

MULTIPRODUCT COST FUNCTIONS AND SCALE ECONOMIES IN BANKING

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ABSTRACT

This study provides new and efficient estimates of scale economies in banking. Recent criticism of the incorrect specification of homogeneity restrictions on the translog cost functions is addressed, and correct estimations are provided. The results indicate that such misspecifications do affect measures of scale economies. The study covers 1980 to 1983 for unit and branch banks. The estimation is further enhanced by introducing factor share equations invoking Shephard's lemma and using an iterative Zellner procedure. The results fail to indicate scale economies for the overall sample. Some evidence of small degrees of scale economies is observed in parts of the sample.

INTRODUCTION

The literature in banking cost studies is abundant in the number of studies conducted, the variety of techniques used, and the results provided (for a good survey see Kolari and Zardkoohi [8] and Mester [9]). The study of bank cost functions demands our attention due to its possible implications for the optimum firm size, the market structure in banking, and the related issues of regulation. To date, there is no consensus on these issues.

Many earlier researchers have used the transcendental logarithmic (translog) cost function specifications to characterize the banking costs (Benston, Hanweck, and Humphrey (BHH) [2]; Benston, Berger, Hanweck, and Humphrey (BBHH) [1]; Gilligan, Smirlock, and Marshall (GSM) [7]; Murray and White (MW) [10]; Mester [9]; and more). BHH, BBHH, and GSM, among others, have used the Functional Cost Analysis (FCA) Program data as compiled by the Federal Reserve banks. Their results have indicated that scale economies are ex-

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hausted at very small banks—those with less than \$50 million in deposits.

The accuracy of the results of the GSM and MW studies has been questioned recently by Zardkoohi, Rangan, and Kolari [12] due to misspecifications in the impositions of symmetry and linearity constraints in estimations. Caution has been indicated in interpreting the results of these major and often cited studies.

This study introduces a better methodology for estimating scale economies in multiproduct banking firms. It does so by providing technically accurate, and more efficient, estimators. Accuracy is increased through the correct specification of symmetry and linearity constraints, and efficiency of the parameter estimators is increased by including factor-share equations. A similar approach has been used by Mester [9] for savings and loans, and by MW for British Columbia credit unions using an iterative seemingly unrelated regressions equations (SURE) technique. As in the BHH and GSM studies, FCA data are used, but for 1980 to 1983.

The paper is organized as follows. The first section discusses the methodology. The next section describes the data and variable definitions. The third section gives the estimation and results. The last section summarizes the study.

METHODOLOGY

Translog Cost Function Revisited

A general multiproduct production function that transforms a vector of inputs X into a vector of outputs Y can be represented by

$$f(Y_1, Y_2, \dots, Y_m, X_1, X_2, \dots, X_n) = 0. \quad (1)$$

It has been shown that there exists a unique multiproduct cost function with factor prices P ,

$$C = g(Y_1, Y_2, \dots, Y_m, P_1, P_2, \dots, P_n), \quad (2)$$

which is the dual to the production function (1) and is more convenient to estimate. We specifically chose the transcendental logarithmic (translog) cost function as the basic functional form for our study (Christensen, Jorgenson, and Lau [5]).

The translog is a flexible functional form that places no a priori restrictions on substitution possibilities among the factors

of production. It allows the average cost curve to attain the U shape. Also, the translog form has another advantage: it implies derived demand equations for the factors of production that are linear in the parameters and will allow us to improve on the efficiency of the parameters. Some of the previous studies in banking that have used the translog cost function failed to recognize this added advantage, and their estimates suffer from this inefficiency in their parameter estimators.

The translog joint cost function for m outputs (Y_i), and n inputs (P_j) can be written as follows:

$$\begin{aligned} \ln C = & \alpha_0 + \sum \alpha_i \ln Y_i + \sum \beta_j \ln P_j \\ & + 1/2 \sum \sum \delta_{ik} \ln Y_i \ln Y_k \\ & + 1/2 \sum \sum \gamma_{jl} \ln P_j \ln P_l \\ & + \sum \sum \rho_{ij} \ln Y_i \ln P_j \end{aligned} \quad (3)$$

where $\delta_{ik} = \delta_{ki}$ and $\gamma_{jl} = \gamma_{lj}$ for symmetry. Not all of the parameters are free, however, since every cost function must exhibit homogeneity of degree one in factor prices in order to correspond to a well-behaved production function. The following linear restrictions on (3) are necessary and sufficient for linear homogeneity in factor prices:

$$\begin{aligned} \sum \beta_j &= 1; \\ \sum \gamma_{jl} &= 0 \quad (l = 1, 2, \dots, n); \\ \sum \rho_{ij} &= 0 \quad (i = 1, 2, \dots, m). \end{aligned} \quad (4)$$

This reduces the number of free parameters in (3) to $(m + n + 1)(m + n)/2$. The results reported by GSM have been shown to have misspecified these constraints in their estimations (Zardkoohi, Rangan, and Kolari [12]). Our results provide correctly specified constraints and thus more reliable estimates. The elasticity of total cost with respect to output will be used to calculate economies of scale in banking. For the translog cost function, the cost elasticities are

$$\begin{aligned} \partial \ln C / \partial \ln Y_i = & \alpha_i + \sum \delta_{ik} \ln Y_k + \sum \rho_{ij} \ln P_j \\ & (i = 1, \dots, m) \end{aligned} \quad (5)$$

Although variations are possible, we will define scale economies as

$$SCE = \sum \partial \ln C / \partial \ln Y_i. \quad (6)$$

SCE is less than 1 for scale economies and greater than 1 for diseconomies.

A More Efficient Way of Estimation

As was done in some earlier studies of economies of scale in banking, we could proceed to estimate the parameters of the cost function (3) by simply computing the ordinary least squares estimates. However, as in Christensen and Greene [4] and Diewert [6], and in more recent studies in bank costs (see Kolari and Zardkoobi [8]), we can use additional information to improve the efficiency of the estimators in question. Using Shephard's lemma, we recognize that we can compute the derived demand equations for the factors of production from the joint cost function (3). In logarithmic form, Shephard's lemma can be written

$$\partial \ln C / \partial \ln P_j = (P_j / C)(\partial C / \partial P_j) = (P_j X_j) / C = W_j \quad (7)$$

where W_j is the share of input j in total cost. Applying Shephard's lemma to our joint cost function, we obtain the following additional n cost share equations:

$$W_j = \beta_j + \sum \rho_{ij} \ln Y_i + \sum \gamma_{ij} \ln P_i \quad (j = 1, 2, \dots, n). \quad (8)$$

At this stage, we have not introduced any more unknowns, but we have increased the power of our estimation by adding additional information. Following Christensen and Greene [4], we will proceed to estimate the cost function and the cost share equations jointly as a multivariate regression system. We will obtain maximum likelihood estimates for the system by iterating the Zellner [13] estimation technique (SURE) with one of the cost share equations deleted (since the W_j 's must sum to unity at every observation, one of them becomes redundant, and we avoid the singularity problem of the covariance matrix).

DATA AND VARIABLES

In an attempt to be consistent with major previous studies, we decided to use the same data source but with a more up-to-date sample: specifically, the data as compiled by the Functional Cost Analysis Program of the Federal Reserve Bank of New York for the years 1980, 1981, 1982, and 1983.

The Functional Cost Analysis Program deserves some explanation. This is a voluntary program through which those banks that choose to join provide the Fed with cost data based

on various classified functions of the banks. Approximately 1,000 variables per bank per year are collected. About 800 of these are made available to outside researchers. All information that can possibly lead to some sort of identification of the bank is masked from the researcher. Geographic location (state) codes that were made available to earlier researchers are no longer available. This affects the way we will approximate the cost of labor as well as capital. We will have to use accounting data. We must acknowledge here that these data are prone to window dressing and are stock rather than flow. However, since this is a voluntary program, we expect the data to be relatively clean and accurate.

Another characteristic of the FCA data is that banks do not consistently stay in the program from year to year. Together with the impossibility of identifying them, this otherwise ideal time series is effectively reduced into cross sections of different samples over time. The number of banks as well as the composition (unit versus branch banking) of the data in each year are quite different from the next.

A further important point is that banks with over \$1 billion in deposits are excluded from the analysis; thus, the results may not apply to very large banks. We hope that these exclusions will not severely undermine our results and that the implications we wish to draw from these data will be acceptable for the majority of banking firms. Shaffer and David [11] provide strikingly different results on scale economies using the largest 100 U.S. banks. This might be interpreted as evidence of differences in technologies between large money center banks and the smaller banks that have been examined. Our results and BHH and GSM results can be interpreted for the smaller banks in the U.S. banking markets.

The Sample

The data allow us to differentiate between branch and unit banks. We will make use of this information by splitting our sample into two groups and conducting parallel analyses for both unit and branch banks. We will define our variables as follows:

Total operating costs (TC). Costs are measured as the sum of labor costs and capital expenditures, as used in the input cost measures of the bank.

Bank output (Dep and Loan). We follow BHH, BBHH, and GSM and use the annual average numbers of deposit and loan

accounts serviced as our measures of output. We do acknowledge the questions raised against the use of deposits as outputs rather than inputs. For purposes of comparability, we follow the previous authors. We could not use a finer breakdown of deposit and loan accounts in this study because some banks had zero outputs. The translog form is undefined at zero output levels. (Cebenoyan [3] accommodates five outputs in a hybrid Box-Cox functional form.)

Factor prices (Wage and Cap). We assume that labor and capital are the two factors of bank production. The cost of labor, *Wage*, is measured as average annual salary plus fringe benefits and fees paid to all employees of the bank. The price of capital, *Cap*, will have to be taken from the FCA data for the reasons described earlier, as opposed to using possible geographical proxies that previous researchers were able to obtain. We estimate the cost of capital as the ratio of the sum of furniture and equipment, occupancy, and computer (including software) expenses to the building and equipment less depreciation items from the balance sheet. This gives us a proxy for the cost of capital as dollar expenditures per dollar of capital investment in real assets.

ESTIMATION AND RESULTS

As described in the previous sections, the functional form used for tests of economies of scale will be the translog functional form augmented by the input cost share equations as in Christensen and Greene [4].

Two outputs, *Dep* (total deposit accounts) and *Loan* (total loan accounts) are used for unit and branch banks for each of the years in the sample. To keep the number of variables to a minimum, we refrained from adding any more. The following system of equations has been estimated using the iterative Zellner procedure.

$$\begin{aligned}
 \ln TC = & \alpha_0 + \alpha_d \ln Dep + \alpha_l \ln Loan + \beta_k \ln Cap \\
 & + \beta_w \ln Wage + 1/2 \delta_{dd} \ln Dep^2 + 1/2 \delta_{ll} \ln Loan^2 \\
 & + \delta_{dl} \ln Dep \ln Loan + 1/2 \gamma_{ww} \ln Wage^2 \\
 & + 1/2 \gamma_{kk} \ln Cap^2 \\
 & + \gamma_{wk} \ln Wage \ln Cap + \rho_{dk} \ln Dep \ln Cap \\
 & + \rho_{dw} \ln Dep \ln Wage \\
 & + \rho_{lk} \ln Loan \ln Cap + \rho_{lw} \ln Loan \ln Wage \quad (9)
 \end{aligned}$$

$$\begin{aligned}
W_w = & \beta_w + \rho_{dw} \ln Dep + \rho_{lw} \ln Loan \\
& + \gamma_{ww} \ln Wage + \gamma_{kw} \ln Cap
\end{aligned} \tag{10}$$

where the variables are as defined earlier. Equation (10) is the labor cost share equation. The aforementioned restrictions have been imposed on the model to ensure linear homogeneity and symmetry, avoiding the misspecifications made by GSM.

The estimates of the above system of equations and their t -ratios are provided in Tables 1 and 2 for the four years (1980–1983) and for branch and unit banks.

We then proceeded to estimate economies of scale, *SCE*, defined as the total elasticity of cost with respect to output. We also provided the cost elasticity of each output, *SDEP* and *SLOAN*. Scale economies are measured by

$$\begin{aligned}
SCE = & \partial \ln TC / \partial \ln Dep + \partial \ln TC / \partial \ln Loan \\
= & SDEP + SLOAN \\
= & \alpha_d + \alpha_l + (\delta_{dd} + \delta_{dl}) \ln Dep + (\delta_{ll} + \delta_{dl}) \ln Loan \\
& + (\rho_{dk} + \rho_{lk}) \ln Cap + (\rho_{dw} + \rho_{lw}) \ln Wage. \tag{11}
\end{aligned}$$

If *SCE* is less than 1, we will have marginal costs less than average costs; thus, we will have an indication of economies of scale. If *SCE* is found to be greater than 1, then we will have diseconomies of scale.

The above model has been run on the four years of data as separate cross sections. To test for variations in *SCE* at different size classes, we have split each year's data into size classes by total deposits following BHH, BBHH, and GSM. For lack of better information on where the size classes ought to be, we used Benston's size classes. We also separated each year's sample into unit and branch banks. Unit banks were determined as banks with less than or equal to one full service office. (In the total sample, two banks reported zero full service office. We considered them unit banks.)

The results of this section are reported in Tables 3 through 6. The values reported in the tables are obtained by first estimating the translog system of equations for a particular year for unit and branch banks. Then we split the unit and branch banks into deposit size classes as reported in the tables and obtain the mean values of the variables that go in our measure of scale; namely, $\ln Dep$, $\ln Loan$, $\ln Cap$, and $\ln Wage$. We then multiply these mean values with the corresponding estimated parameters of the equations.

TABLE 1
 TRANSLOG COEFFICIENTS UNIT AND BRANCH BANKS
 1980-1981 (*t*-RATIOS IN PARENTHESES)

| Variable | 1980 | | 1981 | |
|-------------------------------|-----------------------|----------------------|-----------------------|-----------------------|
| | Unit | Branch | Unit | Branch |
| Constant | 11.6951 (5.152) | 1.5996 (.809) | - 5.2678 (- 2.746) | - 2.3778 (- 1.632) |
| ln <i>Dep</i> | - 2.0943 (- 2.453) | .5989 (.842) | 5.5981 (10.342) | 2.9507 (6.171) |
| ln <i>Loan</i> | .3392 (.470) | .1306 (.219) | - 4.2683 (- 6.569) | - 1.6501 (- 4.231) |
| ln <i>Cap</i> | .5755 (9.258) | .7697 (12.209) | .6128 (6.965) | .7727 (12.481) |
| ln <i>Wage</i> | .4244 (6.827) | .2302 (3.651) | .3871 (4.399) | .2272 (3.670) |
| ln <i>Dep</i> ² | .8460 (3.934) | .1535 (.869) | - .6618 (- 3.775) | - .3601 (- 4.407) |
| ln <i>Loan</i> ² | .6758 (4.216) | .2027 (1.306) | .3923 (1.940) | .0336 (.518) |
| ln <i>Dep</i> ln <i>Loan</i> | - .5898 (- 3.293) | - .1588 (- 1.017) | .1695 (.908) | .1655 (2.653) |
| ln <i>Wage</i> ² | .0443 (9.364) | .0461 (9.144) | .0373 (5.453) | .0453 (8.994) |
| ln <i>Cap</i> ² | .0443 (9.364) | .0461 (9.144) | .0373 (5.453) | .0453 (8.994) |
| ln <i>Wage</i> ln <i>Cap</i> | - .0443 (- 9.364) | - .0461 (- 9.144) | - .0373 (- 5.453) | - .0453 (- 8.994) |
| ln <i>Dep</i> ln <i>Cap</i> | .0278 (3.315) | - .0022 (- .306) | - .0038 (- .336) | - .0074 (- 1.177) |
| ln <i>Dep</i> ln <i>Wage</i> | - .0278 (- 3.315) | .0022 (.306) | .0038 (.336) | .0074 (1.177) |
| ln <i>Loan</i> ln <i>Cap</i> | - .0117 (- 1.523) | .0021 (.304) | .0128 (1.185) | .0082 (1.353) |
| ln <i>Loan</i> ln <i>Wage</i> | .0117 (1.523) | - .0021 (- .304) | - .0128 (- 1.185) | - .0082 (- 1.353) |
| Observations | 300 | 351 | 174 | 487 |

Our results indicate that economies of scale are exhausted after \$25 million of deposits for unit banks in 1980, 1981, and 1983, and nonexistent in 1982. As for branch banks, except for 1983, scale economies do not exist for any size in the FCA data. In 1983 scale economies appear as the banks become larger.

These results tend to conflict with the general implications of the BHH and GSM studies. We fail to provide any signifi-

TABLE 2

TRANSLOG COEFFICIENTS UNIT AND BRANCH BANKS
1982-1983 (*t*-RATIOS IN PARENTHESES)

| Variable | 1982 | | 1983 | |
|-------------------------------|--------------------|---------------------|--------------------|---------------------|
| | Unit | Branch | Unit | Branch |
| Constant | -.7425 (-.303) | 1.3224 (.803) | 7.2317 (3.015) | -3.7818 (-1.951) |
| ln <i>Dep</i> | -.2252 (-.216) | .1834 (.294) | -.1129 (-.118) | 2.7624 (3.616) |
| ln <i>Loan</i> | .6167 (.704) | .8902 (1.750) | -.3474 (-.399) | -1.2048 (-1.851) |
| ln <i>Cap</i> | .0886 (1.417) | .9211 (15.285) | .8066 (8.637) | .6392 (11.065) |
| ln <i>Wage</i> | .9113 (14.568) | .0789 (1.309) | .1934 (2.071) | .3608 (6.245) |
| ln <i>Dep</i> ² | .4688 (1.735) | .4173 (2.993) | .1874 (.669) | -.1214 (-.577) |
| ln <i>Loan</i> ² | .3640 (1.860) | .4256 (3.843) | .1976 (.763) | .2253 (1.193) |
| ln <i>Dep</i> ln <i>Loan</i> | -.3597 (-1.615) | -.4221 (-3.655) | -.0999 (-.385) | -.0663 (-.348) |
| ln <i>Wage</i> ² | .0043 (.912) | .0564 (11.507) | .0531 (7.632) | .0384 (8.357) |
| ln <i>Cap</i> ² | .0043 (.912) | .0564 (11.507) | .0531 (7.632) | .0384 (8.357) |
| ln <i>Wage</i> ln <i>Cap</i> | -.0043 (-.912) | -.0564 (-11.507) | -.0531 (-7.632) | -.0384 (-8.357) |
| ln <i>Dep</i> ln <i>Cap</i> | .0340 (2.995) | -.0078 (-1.084) | .0078 (.672) | .0202 (2.849) |
| ln <i>Dep</i> ln <i>Wage</i> | -.0340 (-2.995) | .0078 (1.084) | -.0078 (-.672) | -.0202 (-2.849) |
| ln <i>Loan</i> ln <i>Cap</i> | -.0109 (-1.055) | .0061 (.869) | -.0013 (-.115) | -.0163 (-2.339) |
| ln <i>Loan</i> ln <i>Wage</i> | .0109 (1.055) | -.0061 (-.869) | .0013 (.115) | .0163 (2.339) |
| Observations | 223 | 401 | 234 | 450 |

cant evidence for a U-shaped average cost curve with a minimum at \$25 or \$50 million deposit size class. In contrast, we categorize practically all these banks as being inefficient in costs at these production levels.

We are not interpreting these results as indications that larger banks are less efficient or that deregulation and removal of expansion barriers will not lead to consolidation of market

TABLE 3
1980 ESTIMATES OF PRODUCT AND TOTAL
SCALE ECONOMIES

| Deposit Size (Million \$) | Number of Banks | <i>SDEP</i> (Deposits) | <i>SLOAN</i> (Loans) | <i>SCE</i> (Total) |
|------------------------------|--------------------|---------------------------|-------------------------|-----------------------|
| Unit Banks | | | | |
| 0-25 | 65 | .68 | .24 | .93 |
| 25-50 | 101 | .82 | .36 | 1.17*** |
| 50-75 | 44 | .96 | .39 | 1.35*** |
| 75-100 | 36 | 1.05 | .39 | 1.45*** |
| 100-200 | 42 | 1.06 | .43 | 1.88*** |
| Over 200 | 12 | 1.14 | .56 | 1.70*** |
| Total Sample | 300 | .88 | .36 | 1.24*** |
| Branch Banks | | | | |
| 0-25 | 35 | .80 | .22 | 1.02 |
| 25-50 | 83 | .80 | .24 | 1.04 |
| 50-75 | 77 | .79 | .27 | 1.06** |
| 75-100 | 41 | .79 | .28 | 1.07*** |
| 100-200 | 63 | .80 | .28 | 1.08*** |
| 200-300 | 16 | .81 | .29 | 1.10*** |
| 300-400 | 16 | .81 | .30 | 1.11*** |
| Over 400 | 20 | .80 | .33 | 1.13** |
| Total sample | 351 | .80 | .27 | 1.07*** |

*Statistically different from 1.0 at a 10 percent confidence level for a two-tailed test.

**Statistically different from 1.0 at a 5 percent confidence level for a two-tailed test.

***Statistically different from 1.0 at a 1 percent confidence level for a two-tailed test.

participants. We believe such far reaching conclusions should not be drawn based on FCA data alone.

We must note that our specification of the model is different from GSM's. We economized on the number of variables used by only using the ones that were necessary to have a well-defined translog function. We also used a different time frame. Thus, our results are not directly comparable to those of GSM. Due to the change in the data release practices of the Fed described earlier, it is not possible to duplicate the GSM results. Besides, we would have to use their functional form, which we believe is less satisfactory. To provide some parallels, we have estimated our function and our sample by misspecifying the

TABLE 4
1981 ESTIMATES OF PRODUCT AND TOTAL
SCALE ECONOMIES

| Deposit Size (Million \$) | Number of Banks | <i>SDEP</i> (Deposits) | <i>SLOAN</i> (Loans) | <i>SCE</i> (Total) |
|------------------------------|--------------------|---------------------------|-------------------------|-----------------------|
| Unit Banks | | | | |
| 0-25 | 42 | 1.19 | -.21 | .98 |
| 25-50 | 69 | .76 | .35 | 1.11*** |
| 50-75 | 17 | .66 | .53 | 1.19*** |
| 75-100 | 20 | .40 | .75 | 1.15*** |
| 100-200 | 19 | .36 | .77 | 1.13** |
| Over 200 | 7 | .08 | 1.18 | 1.25*** |
| Total sample | 174 | .74 | .36 | 1.10*** |
| Branch Banks | | | | |
| 0-25 | 40 | 1.04 | -.01 | 1.03 |
| 25-50 | 123 | .92 | .12 | 1.04 |
| 50-75 | 87 | .85 | .20 | 1.05** |
| 75-100 | 64 | .80 | .26 | 1.06*** |
| 100-200 | 95 | .71 | .33 | 1.05*** |
| 200-300 | 22 | .58 | .45 | 1.03 |
| 300-400 | 17 | .50 | .54 | 1.04 |
| Over 400 | 39 | .39 | .64 | 1.03 |
| Total sample | 487 | .79 | .26 | 1.05** |

*Statistically different from 1.0 at a 10 percent confidence level for a two-tailed test.

**Statistically different from 1.0 at a 5 percent confidence level for a two-tailed test.

***Statistically different from 1.0 at a 1 percent confidence level for a two-tailed test.

constraints exactly as in GSM. The scale measures under the misspecified regime indicated that higher degrees of increasing returns to scale are present almost across the board. In 1982, we even observe scale economies for unit banks under \$25 million of deposits, which disappears significantly when correct constraints are imposed. We conclude that such misspecifications did lead to different results.

CONCLUSIONS

This paper provides correct and efficient estimators of translog cost functions for the years 1980 to 1983 for banking

TABLE 5
1982 ESTIMATES OF PRODUCT AND TOTAL
SCALE ECONOMIES

| Deposit Size (Million \$) | Number of Banks | <i>SDEP</i> (Deposits) | <i>SLOAN</i> (Loans) | <i>SCE</i> (Total) |
|------------------------------|--------------------|---------------------------|-------------------------|-----------------------|
| Unit Banks | | | | |
| 0-25 | 41 | .90 | .21 | 1.11* |
| 25-50 | 66 | .92 | .26 | 1.18*** |
| 50-75 | 41 | .95 | .28 | 1.23*** |
| 75-100 | 20 | .99 | .28 | 1.27*** |
| 100-200 | 44 | 1.05 | .24 | 1.29*** |
| Over 200 | 11 | 1.00 | .34 | 1.34*** |
| Total sample | 223 | .96 | .25 | 1.21*** |
| Branch Banks | | | | |
| 0-25 | 31 | .86 | .21 | 1.07* |
| 25-50 | 88 | .85 | .22 | 1.07** |
| 50-75 | 73 | .84 | .23 | 1.07*** |
| 75-100 | 46 | .85 | .23 | 1.07*** |
| 100-200 | 91 | .86 | .21 | 1.07*** |
| 200-300 | 24 | .89 | .18 | 1.07*** |
| 300-400 | 48 | .84 | .23 | 1.07** |
| Over 400 | 33 | .86 | .21 | 1.07 |
| Total sample | 401 | .86 | .22 | 1.07*** |

*Statistically different from 1.0 at a 10 percent confidence level for a two-tailed test.

**Statistically different from 1.0 at a 5 percent confidence level for a two-tailed test.

***Statistically different from 1.0 at a 1 percent confidence level for a two-tailed test.

firms. It corrects the Gilligan, Smirlock, and Marshall [7] study that has been shown to have misspecified the linear homogeneity constraints. It augments the regular translog form by introducing factor share equations and improves the efficiency of the translog estimators. The results indicate that, except in the 1983 branch bank sample, there is no significant evidence of scale economies in the FCA sample covered in the study. Further research is needed on improving the functional form (a hybrid Box-Cox form is provided in Cebenoyan [3]), and tests of subadditivity and scope economies promise to provide us with a better understanding of the cost characteristics of the banking firms.

TABLE 6
1983 ESTIMATES OF PRODUCT AND TOTAL
SCALE ECONOMIES

| Deposit Size (Million \$) | Number of Banks | SDEP (Deposits) | SLOAN (Loans) | SCE (Total) |
|------------------------------|--------------------|--------------------|------------------|----------------|
| Unit Banks | | | | |
| 0-25 | 43 | .68 | .20 | .88* |
| 25-50 | 62 | .75 | .27 | 1.02 |
| 50-75 | 46 | .78 | .33 | 1.11*** |
| 75-100 | 21 | .81 | .34 | 1.15*** |
| 100-200 | 44 | .84 | .37 | 1.21*** |
| Over 200 | 18 | .87 | .52 | 1.39*** |
| Total sample | 234 | .77 | .31 | 1.08** |
| Branch Banks | | | | |
| 0-25 | 20 | .96 | .07 | 1.03 |
| 25-50 | 69 | .87 | .13 | 1.00 |
| 50-75 | 57 | .80 | .19 | .99 |
| 75-100 | 56 | .75 | .24 | .99 |
| 100-200 | 119 | .67 | .29 | .97* |
| 200-300 | 41 | .58 | .36 | .94*** |
| 300-400 | 22 | .51 | .43 | .94** |
| Over 400 | 66 | .38 | .54 | .92* |
| Total sample | 450 | .68 | .29 | .97 |

*Statistically different from 1.0 at a 10 percent confidence level for a two-tailed test.

**Statistically different from 1.0 at a 5 percent confidence level for a two-tailed test.

***Statistically different from 1.0 at a 1 percent confidence level for a two-tailed test.

REFERENCES

- [1] Benston, George J., Allen N. Berger, Gerald A. Hanweck, and David B. Humphrey. "Economies of Scale and Scope in Banking." In *Proceedings of a Conference on Bank Structure and Competition*. Chicago: Federal Reserve Bank of Chicago, 1983, pp. 432-455.
- [2] Benston, George J., Gerald A. Hanweck, and David B. Humphrey. "Scale Economies in Banking: A Restructuring and Reassessment." *Journal of Money, Credit, and Banking* 14(November 1982):435-456.
- [3] Cebenoyan, A. Sinan. "Economies of Scale and Economies of Scope in Multiproduct Banking Firms." Ph.D. diss. New York University, 1986.

- [4] Christensen, Laurits R., and William H. Greene. "Economies of Scale in U.S. Electric Power Generation." *Journal of Political Economy* 84(August 1976):655-676.
- [5] Christensen, Laurits R., Dale W. Jorgenson, and Lawrence J. Lau. "Transcendental Logarithmic Production Frontiers." *Review of Economics and Statistics* 55(February 1973):28-45.
- [6] Diewert, W. Erwin. "Functional Forms for Revenue and Factor Requirements Functions." *International Economic Review* 15(February 1974):119-130.
- [7] Gilligan, Thomas W., Michael L. Smirlock, and William Marshall. "Scale and Scope Economies in the Multi-product Banking Firm." *Journal of Monetary Economics* 13(May 1984):393-405.
- [8] Kolari, James, and Asghar Zardkoohi. *Bank Costs, Structure, and Performance*. Lexington, MA: Lexington Books, 1987.
- [9] Mester, Loretta J. "A Multiproduct Cost Study of Savings and Loans." *Journal of Finance* 42(June 1987):423-445.
- [10] Murray, John D., and Robert W. White. "Economies of Scale and Economies of Scope in Multiproduct Financial Institutions: A Study of British Columbia Credit Unions." *Journal of Finance* 38(June 1983):887-902.
- [11] Shaffer, Sherrill, and Edmond David. "Economies of Superscale and Interstate Expansion." Federal Reserve Bank of New York: Research Paper No. 8612, November 1986.
- [12] Zardkoohi, Asghar, Nanda Rangan, and James Kolari. "Homogeneity Restrictions on the Translog Cost Model: A Note." *Journal of Finance* 41(December 1986):1153-1155.
- [13] Zellner, Arnold. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." *Journal of the American Statistical Association* 57(June 1962):348-368.