COST DISPERSION AND THE MEASUREMENT OF ECONOMIES IN BANKING

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Introduction and Summary

The concept of scale economies in banking is important because it implies that larger banks may have an inherent cost advantage over smaller ones.[1] Such a competitive advantage could be increased if large banks found it easier to become even larger. This situation could occur if bank mergers were more freely permitted or nationwide banking became a reality. To properly gauge the effects of public policy in this area, it is necessary both to have accurate estimates of cost economies in banking and to determine their potential contribution to differences in relative costs already observed among banks.

Past studies generally have concluded that large banks possess scale economies. It is demonstrated below that these historical estimates of scale economies are small when compared with other influences already operating on bank costs. That is, even if scale economies exist and are statistically significant, they are much less important in conferring competitive advantages than commonly thought. Put differently, the observed variation in cost among banks can be split into (a) scale or cost economies across different-sized banks and (b) cost differences between similarly-sized banks. The first type of variation has been extensively studied while the second is new. Using recent data on all commercial banks, it is shown that estimated cost economies (when they occur) pale in comparison with existing differences in average cost levels.

This effect is easiest to see after all banks have been divided up into four equal groups or quartiles based on the level of their current average costs. The difference in average costs between the 25 percent of all banks with the lowest average costs and the 25 percent of banks with the highest costs is two to four times greater than the observed variation in average costs across bank size classes. These findings suggest that the existence of bank scale economies (or diseconomies) should have little competitive impact relative to those competitive effects which already exist as a result of large differences in cost levels. Thus structural or competitive changes due to cost effects associated with nationwide banking should be relatively small.

While scale economies are seen to be less important in determining cost advantages between large and smaller banks than has heretofore been thought, their accurate measurement is still of interest. In an effort to improve this accuracy, two influences on cost economy estimation are explored. These relate to assumptions that all banks in a sample lie on the same average cost curve (1) over time and (2) across different-sized banks at one point in time.

Over time, as interest rates fluctuate, the cost curve can experience large changes in its slope. Such changes lead to quite different scale or cost economy measurements at different points in time. Thus results based on cross sections of banks for one year may not generalize well to other years. In addition, results based on a cross section of all banks even at one point in time may not generalize well to all bank size classes. This is because different-sized banks can experience significantly different cost economies. Hence looking at all banks together for even a single year, which is the method used in almost all studies, is only weakly justified and should be tested before such results are relied upon. These conclusions are illustrated by computing cost elasticities (showing the percentage change in cost per given percentage change in assets) by separate bank size classes and by separate average cost quartiles of banks for three years (1984, 1982, and 1980). It is shown that accurate cost economy estimates are likely to be obtained if banks are disaggregated by size class or, more importantly, if analyses are performed over time so that interest rate changes do not unduly bias the scale economy estimates obtained.

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* The opinions expressed are those of the author alone. Comments by Bob Avery, Allen Berger, Marvin Goodfriend, Tom Humphrey, Tony Kuprianov, and Dave Mengle are acknowledged and appreciated. Able research assistance was provided by Bill Whelpley and Oscar Barnhardt.

[1] Scale economies exist when average cost falls as bank output rises. One way this can occur is when fixed costs are spread over a greater volume of output (with product mix constant).

Average Costs and Bank Size in 1984

There were 13,959 banks in the United States in 1984. Publicly available balance sheet and cost data on these institutions were collected from the Consolidated Report of Condition and the Report of Income and Dividends. Banks in unit banking states (unit state banks) are treated separately from those in limited and statewide branching states (branching state banks).[2] Past analyses of bank costs have utilized sophisticated models and econometric techniques. In contrast, the analysis undertaken here will rely on the raw data with a minimum of manipulation or application of statistical procedures to illustrate the major points. Technical issues are treated in footnotes. With this approach, it is possible to divide the data up in ways not previously attempted and suggest areas where more sophisticated procedures may be usefully applied in the future.

A Scatter Diagram of Average Costs and Bank Size To date, almost all published studies report the average or mean relationship between bank costs and size. This is because all banks in a sample are pooled together in a single regression equation. In this process some descriptive information about the sample, such as its dispersion about the mean, is largely lost. Dispersion in a sample can be inferred by looking at a scatter diagram. The scatter diagrams shown in Figures 1a and 1b relate average bank cost to the size of a bank. Average cost (AC) includes all reported operating costs and interest expenses while bank size is measured by the dollar value of total assets (TA). Figure 1a shows the scatter for 7,661 branching state banks and Figure 1b shows 6,298 unit state banks. Many of the data points shown overlap each other. Since the bank sizes (TA) vary from \$1 million (10^6) to over \$100 billion (10^{11}), the logarithm of total assets was used on the horizontal axis.

If the curve that best fits the scatter of points in these figures happens to be U-shaped, then AC falls as a bank gets larger, reaches some minimum point where costs are constant for further size increases, and then rises for even larger banks. Alternatively, the curve may only fall, or be flat for the entire range, or only rise as banks become larger. A major assumption at this point, regardless of what the curve looks like, is that the observed cost relationship across different-sized banks at one point in time can be used to infer the average result which would apply to any given bank which itself becomes larger, either by core deposit or purchased money growth over time or by bank merger.[3] As seen from the two scatter diagrams, there is considerable dispersion in average costs for the smaller banks. This dispersion is somewhat reduced for larger banks. It is clear that banks of similar size have greatly differing average costs per dollar of total assets.

Costs by Average Cost Quartile The dispersion in average costs can be more easily seen when all banks are ranked by the level of their average cost and placed into average cost quartiles. The dashed lines in Figures 2a and 2b show this result. The highest dashed line (AC_{Q4}) in Figure 2 shows the average cost of that 25 percent of all banks in each of 13 size classes (listed in Table I) with the highest (fourth quartile) individual average costs; the lowest dashed line (AC_{Q1}) shows the same thing for that 25 percent of all banks with the lowest (first quartile) average costs. The solid line (AC_M) reflects the mean average cost for all banks in each size class over all four quartiles together.[4]

Displaying bank cost data by average cost quartiles shows there is more cost variation between the lowest and highest cost quartiles in any given size class than there is between the lowest and highest average cost values in any given quartile across all size classes. An example is the percentage variation between points A and B in Figure 2a. There the variation between AC_{Q1} and AC_{Q4} within size class 7 (\$200-\$300 million in TA) always exceeds the maximum variation along a quartile, such as the percentage variation between points B and C on AC_{Q4} or between points D and E on AC_{Q1}.

The data used to plot Figure 2 are shown in Tables Ia and Ib. Computations from Table I indicate that the maximum variation in branching state banks' average cost along each of the four average cost quartiles is 6, 6, 9, and 12 percent, respectively, for the first to fourth quartiles (with a maximum variation of 8 percent along AC_M, the average cost curve for all banks together). In contrast, the maximum variation between the lowest and highest quartiles occurs

[2] Separate treatment is desirable because statistical analyses have earlier indicated that these two classes of banks are significantly different from one another in terms of how costs vary with size. It should be noted that banks in unit banking states do at times have a limited number of branches while unit banks—those with no branches—exist in branching states.

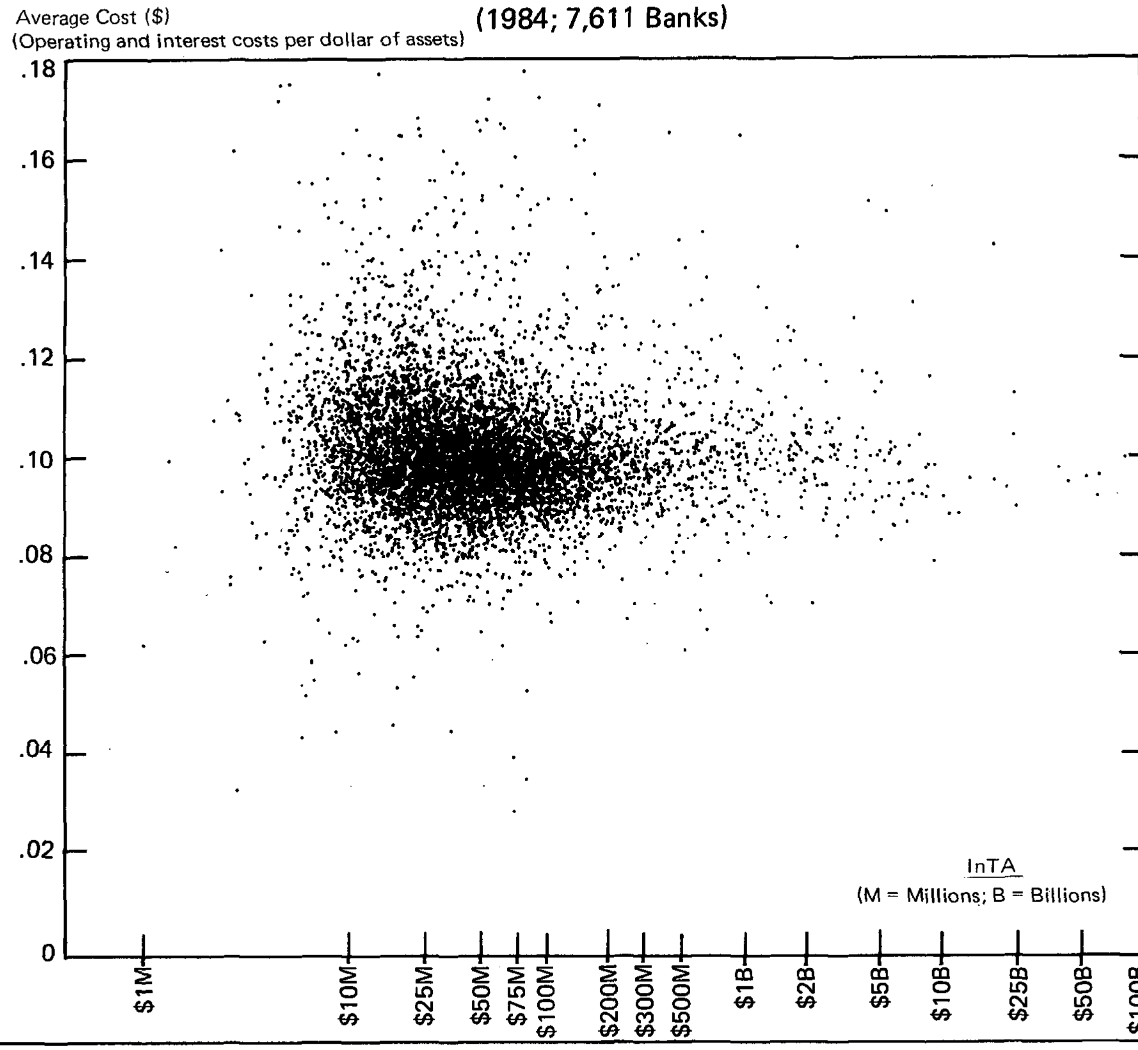
[3] For larger banks, mergers seem to be preferred over waiting for core deposits to grow as the size of the existing market expands. For example, Rhoades [1985] has shown that mergers have accounted for 72 percent of the current size of the twenty largest U.S. banking organizations.

[4] That AC_M is closer to AC_{Q3} than AC_{Q2} indicates that the distribution of individual average costs within each size class is skewed somewhat toward the higher AC values, reflecting more dispersion for the higher cost banks.

Figure 1a

SCATTER DIAGRAM: AVERAGE COST OF BRANCH STATE BANKS

(1984; 7,611 Banks)



at size class 1 and is 49 percent, with a minimum of 26 percent at size class 7. The variation between all banks in these two quartiles across all size classes was 34 percent. In summary terms, the variation between average cost quartiles for branching state banks (34 percent) averages more than four times the variation along a quartile (8 percent).

The same results apply, with only slightly less force, to unit state banks. Here the maximum difference in average cost along each of the first to fourth quartiles are, respectively, 14, 11, 14, and 27 percent (with a 17 percent maximum variation along AC_M). The maximum difference between the lowest and highest average cost quartiles is, however, 52 percent for size class 1, with a minimum variation of 17 percent for size class 12. Across all size classes between these two quartiles, it was 31 percent. In summary terms again, the variation between average cost quartiles (31 percent) for unit state banks averages a little less than twice the variation along a quartile (17 percent). Thus the distribution of individual bank average costs *about* the mean level of average cost for all banks is more important than the distribution of average cost values *along* the mean or any quartile cost curve.

Relative Efficiency: Comparing Mean Average Costs With Those of the Lowest Cost Quartile Figure 3 shows the mean average cost AC_M for both branching (top solid line) and unit state banks (top dashed line) and permits a comparison with the average costs for branching and unit state banks in the lowest average

Figure 1b

SCATTER DIAGRAM: AVERAGE COST OF UNIT STATE BANKS

(1984; 6,298 Banks)

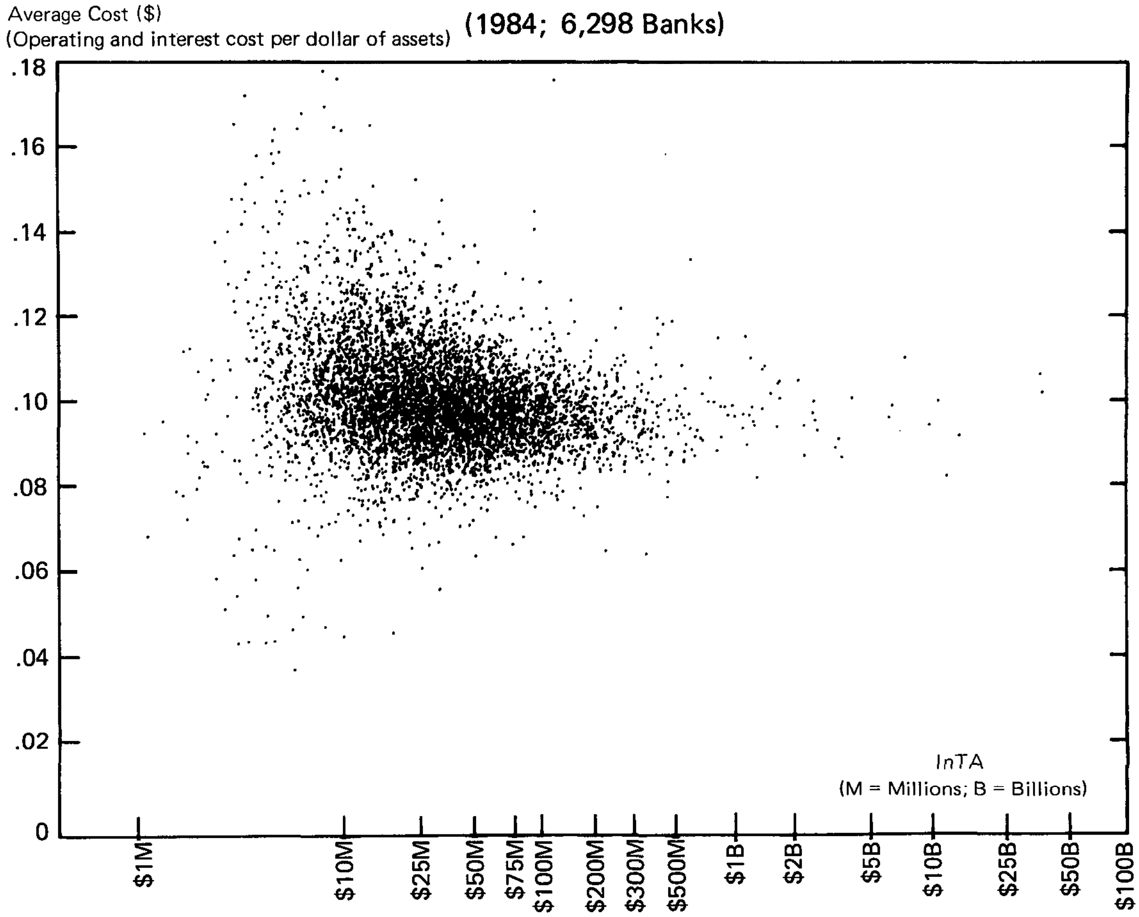


Figure 2a

COST BY AVERAGE COST QUARTILE

(Branch State Banks: 1984)

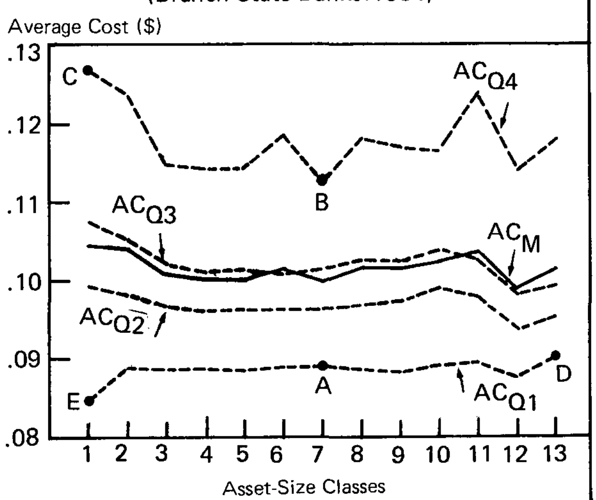


Figure 2b

COST BY AVERAGE COST QUARTILE

(Unit State Banks: 1984)

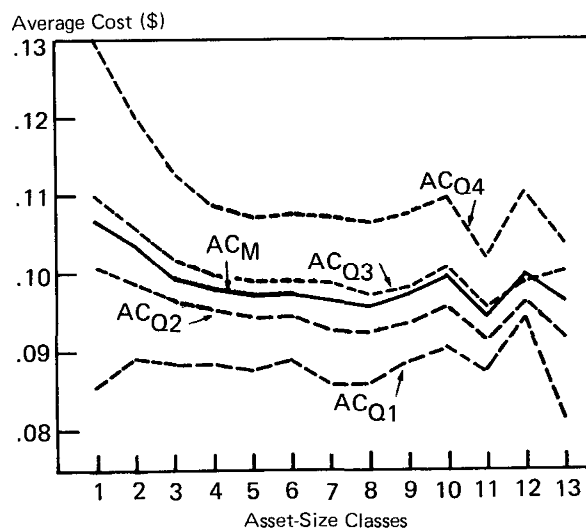


Table Ia
AVERAGE COSTS BY SIZE CLASS AND COST QUARTILE
(Branch State Banks: 1984)

Size Class:	Average Cost Quartile: 1	2	3	4	All Banks	Sample Size	Percent Sample Size
1. $1M-$10M	$.085	$.099	$.108	$.126	$.105	542	7.1
2. $10M-$25M	.089	.098	.105	.124	.104	2,007	26.2
3. $25M-$50M	.088	.097	.102	.115	.100	2,054	26.8
4. $50M-$75M	.089	.096	.101	.114	.100	1,009	13.2
5. $75M-$100M	.089	.097	.101	.114	.100	524	6.8
6. $100M-$200M	.089	.097	.101	.118	.101	738	9.6
7. $200M-$300M	.089	.097	.101	.113	.100	230	3.0
8. $300M-$500M	.089	.097	.103	.118	.102	178	2.3
9. $500M-$1B	.088	.098	.103	.117	.102	159	2.1
10. $1B-$2B	.089	.099	.104	.117	.102	95	1.2
11. $2B-$5B	.089	.098	.103	.124	.104	76	1.0
12. $5B-$10B	.088	.094	.098	.114	.099	30	.4
13. > $10B	.090	.096	.099	.117	.102	18	.2
All Banks	.088	.097	.103	.118	.102	7,660	100.0

(M = millions; B = billions)

cost quartile AC_{Q1} (bottom solid and dashed lines, respectively). Two things stand out. First, average costs between branching and unit state banks are closer together in the lowest average cost quartile (bottom two lines) than they are at the mean (top two lines). Second, the lowest quartile average cost curves represent roughly parallel displacements from the mean average cost curves.

These two results imply that the difference between mean average costs and those for the lowest average cost quartile are due to differing efficiency levels among banks and not due to different technologies used in production of bank outputs or services. For example, use of different technologies to produce bank output, such as building many branches to service customers versus no or few branches (as when branching and unit state banks are contrasted), or relying on core deposits versus purchased money to fund assets (as when small and large banks are compared), generates little difference in the average costs faced by banks either at the mean or at the lowest cost quartile. The roughly parallel shift between AC_M and AC_{Q1} suggests, in addition, that measured scale economies at the mean of all banks should not be markedly different from those computed for the lowest average cost quartile of banks, since the slopes of the plotted curves appear to be similar. This proposition is illustrated next by estimating asset cost elasticities.

Asset Cost Elasticities

Asset cost elasticities (ASCE) show how much costs change as a bank becomes larger. The ASCE is the ratio of the percentage change in bank operating and interest costs to the percentage change in bank asset size. When the ASCE is less than one, cost economies exist as average costs fall for larger-sized

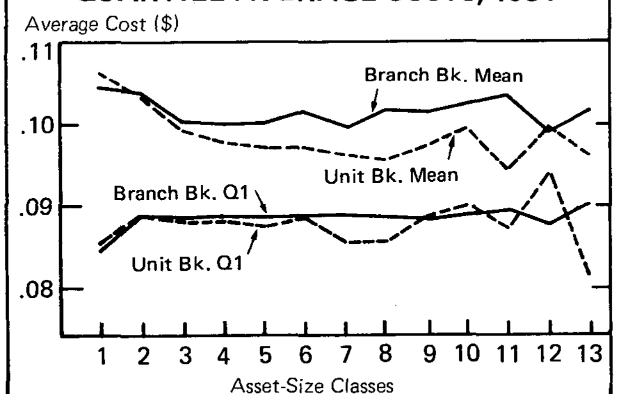
Table Ib

AVERAGE COSTS BY SIZE CLASS AND COST QUARTILE
(Unit State Banks: 1984)

Size Class:	Average Cost Quartile: 1	2	3	4	All Banks	Sample Size	Percent Sample Size
1. $1M-$10M	$.085	$.101	$.110	$.130	$.106	828	13.1
2. $10M-$25M	.089	.099	.106	.120	.103	1,979	31.4
3. $25M-$50M	.088	.096	.101	.112	.100	1,626	25.8
4. $50M-$75M	.088	.095	.100	.108	.098	757	12.0
5. $75M-$100M	.088	.095	.099	.107	.097	349	5.5
6. $100M-$200M	.088	.095	.099	.107	.097	501	8.0
7. $200M-$300M	.086	.093	.099	.107	.096	107	1.7
8. $300M-$500M	.086	.093	.097	.106	.096	78	1.2
9. $500M-$1B	.088	.094	.098	.108	.097	35	.6
10. $1B-$2B	.090	.096	.101	.109	.100	18	.3
11. $2B-$5B	.087	.091	.096	.102	.095	11	.2
12. $5B-$10B	.094	.096	.099	.110	.100	4	.1
13. > $10B	.082	.092	.100	.104	.097	5	.1
All Banks	.088	.097	.103	.116	.101	6,298	100.0

Figure 3

RELATIVE EFFICIENCY: COMPARING MEAN AND LOWEST COST QUARTILE AVERAGE COSTS, 1984



banks. When the ASCE equals one, average cost neither falls nor rises as a bank gets larger and constant cost prevails. Finally, when ASCE exceeds one, average costs rise and diseconomies exist for larger banks.

It is possible to estimate separate asset cost elasticities for each of the size class and average cost quartile cells in Table I. This will indicate if and by how much cost elasticities may differ across 13 separate size classes or among the 4 different cost quartiles. That is, do larger banks have greater cost economies than smaller ones? Does this hold at the mean as well as for each quartile? Do banks currently in the lowest cost quartile experience cost economies which add to their existing advantage of already having lower costs?

To answer these questions, it is sufficient for our purposes to estimate a simple quadratic equation of the logarithm of total costs (ln TC) regressed on the logarithm of bank asset size or total assets (ln TA):

$$(1)\ \ln TC = a + b (\ln TA) + c\ ½(\ln TA)^2.$$

The asset cost elasticity (ASCE) is derived from $\partial(\ln TC)/\partial(\ln TA)$ in (1) and can vary by bank size:

$$(2)\ ASCE = b + c (\ln TA).$$

A major difference between our ASCE and other treatments of bank scale economies is that unlike prior studies we do not "hold other things constant." This difference is a result of asking different questions. The standard approach is to hold constant such things as input prices (the prices of labor, capital, and materials used to produce bank outputs), the number of branches a bank has, and (more recently) the product mix of outputs produced. These things are held constant since, in terms of standard economic theory, scale economies are supposed to measure how costs change at one "plant" as only the scale of output is varied. To estimate this effect empirically, the influence of scale on cost should not be commingled with the effect of other things that change along with scale and affect costs. An alternative question is just as valid and concerns how costs vary at the firm level not only with the scale of output, but also with the myriad of other things that change as a bank gets larger, such as executive compensation, increased reliance on branches to deliver deposit and loan services, and different product mix.[5]

This alternative approach also bears more directly on the political and economic question of the effect of bank mergers or interstate banking on bank costs. Bankers especially wish to determine if and how effectively they can compete with the money center bank who has just moved in down the street or has recently merged with a competitor. These bankers or their Congressmen are not as concerned about what the costs of the money center bank would be at the plant or branch office level (or even the firm level) if everything but scale is held constant. It is precisely because other things vary as a bank gets larger that the political interest is in the bottom line effect on costs as all things along with scale are changed. Thus our ASCE measure addresses a different question from that addressed by other treatments of scale economies.

Asset Cost Elasticities by 13 Size Classes and 4 Cost Quartiles In any data analysis, it is important to choose a classification scheme that does not unduly obscure important differences in the data. For this reason, 13 bank size classes were used in place of the four size class quartiles adopted in Lawrence and Shay [1986a]. If all banks were broken down into only four size class quartiles, the first three quartiles would consist of 75 percent of all banks but only cover those with assets of up to $80 million ($58 million) for branching (unit) state banks. The last quartile would cover the remaining 25 percent of all banks with over 80 percent of all bank assets. This would poorly distinguish between large and smaller banks since branching (unit) state banks in this quartile would range from $80 million to $116 billion ($58 million to $36 billion) in assets.

The ASCEs shown in Tables IIa and IIb are based on separate regressions using equation (1) for each cell in Table I. When all banks are pooled together or when all banks are divided up by size class, ordinary least squares (OLSQ) estimation is appropriate. The same is true when all banks are placed into average cost quartiles on the basis of their *observed* level of average cost and when these quartiles are further subdivided by size class. If, however, the purpose is to obtain the curve of best-fit for those banks which reflect different long-run cost regimes, OLSQ can yield biased estimates and different estimation methods, such as TOBIT, would be preferred.[6] With this qualification in mind, the OLSQ regression results are presented.

When all banks are pooled together, significant (but quantitatively small) cost economies are experienced at the mean. The ASCEs are .99** (.97**) for branching (unit) state banks.[7] In contrast, slightly

[5] In effect, our ASCE is equivalent to the total derivative of costs with respect to all explanatory variables that affect bank expenses (and are correlated with bank size), rather than the partial derivative used to derive scale economies alone.

[6] The OLSQ estimates can be biased in this case since some banks observed to be in, say, the lowest cost quartile will in fact, due to random variations in cost, actually belong to another long-run quartile cost regime and therefore be misclassified. Similarly, some banks which should be in the lowest long-run quartile cost regime will be observed in a different quartile for the same reason. Regardless of whether one is interested in defining quartiles as long-run cost regimes or merely as where bank costs are observed to be at one point in time, heteroscedasticity is likely to be a problem and bias the estimated standard errors.

[7] The t tests were always two tailed and evaluated at the 95 percent (*) and 99 percent (**) confidence intervals. Since at least 4 alternative hypotheses have been estimated, the actual overall confidence intervals are 80 percent (*) and 96 percent (**). This adjustment is accomplished by taking 4 times .05 or .01 and subtracting this value from 1.00 [see Christensen, 1973]. The 4 alternative hypotheses concern: (1) pooling all banks together; (2) dividing up all banks into 13 size classes; (3) dividing up all banks into 4 average cost quartiles; and (4), dividing up each cost quartile into 13 size classes. Since the data have been divided up or pooled so many different ways, the probability of finding some statistically significant parameters and ASCEs by chance alone will have increased. This problem is addressed by looking at the *overall* confidence level, rather than the confidence level that presumes only one version of the model—one type of pooling—has been run.

Table IIa

ASSET COST ELASTICITIES (ASCEs)
(Branch State Banks: 1984)

	Average Cost Quartile:				
Size Class:	1	2	3	4	All Banks
1. $1M-$10M	1.13*	1.01	1.00	.93	1.00
2. $10M-$25M	1.00	1.00	1.00	1.00	.97*
3. $25M-$50M	1.01	1.00	.99	1.01	.97*
4. $50M-$75M	.91	1.00	1.01	1.13*	.97
5. $75M-$100M	1.22	1.03*	1.00	1.04	1.04
6. $100M-$200M	1.00	1.00	1.00	1.08	1.07*
7. $200M-$300M	.99	1.03	1.01	1.06	1.03
8. $300M-$500M	.85	1.00	1.01	1.21	1.10
9. $500M-$1B	1.00	1.01	.99	.93	1.00
10. $1B-$2B	1.03	.99	.96**	1.16	1.05
11. $2B-$5B	1.10	1.00	.98	1.21	1.06
12. $5B-$10B	1.09	.98	.97	.83	.89
13. > $10B	1.02**	.98	1.03*	.74*	1.03
All Banks	1.01**	.99**	.98**	.98**	.99**

different results are obtained when the data are divided up into average cost quartiles (last row of Table II). Minor cost diseconomies are evidenced at the lowest cost quartile of banks (1.01**) with increasing cost economies experienced for banks in successively higher quartiles (going from .99** to .98** or from .98** to .94**). Greater variation in ASCEs occurs by size class (last column of Table II). Here point estimates range from .85 to 1.30, although most are not significantly different from 1.00 or constant costs. While some of the variations in ASCEs appear to be quite large, it has to be remembered that these apply only to the size class indicated. The overall impact on the level of average cost experienced is thus the weighted effect of all size class ASCEs up to the size class being examined, not just the ASCE observed at a particular size class in the table.[8]

A similar diversity in ASCE results apply to the separate estimates by average cost quartile size class where a minimum of pooling is used (rows 1 to 13

[8] For illustrative purposes only, all cells in Table II were reestimated where the regression (1) is linear rather than quadratic (since the restriction c = 0 in (1) is imposed). In this case, the ASCE is a constant within the sampled banks used in each regression. For the most part, there were no changes in the ASCEs computed, showing that straight line segments evaluated at the mean of each cell would give the same results as a curve evaluated at the same point. Only in those few cases where sample size within a cell was very small to begin with, as occurred for the very largest banks, was there any change. But this difference would be expected when sample size is extremely small.

Table IIb
ASSET COST ELASTICITIES (ASECs)
(Unit State Banks: 1984)

Size Class:	Average Cost Quartile: 1	2	3	4	All Banks
1. $1M-$10M	1.16**	1.01	.99	.97	1.00
2. $10M-$25M	1.02	1.00	1.00	.96**	.94**
3. $25M-$50M	1.00	1.00	1.00	.97	.98
4. $50M-$75M	1.05	1.00	.99	.97	1.03
5. $75M-$100M	1.02	1.03	1.01	1.08	.94
6. $100M-$200M	1.00	1.01	1.00	.98	.97
7. $200M-$300M	1.13	.93	1.00	1.11	1.16
8. $300M-$500M	.93	1.05	.98	1.25*	1.05
9. $500M-$1B	1.14	.90	1.00	.94	1.04
10. $1B-$2B	.68	.70*	1.14	.76*	1.09
11. $2B-$5B	[a]	[a]	[a]	[a]	.85
12. $5B-$10B	[a]	[a]	[a]	[a]	1.30
13. > $10B	[a]	[a]	[a]	[a]	1.04
All Banks	1.01**	.98**	.97**	.94**	.97**

[a] Sample size was too small to have positive degrees of freedom and so a regression for this cell was not estimated.

and columns 1 to 4). While the range of variation is larger, only 29 of the 104 ASCEs in Table II are outside the range of .95 to 1.05 and fewer still (12) are significantly different from constant costs.

So, using 1984 data, are there cost economies in banking? Yes, but looking at the results for each average cost quartile (last row) or size class (last column), seemingly only for higher cost and/or smaller banks. Do they confer competitive advantages for larger banks over smaller ones? Not really, for at least two reasons. First, as noted above, the individual cell estimates generally show cost elasticities insignificantly different from constant costs, which would not favor large over smaller banks. Second, even if cost economies were pervasive, the ASCEs would have to be on the order of .49 to .66 to lower costs equivalent to the difference in costs already observed between banks in the highest and lowest cost quartiles.[9] Thus cost economies at large banks would have to be far larger than those measured here or elsewhere (usually between .90 and 1.00 [Benston, 1972]) to dominate existing differences in cost levels and so have a major effect on competition over that which already exists today for similarly sized banks.

Lastly, are cost economies important for public policy purposes? Yes, but not as important as previously believed. The variation in average costs between different-sized banks—the standard measure of cost economies—is much smaller than the existing

[9] The average cost of a $500 million asset branching (unit) state bank at the highest average cost quartile is $.118 ($.106) from Table I. If size were doubled to $1 billion and average cost fell to the level experienced at the lowest cost quartile ($.088 for both sets of banks), the implied ASCE would be .49 (.66) for branching (unit) state banks. Similar values are obtained if, instead, size were doubled from $1 to $2 billion or from $2 to $4 billion.

dispersion of average costs across banks in the same class. Because such dispersion has seemingly not yet resulted in disruptive structural changes in banking, it is unlikely that the existence of significant cost economies or diseconomies at the levels typically estimated will do so either under nationwide banking.

Do All Banks Lie on the Same Average Cost Curve?

Almost all cost studies have assumed that: (1) results based on a cross section of banks for one year can be generalized to other years; and (2) all banks in a cross section can be pooled together when cost economies are being estimated. In effect, previous studies have assumed that all banks lie on the same average cost curve both over time and across different-sized banks at the same point in time. Although these two assumptions can importantly influence the accuracy and acceptability of cost economy estimates, they have been largely overlooked in published analyses. The simple answer to the question posed, Do all banks lie on the same average cost curve?, is "No"; not over time and only sometimes across size classes at one point in time.

Average Costs Over Time: 1980, 1982, and 1984 Purchased funds are heavily used at larger banks while core deposits comprise the main component of bank liabilities at smaller banks. Purchased funds were 12 percent of core deposits plus purchased money at branching state banks with around $50 to $75 million in assets.[10] By the time these banks reach $300 to $500 million in assets, the purchased funds proportion rises to 19 percent. And when assets rise to $2 to $5 billion and then to over $10 billion, the proportion rises further to 36 and 60 percent, respectively. At unit state banks for the same four size classes, the purchased funds proportions are 16, 31, 61, and 78 percent, respectively.

Since core deposits only grow slowly over time, they can not quickly substitute for purchased funds if purchased money costs should rise significantly over a period of a few years. While purchased funds can more easily replace core deposits should purchased funds interest rates fall, interest rates typically vary more rapidly than banks can implement fully offsetting adjustments to their average core deposit/purchased funds liability mix. Consequently, interest rate changes over time can systematically alter the slope of bank average cost curves and thereby change the estimated cost elasticities. Because larger banks rely more on purchased funds, a given rise (fall) in the general level of interest rates will raise (lower) average costs for larger banks more than it will raise (lower) average costs for smaller banks, tilting the curve upward (downward) for large banks.

Interest rates were at a very high level in 1980. The three-month CD rate was 17.4 percent (December, 1980). Four years later, the CD rate had fallen by more than fifty percent, to 8.9 percent (December, 1984). The high interest rates in 1980 are associated with bank average cost curves in Figures 4a and 4b (dotted lines) which almost continuously rise, showing only increasing costs as banks become larger. As interest rates fell, the associated average cost curves for 1982 (dashed lines) and 1984 (solid lines) become semi-U-shaped and flatter. The curves become flatter over 1980 to 1984 for three reasons:

(1) Reduction in interest rates on purchased funds, which primarily lowered the average costs of large banks;

(2) Phase-out of Regulation Q ceilings on small savings and time accounts, which had a larger cost increasing effect on the average costs of smaller banks; and

(3) Lagged effect of inflation on labor and physical capital costs—operating costs—which will have a greater proportional impact on smaller banks, since operating costs are a larger proportion of total cost at these banks.

Thus the time period used for analysis can be important, especially when large changes in interest rates occur, as they did in the late 1970s and early 1980s.[11]

Average Costs at One Point in Time It is also important to determine if all banks can be said to

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[10] Purchased funds (PF) are here defined to be purchased federal funds, CDs of $100 thousand or above, and foreign deposits (which are almost always over $100 thousand). Core deposits (DEP) are demand deposits and small denomination (i.e., less than $100 thousand) time and savings deposits. The percentages are thus PF/(PF + DEP).

[11] When time-series analyses are performed usually only a time dummy variable is specified to capture all time-related changes in bank costs [Hunter and Timme 1986]. But since labor and physical capital prices are usually in nominal terms, shifts in the average cost curve due to these operating cost changes will already be largely captured in the price variables. Consequently, a time dummy variable will really reflect the interest rate cycle, interest rate deregulation, along with productivity and technology changes. Perhaps a more accurate specification, one which would capture better the possibility of a changing cost curve, would be to specify the average interest rate paid by a bank as an input price and let it interact with some measure of bank output as well. This is done in Lawrence and Shay [1986a] and Kim [1986].

Figure 4a

AVERAGE COSTS OVER TIME

(Branch State Banks)

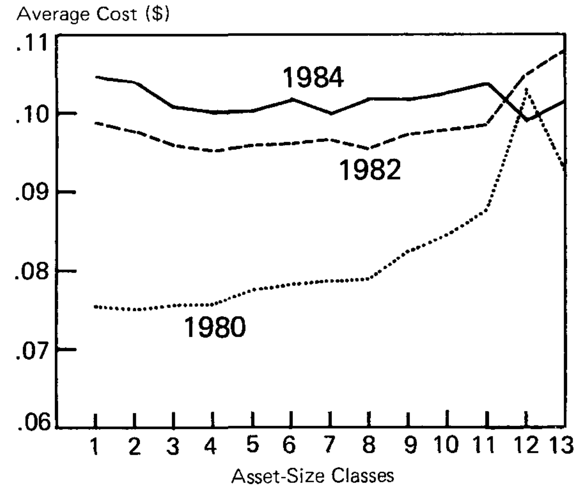
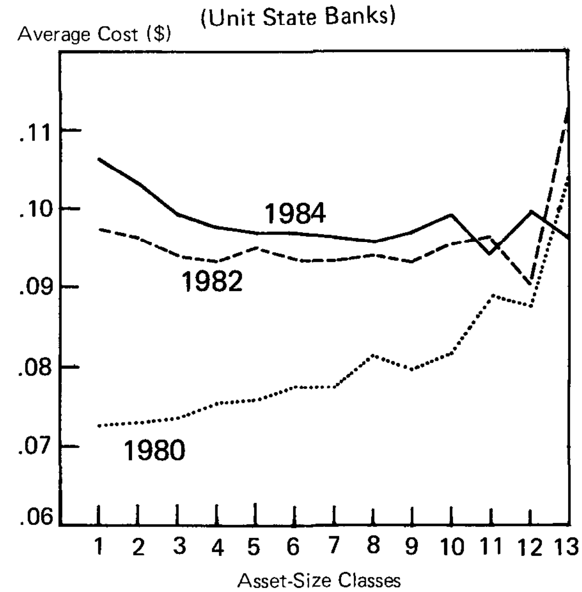


Figure 4b

AVERAGE COSTS OVER TIME

(Unit State Banks)



lie on the same average cost curve at the same point in time, since this has been the premise of almost all bank cost studies performed to date. One way to address this question is to compare actual average costs across size classes for 1984 or 1980 (solid lines in Figures 5 and 6) with the average costs predicted from regressions fitted to the underlying bank data (dashed lines). The fit seems to be best for those banks in the smaller-size classes. Large banks often have a relatively poorer fit. Since 97.2 percent (99.3 percent) of the branching (unit) state banks are smaller than $1 billion (see Table I, last column), the relatively poorer fit for large banks is likely due to the low weight given them in minimizing the sum of their squared errors compared with the much larger weight given to the much more numerous smaller banks.[12]

Tests of Aggregation or Pooling Across Size Classes The usual way to test statistically whether or not all banks lie on the same average cost curve is to divide up the data by size class, run separate regressions for each group, and compare the sum of squared errors of these separate size class regressions with the sum of squared errors obtained when all banks are pooled together in a single regression.[13] In terms of the model used here, this is equivalent to testing to see if the intercept and two slope coefficients are equal to each other across 13 size classes. This null hypothesis was marginally rejected using an F test for both branching and unit state banks for the three years covered (1984, 1982, and 1980).[14] With the exceptionally large samples used here—six to eight thousand banks—rejecting a null hypothesis is not unusual. Thus some would prefer a Bayesian type of approach which permits the "F value" to rise as sample size increases. Applying a Bayesian likelihood ratio rather than a Classical F test leads to the opposite conclusion—pooling across size classes at the mean would not be rejected.[15] While

[12] This fitting problem will not be apparent in the reported R^2s. In the regressions reflected in Figures 5 and 6, plus those for 1982 (not shown), the R^2s ranged from a low of .981 to a high of .997.

[13] Lawrence and Shay [1986a] divided up their Functional Cost Analysis (FCA) data into four size-class quartiles, estimated each one separately, and then tested the hypothesis that the parameters of each size-class quartile estimate were equal across the four identified. This hypothesis of the same technology across size-class quartiles was rejected for each of the four years tested over 1979-1982. Later, when their FCA data were separated into branching and unit state bank categories, this same hypothesis was occasionally accepted [Lawrence and Shay 1986b].

[14] The computed F statistics were 1.84, 3.66, 1.77 (3.38, 6.24, 1.85) for branching (unit) state banks for the three years listed in the text. The critical F value at the 99 percent confidence interval was 1.69 for the 36 parameter restrictions of 39 estimated parameters using sample sizes varying from 6,000 to 8,000. Because the hypothesis tested is actually one of four which were run at the same time, the correct overall confidence interval is 96 percent (or 1.00–(4)(.01)).

[15] The Bayesian likelihood ratio ranges between 8.87 with a sample size of 6,000 to 9.13 for a sample of 8,000. The formula was $[(N-k)/p]/[N^{p/N}-1.0]$ from Leamer [1978, p. 114], where N is sample size, k is the total number of all parameters estimated (here 39), and p is the total number of restrictions (36) placed on the k parameters estimated.

one approach marginally rejects and the other "accepts" pooling across size classes at the mean of all banks, the fact remains that predicted average costs are seen to diverge from actual average costs at the largest banks when all banks are pooled together (Figures 5 and 6).

Lastly, one can test the proposition that all banks in the lowest (highest) average cost quartile lie on the average cost curve for that quartile alone. This is the same question just answered for the cost curve of all banks together only this time applied to the quartile cost curves. Using F tests, the proposition was marginally rejected for the highest cost quartile of banks but sometimes accepted for banks in the lowest cost quartile. In sum, the statistical tests do not always support the proposition that all banks lie on the same average cost curve for a given cross section at one point in time. Unless such pooling is supported through a statistical test or a visual comparison of predicted and actual average costs, scale or cost economy estimation may best be applied to banks disaggregated by size class.

Comparing Asset Cost Elasticities from Separate and Pooled Regressions The importance of size class disaggregation for cost economy estimates is illustrated by comparing cost elasticities from disaggregated and pooled data. The years 1984 and 1980 are illustrated in Tables IIIa and IIIb, since these show the greatest difference in the slope in average cost in Figure 4. This is done once where separate regressions for each size class were run and again when all banks across the size classes were pooled and a single regression was estimated. ASCEs under the heading "Separate" are thus based on the separate parameter estimates for each size class (and repeat, for 1984, those shown in Table II) while ASCEs under the heading "Pooled" are based on a single set of parameters but evaluated using data at the mean of each of the separate size classes.

For both years, the pooled results for all banks together have ASCEs which are significantly different from constant costs and smoothly rise as banks get larger. Relying on the pooled approach, significant cost *diseconomies* would be observed for both large branching and unit state banks at the mean.[16] No such simple generalization is possible for the separate ASCE results since they are seen to fluctuate from economies to diseconomies and back again as banks get larger.[17] Even ASCEs for the same size classes are often quite different when different years are examined. In the separate results, ASCEs are typically not significantly different from constant costs. Thus in neither the pooled nor the separate ap-

Figure 5

ACTUAL AND PREDICTED AVERAGE COSTS: 1984

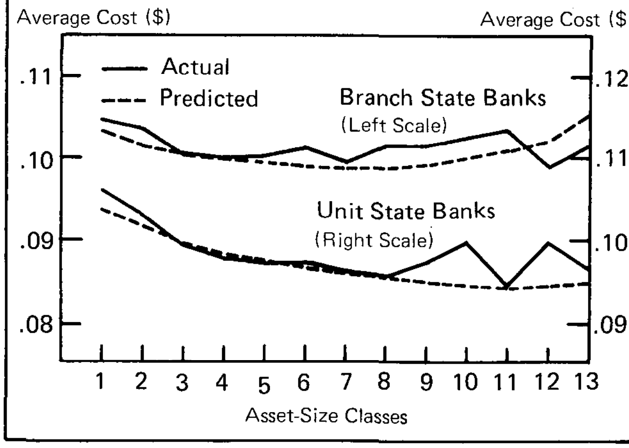
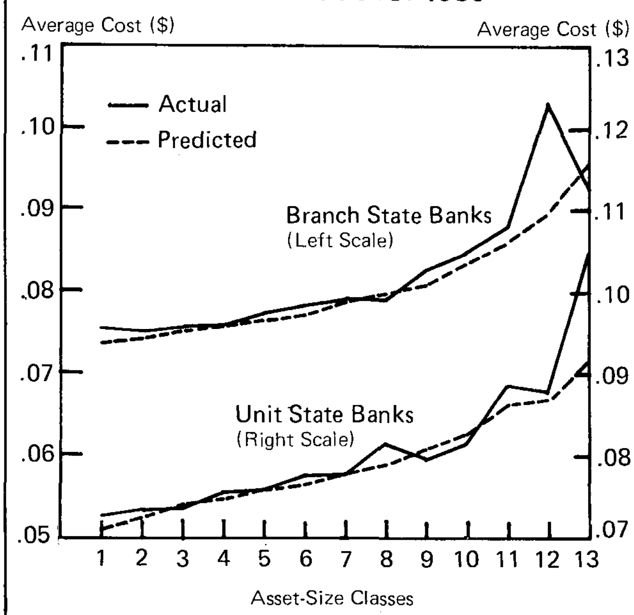


Figure 6

ACTUAL AND PREDICTED AVERAGE COSTS: 1980



[16] These diseconomies are lower in 1984 than they are in 1980, a result illustrated earlier in Figure 4 where mean average cost was plotted. The diseconomy results obtained for larger banks mirror those obtained using FCA data by Benston, Hanweck, and Humphrey [1982] and Gilligan, Smirlock, and Marshall [1984] when it was assumed that all banks did indeed lie on the same average cost curve and the data were pooled. This particular assumption was tested and accepted in Berger, Hanweck, and Humphrey [1987], which also used FCA data.

[17] The same holds for 1982, which is not shown in the table.

Table IIIa
ASSET COST ELASTICITIES (ASCEs) FROM SEPARATE AND POOLED REGRESSIONS (Branch State Banks)

Size Class:	1984 All Banks Separate	1984 All Banks Pooled	1980 All Banks Separate	1980 All Banks Pooled
1. $1M-$10M	1.00	.98**	1.01	1.01**
2. $10M-$25M	.97*	.98**	1.00	1.01**
3. $25M-$50M	.97*	.99**	1.01	1.02**
4. $50M-$75M	.97	.99**	.99	1.02**
5. $75M-$100M	1.04	.99**	.92	1.02**
6. $100M-$200M	1.07*	1.00**	1.08**	1.02**
7. $200M-$300M	1.03	1.00	1.06	1.03**
8. $300M-$500M	1.10	1.00	1.06	1.03**
9. $500M-$1B	1.00	1.01*	1.08	1.03**
10. $1B-$2B	1.05	1.01**	1.12	1.04**
11. $2B-$5B	1.06	1.01**	1.03	1.04**
12. $5B-$10B	.86	1.02**	1.73[a]	1.05**
13. > $10B	1.03	1.03**	1.03	1.05**
All Banks	.99**	.99**	1.02**	1.02**

[a] Based on only 4 observations, one degree of freedom.

proaches are significant cost economies identified for larger banks in 1984 or 1980.

Conclusions

The variation in bank costs has two components. One, the variation in scale or cost economies across different-sized banks, has been extensively studied. The other, differences in cost between similarly-sized banks, is new. Data are presented for all banks in the United States over three years (1984, 1982, 1980) which show that variation in the latter far exceeds variation in the former.

Bank average cost, defined as total operating and interest expenses per dollar of assets, was computed for over 13,000 banks in the United States. These data were arrayed by 13 asset-size classes and 4 average cost quartiles for branching state and unit state banks separately. The mean variation in average cost between the highest and lowest average cost quartiles of banks was 34 percent (31 percent) for branching (unit) state banks. As the mean variation in average cost across size classes was only 8 percent (17 percent), the variation between quartiles was four (two) times the variation across size classes.

Since these existing relative efficiency differences between similarly-sized banks far exceed those obtainable by altering bank size, scale economies are less important in conferring competitive advantages for large banks than is commonly realized. For example, if a $500 million asset bank doubled in size to $1 billion and its average cost fell from that at the highest average cost quartile to that at the lowest quartile, the implied cost elasticity would average .58. This far exceeds the value of bank cost or scale economies measured here or elsewhere, which have historically been on the order of .90 (scale economies) to 1.00 (constant costs). In sum, the competitive implications of scale economies for large banks is seen to be importantly qualified by the existence of off-

Table IIIb

ASSET COST ELASTICITIES (ASCEs) FROM SEPARATE AND POOLED REGRESSIONS (Unit State Banks)

Size Class:	1984 All Banks Separate	1984 All Banks Pooled	1980 All Banks Separate	1980 All Banks Pooled
1. $1M-$10M	1.00	.97**	1.05**	1.02**
2. $10M-$25M	.94**	.97**	.99	1.02**
3. $25M-$50M	.98	.97**	1.01	1.02**
4. $50M-$75M	1.03	.98**	1.09*	1.03**
5. $75M-$100M	.94	.98**	1.22**	1.03**
6. $100M-$200M	.97	.98**	1.02	1.03**
7. $200M-$300M	1.16	.99**	1.40**	1.03**
8. $300M-$500M	1.05	.99**	1.11	1.03**
9. $500M-$1B	1.04	.99*	1.14	1.03**
10. $1B-$2B	1.09	1.00	.99	1.03**
11. $2B-$5B	.85	1.00	[a]	1.04**
12. $5B-$10B	1.30	1.00	[a]	1.04**
13. > $10B	1.04	1.01	[a]	1.04**
All Banks	.97**	.97**	1.02**	1.02**

[a] Sample size was too small to have positive degrees of freedom and so a regression for this cell was not estimated.

setting differences in cost levels or relative efficiency for all sizes of banks due to other (nonscale) causes. The public policy implication is that there appears to be no strong reason to constrain bank mergers or inhibit nationwide banking for fear of conferring important cost advantages on large banks. While there may be other reasons (including a concern about economic concentration in banking) to constrain expansion, reliance on the cost or scale economy argument is not supported by the data developed here or in other recent studies.

In terms of cost or scale economy estimation, it is shown that the approach used in almost all previous statistical studies may benefit from two extensions. First, such estimates may be more accurate if they are obtained from data which has been disaggregated by size class rather than pooled together in a single regression. Of course, if it can be shown that such pooling does not bias the estimates obtained, then disaggregation is not needed. The problem is that such tests sometimes do and sometimes do not support pooling. Second, cost or scale economy results based on a single year's cross section may not generalize well to other years. Thus time series analyses, which combine annual cross sections over different years, will likely yield results which are more general than those for a single cross section. Fluctuations in market interest rates over time can alter the slope of the average cost curve and thereby affect the cost elasticity estimate. Hence the importance of time series analysis in obtaining general results useful for policy purposes.

References

Benston, George J. "Economies of Scale of Financial Institutions." *Journal of Money, Credit and Banking* 4 (May 1972).

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, Part 1).

Berger, Allen N., Gerald A. Hanweck, and David B. Humphrey. "Competitive Viability in Banking: Scale, Scope, and Product Mix Economies." *Journal of Monetary Economics* 19 (November 1987).

Christensen, Laurits R. "Simultaneous Statistical Inference in the Normal Multiple Linear Regression Model." *Journal of the American Statistical Association* 68 (June 1973).

Gilligan, Thomas, Michael Smirlock, and William Marshall. "Scale and Scope Economies in the Multi-Product Banking Firm." *Journal of Monetary Economics* 13 (May 1984).

Hunter, William C., and Stephen G. Timme. "Technical Change, Organizational Form, and the Structure of Bank Production." *Journal of Money, Credit and Banking* 18 (May 1986).

Kim, Moshe. "Banking Technology and the Existence of a Consistent Output Aggregate." *Journal of Monetary Economics* 18 (September 1986).

Lawrence, Colin, and Robert P. Shay. "Technology and Financial Intermediation in Multiproduct Banking Firms: An Econometric Study of U.S. Banks, 1979-1982." In *Technological Innovation, Regulation, and the Monetary Economy,* edited by Colin Lawrence and Robert Shay. Cambridge, MA: Ballinger Publishing Co., 1986a.

Lawrence, Colin, and Robert P. Shay. "Scale Economies in Commercial Banks Revisited: Do the Findings Make Sense?" Working Paper, Graduate School of Business, Columbia University (September 1986b).

Leamer, Edward E. *Specification Searches: Ad Hoc Inference With Nonexperimental Data.* New York: John Wiley & Sons, 1978.

Rhoades, Stephen A. "Mergers Among the 20 Largest Banks and Industrials, All Bank Mergers (1960-1983), and Some Related Issues." *Antitrust Bulletin* 30 (Fall 1985).