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MEASURING ECONOMIES OF SCALE AND SCOPE IN AGRICULTURAL BANKING

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The efficient size of agricultural banks is an issue that will remain important for the rest of the 1990s. The consolidation that is occurring in the rest of the financial services industry has spilled over into agricultural banks. This consolidation has raised concern among the general populous as to whether the consolidated banks will continue to lend to agriculture as has been in the past. In addition, major concerns rest in whether consolidation is moving agricultural banks down their cost curves to achieve greater efficiency, or whether consolidation is resulting in greater market power without achieving cost savings. The study of the production technology of financial institutions can determine whether and to what degree economies of size exist and how agricultural lending will fit into the overall business plans of consolidated banks.

Generally, empirical studies have used either duality theory with the estimation of cost functions or nonparametric estimation methods to assess efficiency in the financial services industry. The purpose of this study is to estimate an indirect multi-product cost function to examine the cost structure of agricultural banks. The uniqueness of this study, when compared to previous studies of efficiency of the financial services industry, is the disaggregation of the outputs so that agricultural lending can be studied.

Clark reviewed 13 studies that measured economies of scope for commercial banks, credit unions, and savings and loan associations. Clark found that these studies offered four broad conclusions: 1) overall economies of scale exist at low levels of input, 2) no consistent evidence of economies of scope, 3) some evidence of cost complementarities, and 4) the results seem to be robust among financial institutions.

Humphery also reviewed studies which examine the issue of bank economies of scale. Humphery found that little cost savings exist for increases in size alone. He found that significant benefits accrue from loan diversification. Humphery also found that the differences in cost structure within the same size category is large compared to measured cost economies.

Featherstone recently examined studies of multiproduct cost bank structure. He found most studies had rejected the hypothesis of homothetic production technologies. Thus, the aggregation of output into a single commodity is inappropriate. Another common finding in the studies is that some evidence of economies of scale does exist for low levels of output, while diseconomies of scale exist for high levels of output. However, the statistical significance of these results is not all that strong. Each of these studies also find that global economies of scale are positive and exist, however, the estimates are not statistically significant.

The paper will be organized in the following manner. First, multiproduct cost concepts will be briefly discussed. A discussion of the empirical model used to estimate the cost structure will follow. The data and procedures used in the estimation of agricultural bank's indirect multi-product cost curves is discussed next. The paper will summarize the empirical findings. Finally, the paper will conclude with an assessment of the strengths and weaknesses of this study and provide comments on future research needs for those interested in agricultural banks.

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Multiproduct Cost Concepts

Multiproduct cost concepts did not arise until the early 1980s (Baumol, Panzar, and Willig). In a multiproduct framework, economies of scale can arise from two sources: product-specific economies and/or economies of scope. Product specific economies are present if the per unit cost of producing an output declines as the output increases. In a multiproduct framework, product specific economies are measured by defining what is known as incremental cost. The incremental cost for the ith output (IC_i) is defined as the cost of producing the entire multiproduct output bundle (C(Y)) minus the cost of producing all of the outputs except the ith output ($C(Y_{N-i})$). Formally:

$$IC_i = C(Y) - C(Y_{N-i}) \text{ where } Y_{N-i} = (Y_1,...,Y_{i-1},0,Y_{i+1},...,Y_N). \tag{1}$$

Product-specific economies of scale (S_i) are then determined by taking the average incremental cost of producing the ith output (IC_i/Y_i) divided by the marginal incremental cost of producing the ith output ($\partial C/\partial Y_i$). Formally:

$$S_i = \frac{(IC_i/Y_i)}{(\partial C/\partial Y_i)}. \tag{2}$$

If S_i is greater than one than product specific economies of scale are said to exist. Product specific economies of scale are most analogous to the single output case of scale economies. This measure can be expanded to include subsets of products if desired.

Economies of scope (diversification) arise from cost savings obtained from the simultaneous production of several outputs together. Economies of scope ($SC_i(Y)$) exist if the cost of producing the optimal level of outputs in "individual firms" is greater than the cost of producing the same optimal output levels in a multiproduct firm. Formally for a two product firm, if

$$C(Y_1) + C(Y_2) > C(Y) \tag{3}$$

then economies of scope exist, where $C(Y_1)$ is the cost of producing output 1 in a single product firm and $C(Y_2)$ is the cost of producing output 2 in a single product firm. For 2 outputs, economies of scope ($SC_N(Y)$) are defined as:

$$SC_N(Y) = [C(Y_1) + C(Y_2) - C(Y)]/C(Y). \tag{4}$$

If $SC_N(Y)$ is greater than zero than economies of scope are said to exist. This indicates the relative increase in cost from a splintering of production into separate groups or the relative cost savings of multiproduct production.

Both economies of scope ($SC_N(Y)$) and product-specific economies (S_i) can be combined to give an overall measure of the returns to scale for an individual firm. These are also referred to as scale economies (S_N). Formally, the measure of economies of scale for a two output firm is:

$$S_N(Y) = \frac{\alpha_1 S_1(Y) + (1-\alpha_1)S_2(Y)}{1 - SC_N(Y)} \tag{5}$$

where α_1 is the first firm's output time the marginal cost as a proportion of the sum of all outputs multiplied individually by their marginal cost.

Economies of scale can then arise under multiple scenarios. If economies of scope are equal to zero, then economies of scale will exist if one of the outputs has constant returns to scale and the other output has increasing returns to scale. Economies of scale can also arise if both outputs have constant returns to scale if economies of scope exist.

Empirical Model

Multiproduct cost concepts were able to develop only after the development and application of duality theory. Rigorous treatment of duality originated in 1953 with a book by Ronald Shephard. This allowed a rapid expansion of the classes of functional forms available for empirical estimation of production relationships. The class of flexible functional forms, which are based on 2nd-order Taylor series approximations, include the translog, generalized Leontief, and the quadratic. The translog is the most commonly applied functional form used in multiproduct cost analysis of the banking industry. A problem encountered with the use of the translog cost function is that outputs are logged in the estimation process. If a financial institution does not produce an output, the log of that output quantity (zero) is undefined. This problem becomes important when calculating incremental costs. A commonly accepted technique is to replace zero outputs with a sufficiently small nonzero value. Cowing and Holtmann; Akridge and Hertel; and Schroeder set zero output values equal to 10 percent of the geometric mean. A drawback of this procedure is that bias may be introduced into the parameter estimates.

A functional form that has been used to avoid this problem encountered with the translog functional form is the normalized quadratic. The normalized quadratic is expressed as:

$$C'=\alpha_0+\sum_{i=1}^{m}\alpha_i w_i' + \sum_{i=m+1}^{n}\alpha_i Y_i+\frac{1}{2}\left(\sum_{i=1}^{m}\sum_{j=1}^{m}\alpha_{ij}w_i' w_j' + \sum_{i=m+1}^{n}\sum_{j=m+1}^{n}\alpha_{ij}Y_i Y_j\right) + \sum_{i=1}^{m}\sum_{j=m+1}^{n}\alpha_{ij}w_i' Y_j \qquad (6)$$

where C′ is the normalized cost, (cost divided by the 0th input price), w_i' is the ith normalized price, and Y_i is the ith output quantity. The cost function is assumed to be twice-continuously differentiable, and linear homogeneous in input prices. Homogeneity is imposed by the normalization process. To satisfy economic theory, the cost function is also concave in input prices and convex in outputs.

Using Shepherd's lemma, the first derivative of the cost function is the compensated input demand functions.

$$\frac{\partial C'}{\partial w_i'}=x_i=\alpha_i+\sum_{j=1}^{m}\alpha_{ij}w_j' + \sum_{j=m+1}^{n}\alpha_{ij}Y_j \ \textit{for}\ i=1,...m-1. \qquad (7)$$

Symmetry is imposed by restricting $\alpha_{ij}=\alpha_{ji}$ in the estimation procedure.

Data and Procedures

The normalized quadratic cost function consists of six outputs and four inputs. The value-added approach was used to define the inputs and outputs. The source of the data was the 1990 Federal Reserve Call Report data. A sample of 7,140 rural or agricultural banks were selected if at least 50 percent if the deposits of branches are not located in a metropolitan service area (MSA) or if the bank had an agricultural loan ratio of 25 percent or higher. The outputs consisted of quarterly averages of transaction deposits (Y4), nontransaction deposits (Y5), nonagricultural real estate loans (Y2), nonagricultural nonreal estate loans (Y3), agricultural real estate and nonreal estate loans (Y1), and other bank output (Y6). The inputs consist of the number of employees (X2), fixed assets (X3), total assets (X0), and total deposits (X1).

The sample size was reduced by 32 banks when price variables were calculated due to the division by zero. The definition of outputs was straight forward except for other outputs. Other outputs consisted of federal funds and total securities. The price for labor was determined by dividing employee expense by the number of employees. The occupancy price was determined by dividing the occupancy expense divided by the fixed asset value (Mester). The interest expense was determined by dividing the interest paid divided by total loans. The other input price was determined by dividing other expense by total assets. The price on which the quadratic function was normalized was other operating expenses. Summary statistics for data are found in Table 1.

Results

The parameter estimates of the cost function and three input demand functions: total deposits, labor, and fixed assets are found in Table 2. The inputs carry the subscript 1 to 3 whereas the outputs carry the subscripts 4 to 9. The estimation procedure was iterative seemingly unrelated regression. The adjusted R-square for the cost function was .9947, .9976 for the deposit equation, .9457 for the employee equation, and .8097 for the fixed asset equation. The t-statistics were significant on 89.1 percent of the parameter estimates which is higher than reported in other studies (Akridge and Hertel, Schroeder, Cowing and Holtmann).

Table 3 presents the price elasticity estimates for deposits, labor, and premises. The elasticity estimates are calculated at the mean of the price and output variables. The own-price elasticities for deposits and labor are negative and close to zero. The own-price elasticity on the premises is positive. This indicates that the curvature properties do not hold and thus estimation needs to take place with curvature properties imposed. Caution must be used when interpreting the results.

Table 4 presents the marginal cost estimates and the product specific economies of scale for each of the outputs. If product specific economies of scale are greater than one, that product is said to be produced in a region of increasing returns. All outputs except other bank output have product specific economies nearly equal to one, indicating constant returns to scale at the mean output. Other bank output has an estimate of 1.33 indicating returns of scale exist at the mean level.

Table 5 presents the economies of scope measure for each of the output products. The economies of scope measures presented in Table 5 represent production splintered into two groups: the product being produced alone and the other five products being produced. Each of the measures is slightly negative indicating the that no economies of scope exist or slight diseconomies. This indicates that the production of these outputs will reduce costs on the order of 4.5 to 8.0 percent. Another economies of scope measure was calculated by splintering production into 6 single product firms. The results indicate that the splintering of outputs into single firms would reduce costs by 27.1 percent.

Finally, a measure of the overall economies of scale for the firm at the mean levels of output was calculated. The results indicate that at mean output levels the overall returns to scale measure is .954. The indicates that for this sample of banks, the outputs are being produced in a region of nearly constant returns to scale or a region of slight diseconomies of scale.

Table 1. **Summary Statistics of Sample Banks (7,108) Observations**

Variable	Minimum	Maximum	Average	Standard Deviation
Y1-Agricultural real estate and nonreal estate loans ($000,000)	0.0	270.2	4.7	7.1
Y2-Nonagricultural real estate loans ($000,000)	0.0	1608.7	14.8	41.1
Y3-Nonagricultural nonreal estate loans ($000,000)	0.0	1317.1	13.0	44.0
Y4-Transactions deposits ($000,000)	0.0	1085.0	12.8	29.4
Y5-Nontransaction deposits ($000,000)	0.0	2690.0	40.0	82.5
Y6-Other bank output ($000,000)	0.0	1215.1	21.5	37.6
X0-Total assets ($000)	1446	4451466	59916	132625
X1-Total deposits ($000)	1866	4591859	59964	136720
X2-Number of employees	1.8	3630.8	32.9	81.2
X3-Fixed assets ($000)	1.0	141910	1187	3119
P0-(X0/total assets)	0.0005	0.1452	0.0113	0.0055
P1-(X1/total deposits)	0.0001	0.1479	0.0487	0.0083
P2-Average salary ($000)	1.5	76.2	27.4	6.4
P3-(X3/fixed assets)	0.002	94.0	0.353	1.505
Cost ($000)	110	389308	4791	11476

Table 2. Parameter Estimates for the 1990 Agricultural Bank Data

Parameter	Estimate	T-Ratio
α_0	-7050.41	-9.27*
α_1	-1695.93	-11.56*
α_2	0.6448	1.70
α_3	-132.49	-18.81*
α_4	2770.18	18.59*
α_5	2339.78	24.77*
α_6	2598.05	28.69*
α_7	-647.91	-6.22*
α_8	-1626.70	-15.96*
α_9	2522.95	26.80*
α_{11}	-440.74	-10.02*
α_{12}	0.2462	4.14*
α_{13}	6.642	15.32*
α_{22}	-.0014	-11.34*
α_{23}	.0169	16.89*
α_{33}	.0232	14.80*
α_{44}	-69.05	-10.08*
α_{45}	-18.96	-4.33*
α_{46}	4.52	1.34
α_{47}	15.67	3.86*
α_{48}	5.41	1.06
α_{49}	-9.67	-1.99*
α_{55}	-3.91	-1.54
α_{56}	-7.89	-3.41*
α_{57}	25.30	7.97*
α_{58}	3.88	1.51

* Significant at the five percent level.

Table 2. (con't) Parameter Estimates for the 1990 Agricultural Bank Data

Parameter	Estimate	T-Ratio
α_{59}	-18.90	-7.06*
α_{66}	-17.27	-7.38*
α_{67}	16.35	5.95*
α_{68}	13.70	5.83*
α_{69}	-21.44	-9.15*
α_{77}	4.63	1.55
α_{78}	-28.16	-8.98*
α_{79}	18.38	6.40*
α_{88}	-6.47	-2.29*
α_{89}	22.57	7.81*
α_{99}	-22.98	-8.29*
α_{14}	666.04	44.53*
α_{15}	-.763	-20.60*
α_{16}	-40.23	-20.84*
α_{17}	629.92	54.03*
α_{18}	-.536	-17.98*
α_{19}	-12.84	-7.39*
α_{24}	712.43	69.34*
α_{25}	-.772	-29.30*
α_{26}	-14.29	-9.40*
α_{27}	1269.91	107.93*
α_{28}	2.76	93.21*
α_{29}	103.03	56.20*
α_{34}	284.01	23.26*
α_{35}	1.06	34.04*
α_{36}	28.12	16.42*
α_{37}	643.94	57.21*
α_{38}	-1.07	-37.75*
α_{39}	-45.22	-28.50*

* Significant at the five percent level.

Table 3. Input Demand Price Elasticities

Quantity	Price: Deposits	Price: Labor	Price: Premises
Deposits	-.0373	.0118	.0044
Labor	.0399	-.1321	.0212
Premises	.0395	.0568	.0011

Table 4. Marginal Costs and Product Specific Economies of Scale for Bank Outputs

Output	Marginal Cost	Product Specific Economies of Scale
Agricultural loans	$ 2039.4	1.0789
Nonag real estate	3317.3	1.0087
Other nonag loans	3411.2	1.0328
Transactions deposits	17797.4	0.9983
Nontransactions deposits	4090.9	1.0316
Other bank output	890.1	1.3254

Table 5. Economies of Scope for Bank Output

Output	Economies of Scope
Agricultural loans	-.0486
Nonag real estate	-.0452
Other nonag loans	-.0541
Transactions deposits	-.0469
Nontransactions deposits	-.0802
Other bank output	-.0722

Conclusions and Implications

The implications from this study will focus along economics implications for agricultural banking and technical issues that still need to be resolved in the banking literature. Any economic implications from this study must be interpreted with care because concavity of input prices and convexity of outputs does not hold globally. The curvature conditions are derived from economic theory and are just as important as conditions which are easily imposed such as symmetry and homogeneity.

Given the results of this study, at the mean size of the banks examined in this study, $60 million, economies of scale are not present. In fact, at the mean bank size, the economies of scale measure is slightly negative. Thus, economies of scale seem to be exhausted at this size of bank output. A second implication is that economies of scope do not exist for any of the individual outputs. Thus, combining agricultural lending into an institution which currently does not have agricultural lending will not lead to economies of diversification. Thus, the results from this study suggest that cost advantages to increasing bank size do not exist at the mean of $60 million in assets.

More technical issues still remain in the agricultural banking literature. The first issue is that studies which examine the relative efficiency of various financial institutions must be cautiously interpreted. If the cost function does not adhere to conditions derived from economic theory, how trustworthy are the estimates reported in this paper or other papers? The results suggest that curvature properties may not hold in the estimation process. A second technical point deals with the determination of input prices in many studies of banking. For example, using total deposits as a measure of quantity to determine more than one price ratio for different commodities is inappropriate. This can be seen by examining equation (7). In actuality, the dependent variable on each of the input demand equations is total deposits. This fact is often masked by the use of the translog cost function. The definition of input quantities in a service institution is an area that continues to need much input. Future research will focus on the imposition of curvature properties and the definition of input quantities.

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