AN ANALYSIS OF FACTORS AFFECTING THE ECONOMIC VIABILITY OF DAIRY FARMERS USING A MULTI-ORDERED RESPONSE MODEL

by

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This investigation concerns the relevant factors that are contributing to financial stress among dairy farmers in the South. Government price support programs in recent years have encouraged expansion in dairy farming. Some of the expansion was financed with loans at high interest rates. Due to drought some years many farmers had to spend funds to buy feed in addition to that already spent to grow feed. Dairy policy changes in the 1981-83 period, in effect, froze or lowered milk prices to dairy farmers.

The average debt-asset ratio for farms in the southern region has increased from the 17-18% range in past years to 22% in 1982 (Sullivan and Wilson). This shift may lead to as many as 3,000 southern farmers leaving the business in the near-term. The intent of this paper is to analyze the factors contributing to financial stress of southern dairy farmers by means of survey data rather than taking a census. The objectives of the paper are (a) to present a model of financial stress and (b) to explain differences in southern dairy farmers economic viability.

Economic Model

The financial soundness of a firm may be measured by the solvency ratio as determined by the asset to debt relationship (Penson and Lin). A measure of the existence of sufficient assets to satisfy all debts represents the overall financial soundness of the firm. The willingness to assume various levels of financial risk may also affect solvency ratios.

Under some economic conditions, assuming additional risk may lead to insolvency even though the firm did not plan to become worse off financially (Lee, Boehlje, Nelson. and Murray). The dairy farmer, as financial manager, must make decisions in an environment of risk and uncertainty. He is assumed to have a utility function that is profit-maximizing with a preference for lower amounts of risk. Thus, the dairy farmer faces a set of alternatives with which he would have risk preferences toward using. Measures of risk preferences that explain differences in asset/debt ratios, in themselves, are difficult to determine (Musser, White and Smith). However, several proxies can be used to explain differences.

The following factors were hypothesized to explain financial stress on dairy farm viability. Younger dairy farmers are willing to assume greater financial risk to become established or as dairy farmers get older they assume less risk as time to pay off is not in their favor. If the farmer has been a good manager, then with additional years of experience (a human capital variable) he should be moving toward an improved asset/debt relationship.

Education (another human capital variable) may be related to the willingness to assume risk. The higher the educational level, the better the expected managerial ability, the greater the expected risk one is willing to assume. However, higher education levels should result in an increased ability to manage the dairy farm, and with better management, profitability should improve resulting in a better asset to debt liability ratio. Thus,. the sign of the education

variable is indeterminant. Economic conditions may be such that level of education makes little difference.

The higher the level of milk production per cow the greater the expected profit and thus a positive expected affect on assets to debts. The size of the dairy farm operation, as determined by the number of cows, may positively affect the asset to debt ratio. However, if investments have been made to increase herd size through heavy borrowing, then size could affect the ratio negatively.

Ownership arrangement is hypothesized to affect the asset to debt relationship. Individual owners of dairy farms are expected to have a better ratio than partnerships or corporations. In the decision making process, this assumes individual owners do not assume as high a risk level as other types of ownership.

Specialization in dairy farming is expected to have a positive affect on the asset to debt ratio. Raising dairy animals for replacements instead of purchasing is a form of specialization. Several management practices that are recommended to dairy farmers to improve the efficiency of their operations should have a positive affect on economic viability.

Data

Data were obtained from a random sample of dairy operators located in 11 southern states. A mail questionnaire was sent to dairy farmers in February 1983 with followup letters and questionnaires. In most of the states more than 50% of the dairy farmers in the sample returned usable questionnaires. The final sample included 3,647 dairy

farmers. Since some questions were not answered by some dairy farmers, observations with missing data were excluded.

Given the sensitivity of a farmer's financial soundness, the asset to debt liability ratio was recorded as a discrete variable. Thus, in order to analyze the problem concerning financial leverage, risk aversion and financial soundness, dairy farmers were asked the question: "If you sold your dairy farm, equipment and dairy herd today what percent of the sales price after all debts had been paid would you be able to retain?" The following grouping was provided for them to check: (1) 0-24% of the sales value retained; (2) 25-49% of the sales value retained; (3) 50-74% of the sales value retained; and (4) 75-100% of the sales value retained.

Those farmers whose liabilities were greater than assets would fall in the first choice. Group 1 would be considered in dire financial stress even at a ratio of 24%.

Farmer-specific variables expected to influence the farmer's asset to debt liability ratio were number of cows (in 100's) in the herd (COWS), ratio of dairy herd born and raised on the farm (PBRA), production (in 1000 pounds) of milk per cow (PROD), the number of years the dairy farm has been operated by principal operator (YREX), amount of income (in $1000) obtained from non-farm sources (OINC), and discrete variables representing ownership arrangement and formal education level of the principal operator. Four ownership arrangements, individual ownership-the base-(INDO), father-son partnership (FSPR), family-relative partnership (FRPR) and family corporation (CORP), were each treated as a dichotomous variable, 1 if a given

ownership and 0 otherwise. Six levels of education, no high school-the base-(NHSC), some high school (SHSC), high school graduate (HSCG), technical training beyond high school (HSTT), some college (SCOL) and college graduate (COLG), were each treated as a dichotomous variable, 1 if level obtained and 0 otherwise.

Econometric Specification

Given that the asset to debt liability ratio is a discrete variable instead of a continuous variable, the use of ordinary least squares would result in biased and inefficient estimates (Judge, et al.). With this specification of the dependent variable, a multi-response ordered model, as discussed in Amemiya, is required for estimation. However, the model discussed in Amemiya is not totally correct for the problem in this paper in that the unobservable continuous variable is assumed to range from $-\infty$ to $+\infty$ and the limits are unknown. In this analysis, the range is 0 to 100 percent (i.e., truncated) and the limits are known. Thus, the model as discussed in Amemiya must be modified to incorporate the additional information. The discussion in this section presents a multi-response ordered model used in this analysis.

The unobservable continuous asset to debt liability ratio of the t^{th} farmer is denoted Y_t and is assumed to be linearly related to a vector of observed farmer-specific characteristics (e.g., human capital, demographic and production). In explicit form one has

$$(1) \quad Y_t = X_t\beta + e_t \qquad 0 \leq Y_t \leq 100$$

where

X_t = a row vector of farmer-specific variables and β is a column vector of parameters to be estimated. The unconditional distribution of e_t is assumed to be $N(0,\sigma^2)$ so that the conditional distribution of Y_t is:

$$(2)\quad f(Y_t) = \frac{g_t(Y_t)}{\int_0^{100} g_t(Z)dZ} \quad 0 \leq Y_t \leq 100 \quad \text{and}$$

$$(3)\quad g_t(Z) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(Z-X_t\beta)^2}{2\sigma^2}\right).$$

Now Y_t is not observable but a vector of binary variables indicating which range of asset to debt liability ratio selected by the t^{th} farmer is denoted $D_t = [d_{1t},\ldots,d_{4t}]$ where

$$d_{jt} = \begin{cases} 1 \text{ iff } \mu_{j-1} \leq Y_t \leq \mu_j \\ 0 \text{ otherwise} \end{cases}$$

with $j = 1,\ldots,4$ and $\mu_0=0$, $\mu_1=25$, $\mu_2=50$, $\mu_3=75$, and $\mu_4=100$.

The likelihood that $d_{jt} = 1$ is:

$$(4)\quad P_{jt} = \Pr\{d_{jt}=1\} = \Pr\{\mu_{j-1} \leq Y_t \leq \mu_j\}$$

$$= \frac{\int_{\mu_{j-1}}^{\mu_j} g_t(z)dz}{\int_0^{100} g_t(z)dz} = \frac{N(\phi_{jt})-N(\phi_{j-1,t})}{N(\phi_t^+)-N(\phi_t^-)}$$

where $\phi_{jt} = \frac{\mu_j - X_t\beta}{\sigma}$, $\phi_t^+ = \frac{100-X_t\beta}{\sigma}$, $\phi_t^- = \frac{-X_t\beta}{\sigma}$, and

N is the standard normal CDF.

Thus, the likelihood function for the full sample is:

$$(5)\quad L(\beta,\sigma) = \prod_{t=1}^{T} \prod_{j=1}^{J} P_{jt}^{d_{jt}}.$$

The log-likelihood function is:

$$(6)\quad \log L(\beta,\sigma) = L^{*} = \sum_{t=1}^{T} \{ \sum_{j=1}^{4} d_{jt}[\log(N(\phi_{jt})-N(\phi_{j-1,t})) - \log (N(\phi_{t}^{+})-N(\phi_{t}^{-}))]\}.$$

The β vector and σ which would maximize equation (6) were solved for by maximum likelihood using the quadratic hill-climbing algorithm in the numerical optimization computer package of Goldfeld and Quandt. The parameter estimates are consistent and asymptotically efficient.

Results

The coefficients obtained from the maximum likelihood procedure are presented in Table 1. A positive sign is associated with improved solvency. Since differences were expected among the eleven states in the probability of a farmer being in a specific asset to debt liability ratio group, states were entered as intercept shifters with Georgia as the base.

As indicated by the likelihood ratio test, the model was statistically significant at the .05 level. The model correctly classified approximately 53 percent of the dairy farmers which is good.

All of the farmer-specific variables were statistically significant in explaining a farmer's asset to debt liability ratio grouping. Size of the dairy herd has a negative effect on solvency. This implies that dairy farmers increased their herd size through borrowing probably in response to recent dairy farm programs. The proportion of the dairy herd born and raised on the farm, production per cow and operator experience have the expected positive effect on solvency.

Amount of income obtained from non-farm sources was included in the analysis to test the general perception that farmers are forced to

Table 1. Maximum likelihood coefficients and the respective asymptotic t-ratio of the multi-ordered response analysis of economic viability of dairy farmers, 11 southern states, 1983[a]

Variable	Mean	Coefficient	Asymptotic t-ratio
Intercept		-326.360	-18.264
COWS	1.076	-41.295	-15.604
PBRA	.699	380.137	28.090
PROD	13.307	12.347	14.119
YREX	17.500	9.584	27.280
OINC	5.094	3.050	15.923
State			
AL	.053	-54.990	-5.556
AR	.089	129.269	13.775
KY	.106	79.060	9.059
LA	.070	69.927	7.630
MS	.075	-8.274	-.935
NC	.115	75.912	8.726
SC	.054	-28.637	-2.952
TN	.097	46.087	5.435
TX	.120	136.427	15.181
VA	.138	115.033	12.723
Ownership			
FSPR	.207	60.359	11.313
FRPR	.100	28.884	4.595
CORP	.077	60.158	7.869
Education			
SHSC	.106	-67.782	-7.775
HSCG	.392	-28.859	-4.038
HSTT	.060	-78.999	-7.911
SCOL	.190	-46.048	-5.895
COLG	.164	-27.982	-3.455
Management			
FORM	.337	-86.414	-17.637
INDR	.543	-45.247	-11.199
χ^2 value	1597.800		
Degrees of freedom	25		
Pseudo-R^2	.473		

a. There were 2,726 observations with the following breakdown by solvency group: 16% for group 1, 15% for group 2, 23% for group 3 and 46% for group 4.

obtain non-farm income as their solvency deteriorates. The results indicate that this perception is incorrect. Larger amounts of non-farm income are associated with better asset to debt liability ratios.

The type of ownership, with individual ownership the base, have the opposite effect on the asset to debt liability ratio than was hypothesized. That is, father-son, family-relative and family corporation have a higher probability of having a better solvency than an individual owner. This implies that group decision making has a more positive influence on solvency.

Education levels were compared to no high school education (the base). All of the education levels in relation to the base have a negative effect on solvency. Even though a farmer with a higher level of education is assumed to be more willing to take risk, his increased managerial capacity should enable him to respond to unfavorable economic conditions. Yet, the results imply that the current economic conditions are of such a magnitude that education does not help the dairy farmer in his solvency. This finding is further strengthened by the results of the management practices. While use of these practices should improve the efficiency of the operation, the coefficient signs indicate that using these practices does not improve solvency.

The coefficients from the ordered response model do not have any economic interpretation except for qualitative effects and for statistical testing the significance of a particular independent variable. Thus one usually investigates the derivative of the probability with respect to a particular independent variable in order to predict the effect of changes in that variable on the probability of belonging to

a group. However, this procedure can not be used for discrete variables. Since several discrete variables are used to represent a certain factor like state and education, the actual probability associated with a given discrete variable (holding all other variables at the sample mean except for the other discrete variables in that particular group which are set equal to zero) is computed. The results are shown in Table 2.

If a dairy farmer increased his herd size by 100 head, his probability of being in group 4 (75-100% solvency) decreases by .05 of a probability point while his probability of being in groups 1 and 2 (0-49% solvency) increases by .02 of a probability point. If the farmer increased production per cow by 1000 pounds, his probability of being in group 4 would increase while the probability of being in groups 1 and 2 would decrease. Similar relationships are found for proportion of dairy herd born and raised, experience and non-farm income.

For the discrete variables the probability levels increase across the asset to debt liability ratio groups (i.e., from low solvency to high solvency) independent of which discrete variable is examined. The probability for group 4 (75-100% solvency) is significantly larger than the probability in another group.

Conclusions

This paper presents an analysis of factors affecting the economic viability of southern dairy farmers. Data obtained from a survey of dairy farmers in 11 southern states and a multi-ordered response model are used to make inferences concerning dairy farmers solvency.

Table 2. Probability of dairy farmers being in various economic viability groups, 11 southern states, 1983

Variable	Asset to Debt Liability Ratio			
	0-24%	25-49%	50-74%	75-100%
Continuous		Probability Derivative		
COWS	.023	.022	.004	-.049
PBRA	-.209	-.204	-.035	.448
PROD	-.007	-.007	-.001	.015
YREX	-.005	-.005	-.001	.011
OINC	-.002	-.002	-.000	.004
Discrete		Probability Level		
State				
GA	.131	.201	.287	.380
AL	.176	.230	.279	.315
AR	.060	.133	.276	.532
KY	.082	.159	.285	.474
LA	.087	.164	.286	.464
MS	.138	.206	.286	.370
NC	.084	.160	.285	.471
SC	.154	.216	.284	.346
TN	.101	.176	.287	.435
TX	.057	.130	.274	.539
VA	.066	.140	.279	.516
Ownership				
INDO	.101	.177	.287	.434
FSPR	.070	.145	.281	.505
FRPR	.085	.161	.285	.468
CORP	.070	.145	.281	.505
Education				
NHSC	.071	.147	.281	.500
SHSC	.108	.183	.288	.421
HSCG	.086	.162	.285	.467
HSTT	.116	.189	.288	.407
SCOL	.095	.171	.287	.447
COLG	.085	.162	.285	.468
Management				
None	.064	.138	.278	.520
FORM	.109	.184	.288	.419
INDR	.085	.162	.285	.468

At the means of the variables for the total sample, there was differences among the 11 southern states of dairy farmers solvency. However, examination of the probability levels for the discrete variables reveal that dairy farmers as a group have a higher probability for the higher solvency ratio than for the low solvency ratio. This implies that dairy farmers in 1983 were not in as dire financial strait as other groups of farmers. Yet, this does not preclude them from joining the other groups in the near future given the changes in dairy policy.

Non-farm income was not positively related to the lessening of solvency. Dairy farmers do not seem to be forced to obtain non-farm income to offset their solvency problem.

The negative relationship of education was not expected. One would expect a positive relationship due to an increase in managerial capacity. However, the empirical relationship indicates that the economic conditions were such that an increase in managerial capacity did not help farmer's solvency.

The methodology used in this analysis provides the means of identifying differences among dairy farmers in their financial stress without having to take a census. Farmer-specific characteristics, both human capital and production, were identified that influence economic viability as well as measure the probability of having a certain level of solvency.

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