A Structural Approach to Estimating Rate of Return Expectations of Farmers

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Abstract

A dual cost function approach is developed as an alternative to time series and simplistic approaches for estimating farmers' expected operating rates of return on assets. A translog restricted cost function is estimated using data provided by 152 North Carolina dairy farmers over the period 1976 through 1986. The predicted costs from the fitted restricted cost function are used to construct estimates of farmers' expected operating rates of return on assets. The estimates from this structural approach explain more of the variation in observed rates than do time series estimates or sample mean observed rates.

Key Words: estimating expectations, rate of return, translog cost function.

Farmers' expected operating rates of return on assets (EROA) are precise variables which are not directly observable. However, farmers' EROA and other expected variables are required in many theoretical models such as the model of optimal capital structure (Collins) and expected value-variance (EV) models (Barry, Baker and Sanint). Since farmers' EROA are not directly observable, a structural econometric approach is developed that may be used in empirical studies to estimate farmers' EROA. Also, structural approach estimates of farmers' EROA are compared to estimates from two alternative approaches.

Duality theory offers a structural approach for estimating expectations and is discussed here as an alternative to conventional time series and simplistic (historical sample means) approaches. Time series approaches are often difficult to implement with firm-level cross-section and time-series data as a result of the inadequate length of the time series. Time series approaches also tend not to identify the causes of variation in rates of return. Thus information that is of interest in its own right is lost. For example, how EROA vary with farm size has obvious implications for long run viability of farms. Fried discusses structural, time series and historical sample mean approaches to estimating EROA for EV models. In particular, estimates from structural approaches are more in accord with actual behavior than are historical estimates of EROA. Although the historical sample mean approach is simple, the approach will not be accurate unless EROA is at its sample mean. In addition, the historical sample mean approach, like the time series approach, does not identify the causes of variation in rates of return.

EROA are defined as expected returns divided by assets. Expected returns are expected gross returns less expected costs net of interest. The expected costs net of interest are generated by

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an estimated translog cost function. The cost function is an element of the structural approach applied to 152 dairy farms in North Carolina using annual data from 1976 through 1986.

The rate of return on assets is a measure of the profitability of the farm, and likewise the total investment. While it is certainly true in theory that all investments of similar risk and term should have the same rate of return, we observe different rates of return across farms that have similar enterprises.

Many studies have examined the impact of expected returns on asset values, in particular real estate values (Falk; Featherstone and Baker; Tegene and Kuchler; Alston; Burt; Melichar). All of these studies utilized aggregate data. Although there appears to be a direct relationship between expected returns and asset values at the aggregate level, the relationship may be more indirect at the farm level. In general, farmers determine their market value of assets based on what similar assets have sold for recently, i.e., the market value is based on an average of comparable sales. However, the value of an individual comparable sale is based on the particular buyer's return expectations and capitalization rate, i.e., income capitalization (Murray et al., pp. 26 - 28). Therefore, an individual farmer's market value of assets is ultimately based on average expected returns of other farmers. Yet, farmers have different (heterogenous) expected rates of return on these assets because of differences in farmers' returns and return expectations. Farmers having heterogenous expectations is consistent with Brown and Brown (p. 164):

There are two ways in which uncertainty [about the future] can be defined. One might postulate that no one knows for sure what will happen in the future but that each decision maker assigns the same probabilities to each possible future event. More realistically, uncertainty implies decision makers have differing probability estimates for future events.

Estimates of these heterogenous expectations are required by many theoretical models for empirical analysis.

The methodology and data used to estimate farmers' EROA are considered in the next section followed by the presentation, estimation and results of the translog restricted cost function as an element of the structural approach. Next, two alternative approaches, time series and simplistic, are presented. Then estimates of farmers' EROA from the structural approach are compared to the time series and simplistic approaches. Finally, concluding comments are offered.

Methodology and Data

A farmer's operating rate of return on assets is net farm income plus interest expense divided by the average of beginning and ending assets:

$$r_{it} = (NFI_{it} + INT_{it})/A_{it}$$
$$= (GR_{it} - C_{it})/A_{it},$$

where r_{it} is the operating rate of return on assets, NFI_{it} is net farm income, INT_{it} is interest expense, GR_{it} is gross operating returns, C_{it} is operating cost net of interest expense, and A_{it} is the average of beginning and ending assets for farmer i in year t.[1] If C_{it} includes interest expense, r_{it} is understated. Therefore, C_{it} is operating cost net of interest expense.

A structural approach for estimating a farmer's EROA is to estimate a cost function. The predicted cost from the cost function net of interest expense is used to construct an estimate of a farmer's EROA. The estimate is:

$$\hat{E}(r_{it})_T = (GR_{it} - \hat{C}_{it})/A_{it}, \quad (1)$$

where E is the expectations operator and $\hat{C}_{it}$ is the estimated, or predicted, expected operating costs net of interest expense. Equation (1) defines dairy farmers' EROA when they are assumed to know in advance their gross operating returns for the period. This assumption is based on dairy farmers knowing the price they will receive for their milk production because of announced government support prices and farmers' milk production being restricted by their production base.[2] If farmers are uncertain about gross operating returns (if gross operating returns is a random variable), a profit function would be more appropriate for the numerator of (1).

The data used to estimate the cost function are composed of cross-section and time-series records for individual dairy farmers appearing in the annual North Carolina Dairy Farm Business Summary (Benson, et al., Dairy Summary). The records are provided by 152 dairy farmers participating in the North Carolina State University Farm Business Records Program. The time-series covers the period 1976 through 1986. Dairy farmers participated for an average of approximately five years in the Dairy Summary. Reasons for not participating in the Dairy Summary for the entire eleven years range from having started farming during the period, withdrawing from farming during the period, having incomplete records for some years, discontinuing the record keeping service, or for other reasons. The specific reasons are not recorded.

Only farms from the Farm Business Records Program with dairy production accounting for a minimum of 70 percent of the total value of farm production are contained in the Dairy Summary. Most of the dairy farms included in the Dairy Summary easily exceed this percentage. Thus, the vast majority of farms included in the Dairy Summary are specialized dairy farms without other significant farm enterprises. Records provided by dairy farmers are checked annually by personnel in the North Carolina Agricultural Extension Service for completeness and accuracy. Additional information concerning the data may be found in Ahrendsen.

Structural Approach

A translog restricted cost function is used here to provide an estimate of $\hat{C}_{it}$ in (1) so a structural approach estimate of a farmer's EROA may be constructed. During the past two decades, cost functions have received considerable attention as a method for estimating the structure of production. The popularity of cost functions is attributed to the application of duality theory and the advent of flexible functional forms. A subset of inputs (variable inputs) are considered to be in short-run equilibrium subject to the levels of remaining inputs (fixed, or quasi-fixed, inputs) in the following analysis.

A general production function is considered:

$$Y = F\,(\mathbf{X}, \mathbf{Z}, t), \tag{2}$$

where Y is output, $\mathbf{X}$ is a vector of variable inputs, $\mathbf{Z}$ is a vector of quasi-fixed inputs, and time, t, represents technological change. Brown and Christensen have shown that if the production function in (2) has convex isoquants and cost is minimized with respect to variable inputs conditional on the level of output and fixed inputs, then there exists a restricted cost function that is dual to the production function:

$$C = C\,(Y, \mathbf{w}, \mathbf{Z}, t), \tag{3}$$

where $\mathbf{w}$ is a vector of variable input prices and the other variables are as defined after (2). The properties of the restricted cost function are: continuous and linearly homogeneous in variable input prices, monotonically increasing and concave in variable input prices, nondecreasing and convex in output, and nonincreasing and convex in fixed inputs. The translog functional form was chosen for econometric estimation because of its flexible form and ability to estimate underlying technologies.

The translog restricted cost function with an additive error is:

$$\begin{aligned} \ln C = \; & a_0 + a_y \ln Y + \sum_i a_i \ln w_i + \sum_i b_i \ln Z_i \\ & + \tfrac{1}{2} c_{yy} (\ln Y)^2 + \tfrac{1}{2} \sum_i \sum_j c_{ij} \ln w_i \ln w_j \\ & + \tfrac{1}{2} \sum_i \sum_j d_{ij} \ln Z_i \ln Z_j + \sum_i f_{iy} \ln Y \ln w_i \\ & + \sum_i \sum_j f_{ij} \ln w_i \ln Z_j + \sum_i g_i \ln Y \ln Z_i \\ & + h_t\, t + \tfrac{1}{2} h_{tt}\, t^2 + e_c, \end{aligned} \tag{4}$$

where ln is the natural logarithm. Hicks-neutral technological change is implicitly imposed since time is separable from the other variables of the model. Symmetry of the cross-price and cross-fixed factors is imposed by requiring:

$$c_{ij} = c_{ji} \text{ and } d_{ij} = d_{ji}, \quad (5)$$

for all i, j combinations. Homogeneity of degree one in variable input prices is imposed by requiring:

$$\sum_i a_i = 1, \; \sum_i c_{ij} = \sum_i c_{ji} = \sum_i f_{iy} = \sum_i f_{ij} = 0, \quad (6)$$

for every j. Constant returns to scale to output and fixed factors is imposed on the underlying production technology by requiring:

$$a_y + \sum_i b_i = 1,$$

$$f_{iy} + \sum_j f_{ij} = 0, \text{ for every } i;$$

$$c_{yy} + \sum_i g_i = 0,$$

$$g_j + \sum_i d_{ij} = 0, \text{ for every } j. \quad (7)$$

The variable input share equations derived from Shephard's lemma are:

$$S_i = a_i + f_{iy} \ln Y + \sum_j c_{ij} \ln w_j + \sum_j f_{ij} \ln Z_j + e_i, \quad (8)$$

for every i, where S_i is the cost share of variable input i, $S_i = w_i X_i / \Sigma w_i X_i$, and e_i is an additive error term with mean zero and constant variance. The adding up restriction is:

$$\Sigma S_i = 1. \quad (9)$$

Output, Y, is measured in hundredweights of milk sold by a farmer per year. Milk sales accounted for approximately 86 percent of gross returns for farmers in the Dairy Summary. The two quasi-fixed factors of $\mathbf{Z}$ are the average real value of year-beginning and year-ending productive assets, A_p, and hours of family labor per year, L.[3] Family labor is assumed to be in disequilibrium, and thus, it is treated as a quasi-fixed asset. Cost, C, is measured as operating cost net of interest expense.

The two variable inputs of $\mathbf{X}$ in the production function (2) are purchased feed and all other variable inputs. The corresponding variable input prices of $\mathbf{w}$ are purchased feed price, w, and all other variable input price, q. The North Carolina price of 16 percent protein dairy feed (U. S. Department of Agriculture, *Agricultural Prices*) is a proxy for purchased feed price for North Carolina dairy farmers. A price index was constructed for the price of all other variable inputs:

$$q_t = \sum_{k=1}^{9} (\text{Share})_{kt} \, I_{kt}, \quad (10)$$

where I_{kt} is the year t unweighted price index for k = wages, rent, supplies, fuel, seed, fertilizer, chemicals, taxes, and livestock (U. S. Department of Agriculture, *Agricultural Statistics*). These nine categories are combined because the primary focus is on estimating expected cost not the production technology. $(\text{Share})_{kt}$ is the mean cost share of the Dairy Summary data for year t and input k, where purchased feed expense and interest expense are excluded. Feed expense is excluded because it already has been included as a separate variable input, and interest expense is excluded because the ultimate objective is estimating farmers' EROA. The cost share of purchased feed expense, S_w, is approximately 40 percent and the cost share of all other inputs expense, S_q, is approximately 60 percent.

ARIMA Models of Input Prices

Estimates of farmers' input price expectations are required to estimate the cost function. Two methods of estimating price expectations are used. The first method is to identify an autoregressive-integrated-moving average (ARIMA) model of input prices.

Input prices are assumed to be the same for all farmers within a year, and it is assumed that the stochastic process generating input prices is known. The best estimate of farmers' expectations is an estimate of the stochastic process. The stochastic process generating input prices is identified and estimated by using SAS procedure ARIMA (Brocklebank and Dickey). The ARIMA models are estimated with the goal of forecasting farmers' expectations of input prices within sample.

Following Judge, et al. (Chapter 7), a standard autoregressive and moving average error model is:

$$w_t = \alpha_1 w_{t-1} + \alpha_2 w_{t-2} + \ldots + \alpha_p w_{t-p} + v_t + \beta_1 v_{t-1} + \ldots + \beta_q v_{t-q},$$

where w_{t-i} is the realized input price during period $t-i$ and v_t is white noise. This process is called an autoregressive moving average process of order (p,q) or ARMA (p,q). Stationarity and invertibility conditions are satisfied when the ARMA models are estimated for input prices. The ARMA models are identified by following Brocklebank and Dickey (pp. 43-67), which is the same procedure used by Box and Jenkins.

The price of feed was identified to follow a first-order moving average process:

$$w_t = a_0 + v_{wt} + a_1 v_{wt-1}, \tag{11}$$

where a_0 and a_1 are unknown parameters and v_{wt} is white noise. Farmers' expectations of purchased feed prices are then presumed to be generated as:

$$\hat{w}_t = \hat{a}_0 + \hat{a}_1 v_{wt-1}. \tag{12}$$

The price of all other inputs was identified to be first-order autoregressive:

$$q_t = b_0 + b_1 q_{t-1} + v_{qt}, \tag{13}$$

where b_0 and b_1 are unknown parameters and v_{qt} is white noise. Farmers' expectations of all other input prices are then presumed to be generated as:

$$\hat{q}_t = \hat{b}_0 + \hat{b}_1 q_{t-1}. \tag{14}$$

The ARIMA estimates of equations (11) and (13) are in table 1.

If farmers had perfect foresight for a year, realized prices become the expected prices. Realized prices are used in lieu of the predicted prices ($\hat{w}$ and $\hat{q}$) in an alternative estimation of the cost function. The comparison of the two structural approach EROA estimates resulting from the two estimated cost functions indicates the degree of uncertainty injected by farmers having to project input prices.

Results from Cost Function Model

The cost equation (4) and the share equation (8) for feed are jointly estimated using Zellner's seemingly unrelated regression technique, subject to constraints (5) through (7). The estimated parameters from $C(Y, \hat{w}, \hat{q}, A_p, L)$ with predicted prices and $C(Y, w, q, A_p, L)$ with realized prices are presented in tables 2 and 3. The monotonicity and curvature conditions are satisfied at a point of approximation where w, $\hat{w}$, q, $\hat{q}$, Y, A_p, and L are indexed to one and t is indexed to zero (Capalbo and Antle, pp. 76-80).

The own-price and cross-price input demand elasticities are computed by:

$$\eta_{ii} = c_{ii}/S_i + S_i - 1 \tag{15}$$

and

$$\eta_{ij} = c_{ij}/S_i + S_j. \tag{16}$$

The elasticities are functions of shares and the c_{ij} parameters. The estimates of these parameters, their standard errors, and the cost shares are all random variables. However, the elasticities can be evaluated at any point in the domain. Here they are evaluated at the mean of the cost shares ($\bar{S}_w$ = 0.405, $\bar{S}_q$ = 0.595), which is a fixed point. Therefore, the standard errors of the elasticities at that fixed point in the domain are estimated to be:

$$\hat{\sigma}_\eta = \hat{\sigma}_c/\bar{S}_i, \tag{17}$$

where $\hat{\sigma}_c$ is the estimated standard error of parameter c_{ij} and $\bar{S}_i$ is the mean of cost share i. The estimated elasticities and their standard errors are presented in table 4. The elasticities are inelastic, which was expected a priori. Also, the elasticities do not differ substantially between using predicted prices from an ARIMA model or using realized prices to estimate the restricted cost function.

From the results presented in table 2, costs increased at an average annual rate of 0.02 percent, evaluated at the average t of the data, which is equal to 81.365. However, this estimate of technical change is extremely small and statistically insignificant. When realized prices are used to estimate the restricted cost function (table 3), technical progress occurred at an average annual rate of 0.5 percent, evaluated at the average t of the data. This result is statistically significant and seems reasonable for the 1976 through 1986 time period.

Table 1. Parameter estimates from ARIMA models used to estimate purchased feed price w, price of all other inputs q, and average industry rate of return[a]

Model	Dependent Variable	Intercept	Parameter AR1	Parameter MA1	Time Series Mean	Ljung-Box[c] χ^2
(11)	w	72 4323 (54.78)	[b]	0.72898 (4.77)	71.9598	3.20
(13)	q	6.79949 (11.42)	0.87065 (5.16)	[b]	54.2159	4 47
(23)	$\dot{r}_t$	0.06175 (9.22)	0.41193 (2.02)	[b]	0.1036	3.71

[a]Parameter "t" values are presented in parentheses

[b]The parameter was not identified to be relevant from the identification process.

[c]*Test statistic for the null hypothesis: residuals are white noise. The corresponding critical value* with four degrees of freedom at the five percent significance level is 5.39

Table 2. Parameter estimates for translog restricted cost function with predicted prices[a]

Parameters	Estimates	Parameters	Estimates
a_0	-4.6770 (4.9049)	d_{LL}	-0.0014 (0.0019)
a_y	1.2374 (0.0997)	f_{wy}	0.0566 (0.0078)
a_w	0 5610 (0.2299)	f_{qy}	-0 0566 (0.0078)
a_q	0.4390 (0.2299)	f_{wA}	-0.0691 (0.0079)
b_A	-0.2019 (0.1035)	f_{wL}	0.0126 (0 0018)
b_L	-0.0355 (0.0196)	f_{qA}	0.0691 (0.0079)
c_{yy}	0.1153 (0.0386)	f_{qL}	-0.0126 (0.0018)
c_{ww}	0.1227 (0.0355)	g_A	-0 1127 (0.0392)
c_{wq}	-0.1227 (0.0355)	g_L	-0.0026 (0.0068)
c_{qq}	0.1227 (0.0355)	h_t	0.0572 (0.1208)
d_{AA}	0.1087 (0.0408)	h_{tt}	-0.0007 (0 0015)
d_{AL}	0.0040 (0.0069)		

System weighted R^2 = 0.8844. s^2 = 0.0219

[a]y = milk output, w = purchased feed price, q = price of all other inputs, A = productive assets, and L = family labor. *Standard errors are in parentheses.* Number of observations equal 802

Table 3. Parameter estimates for translog restricted cost function with realized prices[a]

Parameters	Estimates	Parameters	Estimates
a_0	9.5548 (4.9482)	d_{LL}	-0.0007 (0.0019)
a_y	1.2363 (0.1005)	f_{wy}	0.0549 (0.0077)
a_w	0.5575 (0.0218)	f_{qy}	-0.0549 (0.0077)
a_q	0.4425 (0.0218)	f_{wA}	-0.0672 (0.0079)
b_A	-0.2122 (0.1044)	f_{wL}	0.0123 (0.0017)
b_L	-0.0241 (0.0198)	f_{qA}	0.0672 (0.0079)
c_{yy}	0.1086 (0.0389)	f_{qL}	-0.0123 (0.0017)
c_{ww}	0.1508 (0.0320)	g_A	-0.1085 (0.0395)
c_{wq}	-0.1508 (0.0320)	g_L	-0.0001 (0.0069)
c_{qq}	0 1508 (0.0320)	h_t	-0.2893 (0.1218)
d_{AA}	0.1076 (0.0412)	h_{tt}	0 0035 (0.0015)
d_{AL}	0.0008 (0.0070)		
System weighted R^2 = 0.8850.		s^2 = 0.0223	

[a] y = milk output, w = purchased feed price, q = price of all other inputs, A = productive assets, and L = family labor. Standard errors are in parentheses. Number of observations equal 802

Structural Approach Estimates

The structural approach estimate of a farmer's EROA is:

$$\hat{E}(r_{it}) = \frac{GR_{it} - \tilde{C}_{it}(Y, w, q, A_p, L)\, e^{\frac{1}{2}s^2}}{A_{it}} \qquad (18)$$

where $\tilde{C}_{it}$ is predicted operating cost from the estimated cost function for farmer i in year t and s^2 is the estimated variance of the restricted translog cost function. The adjustment $e^{\frac{1}{2}s^2}$ to predicted operating cost $\tilde{C}_{it}$ generates a consistent estimator of expected operating cost. A consistent estimate of the operating cost median is generated without the adjustment (Goldberger).

In this section a translog restricted cost function was estimated. Estimates of own-price input demand elasticities were inelastic and insensitive to whether the restricted cost function was estimated with predicted prices generated by ARIMA models or with realized prices. The estimated change in technology depended on whether predicted prices or realized prices were used to estimate the restricted cost function. The only statistically significant estimate of technical

Table 4. Input demand elasticities estimated from the translog restricted cost functions, evaluated at the means of cost shares[a]

	Function estimated using:	
	Predicted Prices	Realized Prices
η_{ww}	-0.2919 (0.0877)	-0.2227 (0.0789)
η_{wq}	0 2919 (0.0877)	0.2227 (0.0789)
η_{qq}	-0.1989 (0.0598)	-0.1517 (0.0537)
η_{qw}	0 1989 (0.0598)	0 1517 (0.0537)
$\bar{S}_w$	0.40521	
$\bar{S}_q$	0.59479	

[a] w = purchased feed price, q = price of all other inputs. Standard errors (see text) are presented in parentheses The own-price and cross-price elasticities sum to zero since input demand is homogenous of degree zero in w and q by Euler's theorem.

change was technical progress at an annual rate of 0.5 percent when realized prices were used to estimate the cost function.

Time Series Approach

A time series approach is a conventional method for estimating expectations (Moss, Shonkwiler and Ford). However, time series approaches are often difficult to implement with firm-level cross-section and time-series data as a result of the inadequate length of the time series. Since this is the case for the data used in the study presented here, i.e. most farmers are not in the Dairy Summary for the entire time-series, a method is developed to estimate farmers' EROA using an ARIMA model. Time series approach estimates are then compared to structural approach estimates generated in the previous section.

The approach taken in this section is that individual farmers form their own EROA relative to their expectation of an industry operating rate of return on assets. Consider the operating rate of return on assets for the dairy industry to be a random variable, r_t for which the mean μ_t and variance σ_t^2 change through time. The individual farmer's operating rate of return on assets is defined as:

$$r_{it} = r_t + e_{it}, \tag{19}$$

where e_{it} is identically distributed with mean μ_i and variance σ_i^2, and the covariance between e_{it} and r_t equals zero. Thus, the individual farmer's rate of return is the industry rate of return, r_t, plus a component specific to him or her, e_{it}. It is assumed that μ_i is an idiosyncratic effect known to the farmer. The idiosyncratic effect is the effect that differentiates the individual farmer from the average farmer, i.e. the average amount that an individual farmer either out-performs or under-performs the industry average.

An estimate of the industry rate of return in year t is the average rate of return for farmers in the Dairy Summary in year t:

$$\bar{r}_t = \sum_{i \in \Gamma_t} r_{it}/n_t \tag{20}$$

where Γ_t is the set of farmers that participated in the Dairy Summary in year t and n_t is the number of elements in Γ_t.

An estimate of a farmer's idiosyncratic effect μ_i is the average amount that a given farmer's rate of return differs from the average rate of return of farmers in the Dairy Summary:

$$\hat{\mu}_i = \sum_{t \in \Phi_i} (r_{it} - \bar{r}_t)/m_i, \quad (21)$$

where Φ_i is the set identifying the years in which farmer i participated in the Dairy Summary and m_i is the number of elements in Φ_i.

The EROA for farmer i in year t equals the farmer's expectation of the industry rate of return plus the farmer's idiosyncratic effect:

$$E(r_{it})_T = E(\bar{r}_t)_T + \mu_i, \quad (22)$$

where T signifies the time series approach.

The data used to estimate farmers' expectations of the industry operating rate of return on assets, $E(\bar{r}_t)_T$, are average rates of return from the Dairy Summaries for the years 1965 through 1986. The years 1965 through 1975 are included to establish a longer time series of average rates of return. Farm-level panel data are not available for the years 1965 through 1975.

An ARIMA model to estimate farmers' expectations of industry operating rates of return was identified to be first-order autoregressive:

$$\bar{r}_t = c_0 + c_1 \bar{r}_{t-1} + u_{1t}, \quad (23)$$

where c_0 and c_1 are unknown parameters and u_{1t} is an independent and identically distributed normal error. Farmers' expectations of industry operating rates of return are then presumed to be generated as:

$$\hat{E}(\bar{r}_t)_T = \hat{c}_0 + \hat{c}_1 \bar{r}_{t-1}. \quad (24)$$

The estimated ARIMA model is presented in table 1. The estimates generated from (24) are the conventional estimates provided by a time series approach using aggregate data.

The estimate of a farmer's EROA from the time series approach when farm-level data are available as in this study is:

$$\hat{E}(r_{it})_T = \hat{E}(\bar{r}_t)_T + \hat{\mu}_i \quad (25)$$

where $\hat{E}(\bar{r}_t)_T$ and $\hat{\mu}_i$ are taken from (24) and (21). By estimating farmers' expectations of industry operating rate of return and their idiosyncratic effect, Dairy Summary data can be used to estimate farmers' EROA using a time series approach. Each farmer has a different EROA in a given year as a result of their individually known idiosyncratic effect relative to the industry mean rate of return.

Simplistic Approach

In addition to estimates of farmers' EROA generated by the time series approach in the previous section, estimates generated by a simplistic approach may be compared to structural approach estimates. A simplistic approach for estimating farmers' EROA is to use historical sample means of observed operating rates of return on assets, r_{it}. A sample mean that is an estimate of a farmer's EROA simply averages the r_{it} for each farmer i:

$$\bar{r}_i = \sum_{t \in \Phi_i} r_{it}/m_i. \quad (26)$$

Another sample mean that is an estimate of a farmer's EROA averages the r_{it} for all farmers observed in year t, $\bar{r}_t$ as in (20). Both of these sample mean estimates are conventional simplistic approaches for obtaining expected returns for use in EV models, see Scott and Baker for an example.

Comparisons

The effectiveness of the structural approach for estimating farmers' EROA is an empirical question. A survey eliciting farmers' EROA would obviously be helpful. Since such a survey does not exist, a different method of evaluation is conducted. Observed operating rates of return on assets (r_{it}) are compared to estimates of farmers' EROA from the structural approach, the time series approach and the simplistic approach.

The criterion used to rank the effectiveness of estimates of farmers' EROA from the three approaches is the percent of total variation of the observed operating rates of return on assets from their sample mean explained by a given estimation approach. Therefore, the R^2s from the regressions of r_{it} on the different approach estimates are used to rank the effectiveness of each approach (Judge, et al. p. 862 and Kennedy p. 207). An alternative criterion used to rank the effectiveness of the different approach estimates of farmers' EROA is the root mean square error between r_{it} and the approach estimates (Kennedy p. 206). Since both criteria yielded the same ranking, only the R^2 criterion is discussed. As a result of the three approaches each having two estimates of farmers' EROA, six regression models were estimated. The regression results are reported in table 5.

The regressions with the independent variables $\hat{E}(r_{it})$ obtained from the structural approach using realized input prices and the structural approach using predicted input prices explain 64 percent and 61 percent of the variation in r_{it} respectively. As expected, the coefficient of determination decreases when farmers have to project input prices to compute EROA.

The regression results with the independent variables $\hat{E}(r_{it})_T$ and $\hat{E}(\bar{r}_t)_T$ from the time series approach have coefficients of determination of 59 percent and 1 percent. These results imply that the conventional time series approach of using aggregate data to estimate farmers' EROA for EV analysis will be of poor quality, at least for this sample of 152 dairy farmers.

In the fifth and sixth regressions presented in table 5, the independent variables are from the simplistic approach. In the fifth regression $\bar{r}_i$ is the independent variable so that for a given i, $\bar{r}_i$ is constant as t varies. Similarly, in the sixth regression $\bar{r}_t$ is the independent variable so that for a given t, $\bar{r}_t$ is constant as i varies. In both of these regressions the estimated intercepts are zero and the slopes are one since the independent variable is the least squares estimator of the group of observations on the dependent variable it is explaining. The corresponding R^2s are 61 percent and 11 percent which are slightly less and much less than the R^2s from the regressions with the structural approach estimates as independent variables (64 percent and 61 percent). Neither $\bar{r}_i$ nor $\bar{r}_t$ would be useful estimates of farmers' EROA if the data were solely either cross-sectional or time-series because the estimates would be identical to r_{it}.

It should be pointed out that $\hat{E}(r_{it})_T$ using idiosyncratic effects and $\bar{r}_i$ are good predictors because there are 152 idiosyncratic effects and 152 $\bar{r}_i$ and many farms had fewer than five observations in the sample. However, the conventional time series approach and $\bar{r}_t$ do not provide information about why r_{it} varies among farmers whereas the structural approach does because of the information contained in the cost function.

From these regression results, the estimates of farmers' expectations obtained from the structural approach better explain the variation in r_{it} than do time series approach estimates or simplistic approach estimates. Also, the structural approach provides information about the variation of r_{it} among farmers because of the information contained in the cost function.

Concluding Comments

Farmers' EROA are necessary components of many theoretical models such as the model of optimal capital structure (Collins) and expected value-variance (EV) models (Barry, Baker and Sanint). However, such expectational variables are not directly observable. The study presented here offers a structural approach as an alternative to time series and simplistic approaches for estimating farmers' EROA. The structural approach provides information about the causes of variation in rates of return whereas the time series and simplistic approaches do not. In addition, time series approaches are often difficult to utilize when firm-level cross-section and time-series data are to be analyzed or provide the basis for analysis.

The cost function provides a structural approach for estimating expectations. Two translog restricted cost functions were estimated. First, a restricted cost function was estimated with predicted input prices generated by ARIMA models. Second, the restricted cost function was estimated with realized input prices. Own-price input demand elasticities were found to be inelastic in both models. Also the elasticities were found to be insensitive to whether the restricted cost function

Table 5 Regressions of observed operating rates of return on assets, r_{it}, on estimates of expected operating rates of return[a]

Approach	Independent Variables	Equation	Parameter Estimates α	β	R^2	Root Mean Square Error
Structural	$\hat{E}(r_{it})$ realized prices	(18)	0.0192 (0 0026)	0.7772 (0.0206)	0 6407	0 0554
Structural	$\hat{E}(r_{it})$ predicted prices	(18)	0.0202 (0 0027)	0 7631 (0 0214)	0 6131	0.0574
Time Series	$\hat{E}(r_{it})_T$ farm level	(25)	-0 0095 (0 0035)	1 0015 (0 0296)	0 5893	0 0592
Time Series	$\hat{E}(r_t)_T$ aggregate	(24)	0.0336 (0 0241)	0.5440 (0 2540)	0 0057	0 0921
Simplistic	r_i by farmer	(26)	$4\ 02 \times 10^{-16}$ (0 0031)	1 0000 (0 0283)	0 6094	0 0577
Simplistic	r_t by year	(20)	$3\ 64 \times 10^{15}$ (0 0092)	1 0000 (0 1020)	0 1072	0 0872

[a]Standard errors are in parentheses Number of observations = 802

was estimated with predicted prices from an ARIMA model or with realized prices. The only statistically significant estimate of technical change was technical progress at an annual rate of 0.5 percent when realized prices were used. The predicted costs from the two estimated cost functions were used to obtain structural approach estimates of farmers' EROA.

When regression results of EROA estimates were compared, the estimates of farmers' expectations obtained from the structural approach were better at explaining the variation in observed operating rates of return on assets than were estimates from time series and simplistic approaches. Based on this criterion, the structural approach was more effective at estimating farmers' EROA using firm-level data from 152 North Carolina dairy farmers.

A cost function may be used as an element of the structural approach for estimating farmers' EROA when farmers' know the gross operating returns they will receive for the year. If the gross operating returns are unknown (random) to farmers, the structural approach may be utilized by estimating a profit function instead of a cost function.

References

Ahrendsen, B.L. "Optimal Capital Structure for the Proprietary Firm: An Empirical Analysis of North Carolina Dairy Farms." Unpublished Ph.D. Dissertation, North Carolina State University, Raleigh, 1990.

Alston, J.M. "An Analysis of Growth of U.S. Farmland Prices, 1963-82." *Amer. J. Agr. Econ.* 68(1986):1-9.

Barry, P.J., C.B. Baker, and L.R. Sanint. "Farmers' Credit Risks and Liquidity Management." *Amer. J. Agr. Econ.* 63(1981):216-27.

Benson, G.A., S.R. Sutter, R.C. Wells, D.C. Pardue, and D.G. Harwood Jr. "Dairy Farm Business Summary and Business Evaluation Workbook." Raleigh. The North Carolina Agricultural Extension Service. Issues 1964-86.

Box, G.E.P. and G.M. Jenkins. *Time Series Analysis: Forecasting and Control.* Revised Edition, San Francisco, CA: Holden-Day, 1976.

Brocklebank, J.C. and D.A. Dickey. *SAS System for Forecasting Time Series, 1986 Edition.* Cary, NC: SAS Institute Inc., 1986.

Brown, K.C. and D.J. Brown. "Heterogenous Expectations and Farmland Prices." *Amer. J. Agr. Econ.* 66(1984):164-69.

Brown, R.S. and L.R. Christensen. "Estimating Elasticities of Substitution in a Model of Partial Static Equilibrium: An Application to U.S. Agriculture, 1947-74," in E.R. Berndt and B.C. Field, eds., *Modeling and Measuring Natural Resource Substitution*, Cambridge, MA: MIT Press, 1981.

Burt, O.R. "Econometric Modeling of the Capitalization Formula for Farmland Prices." *Amer. J. Agr. Econ.* 68(1986):10-26.

Capalbo, S.M. and J.M. Antle. *Agricultural Productivity: Measurement and Explanation.* Washington, DC: Resources for the Future, Inc., 1988.

Collins, R.A. "Expected Utility, Debt-Equity Structure, and Risk Balancing." *Amer. J. Agr. Econ.* 67(1985):627-29.

Falk, B. "Formally Testing the Present Value Model of Farmland Prices". *Amer. J. Agr. Econ.* 73(1991):1-10.

Featherstone, A.M. and T.G. Baker. "An Examination of Farm Sector Real Asset Dynamics: 1910-85." *Amer. J. Agr. Econ.* 69(1987):532-46.

Fried, Joel. "Forecasting and Probability Distributions for Models of Portfolio Selection." *J. Finan.* 25(1970):539-54.

Goldberger, A.S. "The Interpretation and Estimation of Cobb-Douglas Functions." *Econometrica* 35(1968):464-72.

Judge, G.G., W.E. Griffiths, R.C. Hill, H. Lutkepohl, and T.C. Lee. *The Theory and Practice of Econometrics.* New York: John Wiley & Sons, 1985.

Kennedy, Peter. *A Guide to Econometrics.* Cambridge, MA: MIT Press, 1985.

Ljung, G.M. and G.E.P. Box. "On a Measure of Lack of Fit in Time Series Models." *Biometrika.* 65(1978):297-303.

Melichar, Emanuel. "Capital Gains versus Current Income in the Farming Sector." *Amer. J. Agr. Econ.* 61(1979):1085-92.

Moss, C.B., J.S. Shonkwiler and S.A. Ford. "A Risk Endogenous Model of Aggregate Agricultural Debt." *Agr. Finan. Rev.* 50(1990):73-79.

Murray, W.G., D.G. Harris, G.A. Miller and N.S. Thompson. *Farm Appraisal and Valuation.* Ames, Iowa: The Iowa State University Press, 1983.

Scott, J.T. and C.B. Baker. "A Practical Way to Select an Optimum Farm Plan under Risk." *Amer. J. Agr. Econ.* 54(1972):657-60.

Tegene, Abebayehu and Fred Kuchler. "An Error Correcting Model of Farmland Prices." *Applied Econ.* 23(1991):1741-47.

U. S. Department of Agriculture. *Agricultural Prices, Annual Summary.* Washington, DC, various issues.

U. S. Department of Agriculture. *Agricultural Statistics.* Washington, DC: U. S. Government Printing Office, various issues.

Zellner, A. 1962. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests of Aggregation Bias." *J. Amer. Statistical Association.* 57(1962):348-68.

Endnotes

1. The definition of the operating rate of return on assets used in this study excludes an allowance for operator and family labor and management.

2. The price North Carolina dairy farmers receive for their milk production during the study period depends to a large extent on their production relative to the base they own and on the price processing plants are receiving. The Minnesota-Wisconsin (M-W) price is a component in the milk price formula determining milk prices in North Carolina and in Federal milk-marketing orders. During periods of surplus production of milk in the United States (much of the time period analyzed in the study presented here), the support price of milk undergirds the M-W price and, thus, the price structure for milk sold by North Carolina dairy farmers. In addition, as farmers approach and/or exceed their base production, the price they receive on their production decreases. Thus, there is a pricing incentive not to exceed base production. A seasonal production base plan was adopted on September 1, 1990 as the result of Federal milk-marketing order 5 forming the Carolina order. The North Carolina Milk Commission ceased operations on December 31, 1990.

3. There are two asset variables used in the study: real value of total assets (A) and real value of productive assets (A_p). The real values of these assets are the market values of the assets deflated by the producer price index (1967 = 100), where the market values are provided by the farmer. The real value of total assets is the denominator of equation (1) (sample mean = $192,556). The real value of productive assets (land, buildings, machinery, feed and crops, and livestock) is a subset of total assets and is a variable in the cost function (sample mean = $178,390).

   Family labor (L) is the sum of operator and partner's unpaid labor and family unpaid labor measured in hours (sample mean = 4,358). Operator and partner's unpaid labor is computed on the basis of 220 hours of labor per month. Family unpaid labor is based on the hours of unpaid labor supplied by family members. As a result of data limitations, adjustments are not made for differences in human capital.