Perhaps few farms that reduced production from five to 30 percent reduced it enough to fall to a smaller size category. This is likely, especially if the majority of participating producers were in the small- and medium-sized categories; it is likely that smaller producers participated in the program to a greater extent than larger ones given their probable higher average costs.

The sign for contraction of large farms due to the 1985 milk diversion program is negative and significant. During the milk diversion program of 1984, producers culled low-producing cows and maintained the higher producing ones. At the end of the program in March, 1985, higher producing existing cows were in production and higher producing replacements came into production. By the July–December period of 1985, which our data represents, there were no production limits. Farmers had, thus, increased their feeding of concentrates and replaced previously culled animals with higher producing ones, increasing production over the 1984 level.

The dairy termination program appears to have increased the probability of all size categories exiting dairy production. In the first year of the program, 1986, exit increased in all but the extra-large category; in 1987, exit movement of the extra-large size category was increased. If bid prices increased over the course of the sign-up, this is an expected outcome since the extra-large producers with greater size economies would require a higher bid price in order to exit production. These results support those of Carley, who asserts that participation in the program effectively decreased milk production in most southern states.

Remaining in the small-size category is less probable for small dairies in the Northwest and Other regions of Louisiana than in the Southeast region. Both (i) expansion movement into the larger size categories for small, medium, and large farms and (ii) exit movement of the medium, large, and extra-large dairy farms are more probable in the Northwest and other regions than in the Southeast. These estimates reflect the trend that the Southeast region of Louisiana is retaining a higher proportion of its dairy farms than the other regions. In the other regions, exit is occurring rapidly, existing farmers have expanded rapidly, and there are fewer milk plants to buy milk. Agglomeration economies[5] associated with dairy production, processing, and distribution appear to be decreasing quickly in those regions of production.

Estimating the Future Structure of the Louisiana Milk Production Industry

The model was used to predict the future structure of the Louisiana milk production industry through the year 2000. While these results should be viewed with caution due to the potential compounding of errors associated with predictions from Markov chain models, they provide useful insights into how the economic environment under alternative scenarios would likely affect industry structure. The baseline scenario assumes that milk prices follow predictions of FAPRI, including an increased milk price in 1996 and a gradual decrease thereafter. Feed prices are assumed to increase in 1996 and 1997, and decrease thereafter (USDA–NASS). Feed prices for 1999 and 2000 are assumed to follow the trend prior to 1996. Average milk produced per cow was regressed against time over the period studied, 1981–1995; the trend is assumed to continue. Prime interest rate and the debt-equity ratio are assumed to equal the mean of period 1993–1997. It is assumed that no special gov-

[5] Agglomeration economies are external economies that arise as an industry develops in a region, reducing the costs that industry players must expend to conduct business. See Gilmour for more discussion.

Table 3. Projections of the Number of Dairy Farms, Louisiana, 2000

	Unit	Entry/ Exit	Small	Medium	Large	Extra Large	Total
Production 1995	No.	582	182	259	104	60	605
Baseline							
Projection 2000	No.	681	101	232	117	56	506
Change	Percent	17	−45	−10	13	−6	−16
Milk Price $14.50, Adjusted by Consumer Price Index							
Projection 2000	No.	657	114	239	115	65	530
Change	Percent	13	−37	−8	11	8	−12
Milk Price $15.50, Adjusted by Consumer Price Index							
Projection 2000	No.	637	124	243	113	71	550
Change	Percent	9	−32	−6	9	18	−9
Average Milk Produced per Cow Increased 20 Percent							
Projection 2000	No.	649	68	196	168	106	538
Change	Percent	12	−63	−24	62	78	−11

ernment programs were enacted. The baseline prediction is that there will be 506 dairy farms in operation in 2000, down from 605 in 1995 (Table 3). Decreases occur in the numbers of small-, medium-, and extra-large sized farms, from 182 to 101, 259 to 232, and 60 to 56, respectively. Increases occur in the number of large farms, from 104 to 117. High feed prices in 1996 and 1997 were primarily responsible for the decrease in extra-large farms relative to large farms, with large farms relying more heavily on forages than extra-large farms.

Suppose the average price for all milk were set at $14.50 per hundredweight, and were adjusted by the consumer price index from 1998 through 2000. It is predicted that the number of farms would drop to 530 in 2000. If the average price had been set at $15.50 per hundredweight and adjusted by the consumer price index from 1998 through 2000, it is projected that the number of farms would have been 551 by year 2000. Under both scenarios, small and medium farms decrease in number, while large and extra-large farms increase in number. Small farms are better able to survive under these conditions, while the continued trend toward larger farms under favorable economic conditions allows for expansion of smaller farms and survival of existing extra-large ones. Suppose the average milk produced per cow were increased by 20 percent for the years 1996–2000. The number of farms would decrease to 538 in 2000. An additional scenario involved increasing the price of milk by $1.00 over the baseline, yet not adjusting by the consumer price index. The number of farms in 2000 increased to only 509, relative to the predicted 506 with the baseline.

Conclusions and Implications

The U.S. milk production industry is experiencing rapid structural change, moving toward fewer yet larger farms. This trend has been observed in most agricultural industries in recent history. However, some dairy deficit regions of the U.S. are losing farms rapidly, with total milk marketed decreasing along with farm closures. Based upon a micro-data set including detailed production data of all dairy farms in Louisiana, results of this study indicate that a number of factors have significantly affected the structure of the dairy industry, including milk and input prices, technology that has affected dairy cow productivity, agricultural policies that have provided incentives for early retirement and reduction in milk production, and farmers' financial conditions.

If real milk prices decrease in the near future, as projected by FAPRI through 2005, it is likely that an increased proportion of dairy farms will exit. Massive exodus could greatly affect the industry's viability in the near future, given that few farms would expand to larger size categories and few entries would occur. On the other hand, real soybean meal and corn prices are projected by FAPRI to decrease through 2000. Thus, part of the increased exit of dairy farms expected due to lower milk prices could be offset by lower feed prices through 2000. However, we were surprised that feed prices were not highly significant, perhaps partly due to the region's heavy reliance on forages. Thus, a proportionate decrease in feed prices relative to milk prices is unlikely to decelerate the exodus of farms in this region greatly.

One type of legislation that is currently being considered in a number of states is a southern regional compact, similar to that adopted by the Northeast. The compact would raise the price of milk and adjust it annually by the consumer price index. Results of this study indicate that if the price were set high enough farm exit would likely decelerate significantly. In addition, if milk prices were increased modestly, but not adjusted by the consumer price index, significant exit would likely continue to occur though at a slower rate. However, before such legislation should be adopted, more study will be needed to determine how additional milk supplies would be handled and how they would affect the market price of milk outside the region.

Government programs such as the Dairy Termination Program can be effective in meeting the objectives of decreasing milk supply. In the case of a region where few farms remain and farm numbers are shrinking, such a program can significantly affect the viability of that region in milk production. Given (*i*) the large number of less-efficient farms with higher average variable costs in marginal production regions, (ii) milk producers with rapidly increasing suburban land values in some marginal regions that have historically served as a milk source for nearby metropolitan areas (such as the milk production region north of New Orleans), and (iii) the large number of older producers that remain in marginal regions, it is likely that such a program would be very attractive to many producers.

Other variables also appear to have been significant in affecting exit and consolidation of the dairy industry, including interest rates, debt-equity positions of producers, and the Milk Diversion Program. Fewer estimates for the Milk Diversion Program were significant than were anticipated. However, in an analysis with more and narrower size categories, it is likely that the movement to smaller size categories would have been detected since the decrease in milk production ranged only from five to 30 percent; small- and medium-sized farms likely did not decrease production enough to move to a smaller size category. On the other hand, the trade-off with an increased number of size categories would have been that fewer firms could be observed in each category, reducing the ability to predict the actions of a typical firm.

Louisiana farmers continue to be plagued by among the lowest average milk production per cow in the U.S.—in 1996, the average milk produced per cow per year was 10,744 pounds, while the U.S. average was 16,500 pounds. While some of this lower production is due to environmental conditions under a forage-based system, sound management practices could increase productivity and competitiveness, decreasing exit.

Environmental concerns continue to be of major importance to most livestock farmers due to the large amounts of manure that are produced on increasingly large livestock facilities of all types. During the period examined, significant attention was given to the Tangipahoa River in southeastern Louisiana, where many dairy farms are located. Since 1988, plans have been developed for decreased dairy waste disposal into the river, though deadlines for producer compliance are late 1998 and 1999. It is anticipated that some producers will elect to discontinue production in the face of increased investment in waste disposal facilities. Similar environmental concerns have affected dairy industry structure across the U.S. The Environmental Protection Agency's recent proposed strategy for addressing environmental and public health impacts from animal feeding operations will likely further affect industry structure, particularly in regions with large, confined dairy operations. Future research examining the impacts of such programs as they develop will be of interest to the dairy industry.

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