Some Evidence on the Impact of Quasi-Fixed Inputs on Bank Scale Economy Estimates

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Studies of bank production and costs have increased understanding of the production process in financial institutions and influenced public opinion about banking consolidation. However, the robustness of these studies' conclusions has not been established with models that account for the quasi-fixed nature of some bank inputs. Hunter and Timme report on their own analysis comparing bank production function estimates using variable inputs with those that allow some inputs to change only after a time lag. Including quasi-fixed inputs in specifications, the authors conclude, enhances the statistical accuracy of bank cost function analysis but does not substantially alter policy conclusions that arose from earlier studies. As the banking industry evolves, empirical enhancements like those the authors discuss may help policymakers target prescriptions more effectively.

Public policy concerning commercial bank product deregulation, geographic expansion, and consolidation relies heavily on empirical analyses of bank production and cost functions. Policy questions involving bank expansion and consolidation generally center on whether or not larger banks, merely because of their size, are more efficient than smaller banks, while the crux of product deregulation issues is whether banks that are allowed to offer a wide variety of financial services under one corporate banner enjoy lower costs because of certain economies resulting from multiproduct production. Because the absence or presence of these economies is essentially an empirical question, it is easy to understand the policy significance of empirical literature examining bank production and costs.

The seminal studies by Stuart Greenbaum (1967) and Fredrick Bell and Neil Murphy (1968), and, more recently, the papers by George Benston, Gerald Hanweck, and David Humphrey (1982), Jeffrey Clark (1984), Thomas Gilligan and Michael Smirlock (1984), Allen Berger, Hanweck, and Humphrey (1987), William C. Hunter and Stephen G. Timme (1986, 1991), Douglas Evanoff (1988), Colin Lawrence (1989), and Hunter, Timme, and Won Keun Yang (1990), among others too numerous to mention, have all provided valuable empirical evidence related to these efficiency questions.[1] Despite their sometimes seemingly conflicting results, these studies have increased understanding of the production process in financial firms. In addition, this voluminous empirical literature has been influential in solidifying public opinion about banking expansion and consolidation and, as a result, is likely to influence the evolution of the U.S. banking industry.

Public policy prescriptions emanating from the empirical production and cost function literature have been generally consistent. For example, the consensus of the most rigorous studies is that there are indeed significant scale economies at small banks (total assets of \$50 million to \$100 million) and small but significant diseconomies at the largest banks (total assets exceeding about \$25 billion). The results imply that banks having total assets within the $50 million to $25 billion range incur roughly similar average costs of producing basic banking products or services. In economic terms, a relatively flat industry long-run average cost curve prevails over a wide range of asset sizes. An obvious policy implication of this pattern is that consolidations involving very small banks (less than $50 million in assets) that create postmerger firms within this $50 million to $25 billion asset range should be encouraged because significant scale economies can be realized. Consolidations of banks already within this range that produce postconsolidation organizations remaining in the same size range would appear to be innocuous except when excessive market concentration results. Even in the latter case, significant diversification, customer convenience, and product and cost innovation benefits and advantages quite possibly will offset any potentially negative effects.[2]

Although the above conclusions have been found to be robust across studies employing different statistical methodologies, data definitions, output measures, periods, and number of products (outputs) examined, this robustness has not been explicitly established with respect to models that recognize the quasi-fixed nature of many bank inputs.

The purpose of this article is to report on the authors' basic research examining the robustness of bank scale economy estimates derived from a specification or model that explicitly recognizes the quasi-fixed nature of some inputs into the bank production function.[3] The analysis directly compares estimates of bank cost functions that assume completely variable inputs with those that take into account the quasi-fixed nature of core deposits and bank branches for the period from 1984 through 1987.

If the short-run fixity of bank inputs truly affects the efficiency of bank production, then policy recommendations made on the basis of results obtained from models that ignore these fixities could be called into question. On the other hand, if the research findings prove to be robust when quasi-fixed inputs are recognized, then the conclusions found in the bank scale economies literature summarized earlier are further strengthened.

The Nature of Fixed or Quasi-Fixed Inputs

The production characteristics of a firm can be summarized by its short-run or long-run production or cost functions. In economic theory the short run is defined as the period in the production process during which certain factor inputs (that is, the fixed or quasi-fixed inputs) cannot be changed. The long run is the period during which all factor inputs can be varied. While a production function simply depicts the relationship between the output of a good and the inputs (factors of production such as labor, physical capital, and the like) required to make that good, the cost function depicts the relationship between the total production cost and the prices of the inputs required to produce a good (that is, the factor prices). The long-run and short-run modifiers simply establish the degree to which a firm can change the amounts of inputs employed as it attempts to meet profit objectives.

In analyzing a firm's short-run optimizing behavior—profit maximization or cost minimization—it is assumed that some factor inputs cannot be varied. On the other hand, the underlying assumption of long-run analysis is that all factors of production are completely variable and thus can be employed at their long-run equilibrium (cost effective or profit maximizing) levels. Depending on the firm being described, production functions can be of a single- or multiproduct nature.

The short-run fixity of some inputs such as physical capital (for example, buildings, branches, and computer systems) has long been acknowledged in economic theory. Despite this fact, extant studies of bank scale economies assume all inputs to be completely variable, adjusting instantaneously to their long-run equilibrium levels.[4] Furthermore, there are reasons to believe that short-run fixities extend beyond pure physical capital to include factors related to transactions and information costs. For example, the notions of "core deposits" (interest-rate insensitive retail deposits) and the "bank-customer relationship" exhibit characteristics traceable to fixity of bank factor inputs and transactions and information costs.

Core Deposits, Customer Relationships, and Branches

As noted above, core or retail deposits are an example of a bank input with quasi-fixed characteristics.

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Mark Flannery (1982) has argued that such deposits should be considered quasi-fixed inputs because both the bank and its customers incur set-up costs or transaction-specific investment costs when opening new accounts. Flannery has shown that because of these investments a bank is less likely to reduce retail deposits during times when, at the margin, these deposits are not needed but are expected to be needed in the future. As a result, the rate paid on interest-bearing retail deposits during these periods may exceed that paid on purchased funds (for example, negotiable certificates of deposits).

Elsewhere in the literature (see, for example, Gary Becker 1962, Walter Oi 1962, and Donald Parsons 1972) it has been noted that when trading partners incur significant set-up costs, these common expenses provide strong incentives for the parties to continue the relationship, although it may not be profit maximizing in a particular period. Bank customers are less likely to switch banks to avoid incurring further set-up costs and having to become familiar with a new bank's service delivery mechanism. On the lending side, banks' costs associated with learning about customer payment and borrowing habits can also be considered switching or set-up costs. Given that such information is durable, banks find it cheaper to service customers over time and can offer these familiar customers preferred rates (equivalent to repeat business discounts like the points given for consumer charge-card purchases and the frequent-flyer benefits offered by most major airlines).

As noted above, bank physical capital is an obvious quasi-fixed input into the production function. Investment in home and branch offices generally varies little in the short run, primarily because severe costs are associated with quickly building or disposing of these facilities. However, factors other than adjustment costs can make an input quasi-fixed in the short run. Regulation is one such factor. For example, it has been suggested that the Community Reinvestment Act of 1977 has prompted many banks to continue operating branches in certain community areas when it is not cost effective to do so. In the case of branch banking, state restrictions can prevent banking offices from reaching their long-run equilibrium level; although banks may be expected to find alternative means for expanding deposits, such means may not be efficient. This kind of nonequilibrium situation could occur, for example, when a banking organization is forced to expand geographically by way of holding company acquisitions or chain banking as opposed to simply opening new branches.

Total-Cost versus Variable-Cost Functions

In the authors' research, tests of bank-scale economy estimates' robustness in the presence of quasi-fixed inputs were carried out by analyzing two models or specifications of a bank's cost function—the total-cost and the variable-cost specification. Applied to bank production, the total-cost model corresponds to a long-run bank cost function that considers all inputs as variable. Thus, it is assumed that a bank can adjust all factor inputs appropriately to minimize its costs (maximize its profits). In contrast, the variable-cost model essentially assumes that the bank is in equilibrium with respect to a set of variable inputs conditional on the observed levels of the quasi-fixed inputs. The bank's optimizing behavior is carried out subject to certain inputs' being fixed during the period of analysis.

Under the total-cost specification, the bank's total cost—that is, the sum of the quantities of inputs employed multiplied by their factor prices—is expressed as a function of the quantities of outputs produced and all input factor prices. Under the variable-cost specification—because the bank minimizes the cost of a subset of its inputs, conditional on the level of the quasi-fixed inputs (for example, physical capital, core deposits, and so forth)—the relevant costs to be minimized are variable costs (the sum of the quantities of the variable inputs multiplied by their factor prices). Thus, for the variable-cost function total variable costs are expressed as a function of products (outputs produced), the factor prices of the variable inputs employed, and the quantities of the quasi-fixed inputs used in producing the outputs.

Estimating Bank Scale Economies

The notion of scale economies, or, more properly, returns to scale, refers to the rate at which output changes as all input quantities are varied. If, for example, a firm doubles the quantity of its inputs and its output doubles, then its production technology is said to exhibit constant returns to scale. If output increases by less than 100 percent, decreasing returns to scale or diseconomies of scale prevail, and if by more than 100 percent, increasing returns to scale or simply economies of scale prevail. In the above definitions, the term scale serves as a reminder that all inputs are being varied. The concept is a long-run equilibrium concept, and the presence of economies of scale means that the average cost of producing a product, in the long run, declines as more of the product is produced. If, because of the presence of quasi-fixed inputs, banks are not in long-run equilibrium with respect to the quantities of their inputs, scale economy measures derived from cost functions that assume all inputs are variable may be misleading.

For the analysis of bank scale economies presented below, the first step involved specifying and estimating a functional form for each of the cost functions. Once these forms were estimated or fitted to sample data, scale economy measures could be computed and compared. In addition, other economic properties of the two cost function specifications could be examined to determine if one clearly dominates the other in describing bank costs.

Second-order transcendental logarithmic (translog) approximations were used to statistically fit the total-cost and variable-cost specifications. The translog functional form, a generalized or flexible mathematical model capable of approximating many different production technologies, includes most popular specifications as special cases and is able to capture complex patterns of input substitution.[5] These features have gained it wide acceptance in the empirical literature examining production and cost relationships in financial intermediaries.

Variable Definitions

Outputs. The criterion of value added employed by Berger, Hanweck, and Humphrey (1987) was used in the research reported on here to determine the composition of the various output categories examined. In both cost function specifications, output includes wholesale loans, represented by the dollar volume of all commercial and industrial and security loans; consumer loans, comprising the dollar volume of credit cards and other personal loans except for loans secured by real estate; and real estate and other loans, including those secured by real estate, agricultural loans, and others in the wholesale or consumer categories. In addition, an output category is defined to capture the off-balance-sheet activities of the sample banks. These include such items as loan sales, letters of credit, securitization, swaps, and clearing activities, all of which are becoming increasingly important at U.S. commercial banks. This proxy output variable is defined as total noninterest income, including service charges received on transaction and nontransaction deposit accounts. Securities are excluded from the definition of output because banks add only negligible, if any, value to these assets.

Inputs and Input Prices. The inputs into the bank production function are taken to be labor, physical capital (plant and equipment), deposits, and other miscellaneous inputs (for example, director services and advertising). Thus, the cost functions include the following input or factor prices: the price of labor (the total salaries and benefits divided by the number of full-time employees), the price of physical capital (the ratio of occupancy and fixed-asset expense to net bank premises), the price of deposits (the interest rate paid on all deposits divided by the sum of all interest-bearing deposits outstanding), and a proxy price for miscellaneous inputs (pretax noninterest expenses less labor and capital expenses divided by total assets).

Quasi-Fixed Inputs. Core deposits and a measure of physical capital are treated as the quasi-fixed inputs in variable-cost specification. Core deposits are defined as each sample bank's previous year's dollar volume of demand deposits, negotiable orders of withdrawal (NOW accounts), and other interest-bearing checking accounts, savings accounts, and small time deposits. Purchased funds are excluded from the definition of core deposits.

Quasi-fixed capital for a given year is defined as the number of branches the bank operated in the previous year. Branches are chosen as a proxy for quasi-fixed capital inputs because, for planning purposes, they are typically considered fixed in the short run. In addition, branching networks represent a substantial proportion of most banks' investment in physical capital.

Total and Variable Costs. Total costs are defined as total noninterest costs plus allocated interest expense (the product of the ratio of total loans to earning assets times total interest expense). The allocation of interest expense is necessary because securities are not specified as an output and many banks incur a substantial proportion of their interest costs to finance their securities portfolio. The output/cost specification used in this study is consistent with the intermediation approach to examining bank costs discussed in Humphrey (1985).

Variable costs are defined as total costs less the previous year's expenses for premises and fixed assets and interest allocated to core deposits. The interest price of core deposits is defined as the current year's total interest on all deposits less than \$100,000 (for example, NOW accounts, saving and time, IRAs, and Keoghs) excluding all interest on purchased funds (Fed funds, retail repurchase agreements, and jumbo CDs) divided by the sum of all noninterest-bearing demand deposits plus all interest-bearing deposits less than \$100,000, excluding any purchased funds. Total allocated interest equals the interest price of core deposits times the amount of core deposits.

The Data

The data used to estimate the cost functions were taken primarily from the Federal Reserve end-of-year Reports of Condition and Income filed by banks for 1984 through 1987. This period of analysis was chosen for several reasons. First, significant changes in bank regulation and markets occurred in the early 1980s. Hence, combining more recent data with earlier data could have produced misleading results. Second, during the period from 1984 through 1987, retail CDs exhibited characteristics associated with quasi-fixed inputs. That is, for some periods the effective cost of retail deposits exceeded the cost of purchased funds. Data from this period should therefore be particularly useful in examining the impact of quasi-fixed inputs on bank scale economy measures.

Data for all banks having at least $1 billion in total assets as of year's end 1987 and complete data for the entire 1984-87 period were collected. Although these banks represented a small percentage of the total number of U.S. banks operating in 1987, they held approximately 60 percent of all banking assets. Banks in states with unit banking laws were dropped from the sample because analysis of nonunit banking banks is expected to provide more useful insight into issues currently confronting bank regulators. The final sample included 254 banks.

The sample banks were found to vary both with regard to their scales of outputs and their product mixes. As a result, the sample banks were divided into seven subgroups based on total assets as of the year ending 1987. Table 1 presents summary statistics for each of the seven subgroups.

Table 1
Summary Statistics for Sample Banks for 1987[1]
(means and standard deviations in parentheses)

		Output				Quasi-Fixed Inputs	
Asset Size	Number of Banks	Wholesale Loans	Consumer Loans	Real Estate and Other Loans	Other Outputs	Core Deposits	Number of Branches
$1.0–1.5	69	$ .21 (.09)	$ .20 (.12)	$ .35 (.12)	$ .02 (.11)	$ .63 (.15)	33.5 (23.9)
$1.5–2.0	36	.32 (.12)	.26 (.14)	.53 (.15)	.03 (.03)	.92 (.28)	44.5 (25.1)
$2.0–3.0	32	.52 (.22)	.32 (.14)	.79 (.24)	.03 (.01)	1.22 (.27)	49.8 (20.9)
$3.0–5.0	50	.76 (.25)	.52 (.27)	1.21 (.39)	.05 (.03)	1.74 (.45)	83.9 (53.7)
$5.0–10.0	36	1.58 (1.50)	.91 (.45)	2.02 (.66)	.09 (.05)	3.26 (1.08)	118.3 (65.7)
$10.0–25.0	21	4.07 (2.19)	1.48 (.99)	4.35 (1.45)	.20 (.11)	5.88 (2.41)	188.6 (95.5)
$25.0 plus	10	16.51 (7.18)	4.41 (4.07)	20.90 (11.19)	1.04 (.80)	20.57 (10.90)	375.3 (332.2)

[1] *All dollar amounts are in billions of dollars for the year ending 1987.*

Source: Calculated by the authors from data in Consolidated Reports of Condition for Insured Commercial Banks and Consolidated Reports of Income for Insured Commercial Banks filed with the Federal Reserve System.

Results of the Tests

Both the total-cost and variable-cost specifications were statistically fitted using data for the overall sample. However, scale economy estimates are reported for each subgroup identified in Table 1 to account for differences in the subgroups' scale and product mix. Because the cost functions are multiproduct cost functions, the scale economy measures or indices reported below are ray scale economy indices, which are the multiproduct firm equivalent of the traditional scale economy index used in analyzing the single-product firm. In simple terms, a ray scale economy index measures the change in total (or variable) costs as the firm's scale is increased, holding product mix constant. As presented in this article, if a ray scale economy index (RSCE) equals 1.0, constant returns to scale prevail, and if the index is less or greater than 1.0, decreasing or increasing returns to scale, respectively, prevail.

Using pooled data for the years 1985-87, the statistical technique of full information maximization likelihood was used to estimate the two cost specifications' parameters. Including time-dependent dummy or indicator variables accounted for possible structural shifts in the sample banks' production functions during the sample period.

Table 2 reports the estimated ray scale economy indices for the total-cost specification (RSCE-TC) and the variable-cost specification (RSCE-VC) for each of the seven sample bank subgroups for 1985, 1986, and 1987. For the total-cost model the estimated ray scale economy indices for 1985 indicate significantly increasing returns to scale (RSCE-TC > 1.0) for banks with total assets of $5 billion or less. Banks with $5 billion to $10 billion in total assets exhibit approximately constant returns to scale, whereas banks with total assets in excess of

Table 2
Ray Scale Economy Estimates of the Total-Cost and Variable-Cost Models
(standard errors in parentheses)

Asset Size[1]	1985		1986		1987	
	RSCE-TC[2]	RSCE-VC	RSCE-TC	RSCE-VC	RSCE-TC	RSCE-VC
$1.0–1.5	1.042** (.015)	1.038** (.015)	1.056** (.017)	1.028 (.017)	1.074** (.015)	1.052** (.018)
$1.5–2.0	1.033** (.013)	1.031* (.013)	1.053** (.015)	1.030* (.015)	1.064** (.013)	1.039** (.014)
$2.0–3.0	1.020 (.016)	1.025* (.011)	1.031** (.010)	1.024 (.013)	1.045** (.011)	1.025* (.012)
$3.0–5.0	1.009 (.019)	1.009 (.010)	1.023* (.010)	.998 (.011)	1.054** (.013)	1.011 (.011)
$5.0–10.0	.999 (.019)	1.004 (.010)	1.011 (.009)	.997 (.010)	1.030** (.010)	1.010 (.011)
$10.0–25.0	.980 (.013)	.986 (.010)	.996 (.011)	.987* (.011)	1.008 (.016)	1.004 (.012)
$25.0 plus	.940** (.016)	.962** (.013)	.959* (.017)	.956** (.014)	.978 (.017)	.966** (.013)

[1] *Assets are given in billions of dollars for the year ending 1987.*

[2] *"RSCE-TC" denotes the ray scale economies index from the total-cost model; "RSCE-VC" denotes the ray scale economies index from the variable-cost model.*

* *Significant at the .05 level.*

** *Significant at the .01 level.*

Source: Calculated by the authors from data in Consolidated Reports of Condition for Insured Commercial Banks and Consolidated Reports of Income for Insured Commercial Banks filed with the Federal Reserve System.

$10 billion exhibit moderate to large decreasing returns to scale (RSCE-TC < 1.0). The results for 1987, relative to those for 1985, indicate more pronounced increasing returns to scale and more muted decreasing returns to scale. The 1987 estimates suggest that only the largest banks—with assets in excess of $25 billion—exhibit decreasing returns to scale.

A number of factors could account for the apparent change in the sample banks' efficiency between 1985 and 1987. First, because it ignores the presence of quasi-fixed inputs, the total-cost specification may be inappropriate. This possibility will be discussed in detail below when the results obtained under the variable-cost specification are examined.

A second possible explanation for the apparent change is that product mixes of the sample banks may have varied significantly during the period covered. The validity of this explanation was explored by reestimating the ray scale economy indices using the fitted parameter values of the total-cost specification for the year 1987 and the mean output data taken from 1985. The indices obtained under this procedure for 1987 were essentially the same as those reported in Table 2. This analysis, along with other comparisons, suggests that changes in the quantity and mix of outputs among the sample banks did not contribute significantly to the changes observed in the ray scale economy indices using the total-cost specification.

New technology is another factor that could explain the changes observed. If technological change during this period was scale-biased—that is, if it worked to increase the threshold of efficiency in terms of asset size—then, assuming all other factors were constant, banks should have exhibited higher (lower) increasing (decreasing) returns to scale over time. Tests for the presence of scale-biased technological change during the 1985-87 period did reveal the presence of statistically significant scale-biased technological change. Thus, the changes in the ray scale economy indices derived from the total-cost specification can be explained, in part, by a technology-induced shift in the total cost function.[6]

Ray scale economy indices derived from the variable-cost specification are also given in Table 2 for each of the bank subgroups. For 1985 the RSCE-VC indices indicate either increasing or constant returns to scale for banks with total assets in amounts up to $10 billion. Banks with total assets in excess of $10 billion exhibit modest to substantial decreasing returns to scale. Although these results are very similar to those obtained using the total-cost specification, the estimated RSCE-VC indices are relatively stable for the 1985-87 period, indicating a slight but statistically insignificant increase (decrease) in ray scale economies (diseconomies). The lack of time-dependent scale economy indices contrasts sharply to the pattern exhibited by the indices derived from the total-cost specification.

Further testing of the differences between the two cost specifications involved a statistical test to determine which model best fits the sample data. Because the variable-cost specification contains all of the total-cost specification's estimated parameters and total costs differ from variable costs by the amount of fixed costs, the parameters of the total-cost specification are a subset of those used to fit the variable-cost model. Thus, by reestimating the variable-cost specification with total rather than variable costs as the quantity to be explained, a statistical test of the best-fitting model could be conducted. The results of the test indicated that the two specifications are not identical. The more general variable-cost specification was found to provide a more accurate description of the sample data.

Although the variable-cost specification better fits the data, the results in Table 2 show that the ray scale economy indices for both specifications are virtually identical for 1985, and the largest discrepancies appear in 1987, as discussed above. Using the standard errors of the estimates reported in Table 2 for 1987, tests were conducted to see if the differences in the ray scale economy indices are statistically different. These test results indicate that only the indices for the subgroups in the $5 billion–$10 billion and $3 billion–$5 billion total assets categories are statistically different.

Additional insight into the significance of the observed differences can be obtained from an analysis of the projected increases in costs resulting from increases in scale under each specification. This comparison was performed using the statistical results obtained for 1987. For both cost specifications, changes in total and variable costs were computed for each bank subgroup using observed costs, ray scale economies estimates in Table 2, and an assumed 5 percent increase in all outputs. In all cases, the differences in the projected cost increases derived from the two specifications were found to be minor. These comparisons suggest that over the time period examined managerial policy decisions would be fairly similar regardless of which specification was used in the production planning process, even though the variable-cost specification appears to provide a better statistical fit.[7]

Implications and Conclusions

The results of the empirical analyses show that the variable-cost specification better fits the sample data when compared with a total-cost specification. Thus, it would appear that explicitly recognizing the short-run fixity of some bank inputs is required in bank cost function analysis if statistical accuracy is the guiding criterion.

However, the analysis also demonstrates that efficiency measures of the type typically used in public policy debates concerning bank product deregulation, geographic expansion, and consolidation—measures that have traditionally been computed from models ignoring these short-run fixities—will not necessarily produce erroneous policy prescriptions. In the case examined in this article, it is clear that ray scale economy measures produced under the two different cost specifications are essentially identical. It follows that public policy prescriptions based solely on these estimated ray scale economy indices should not be affected by the particular cost specification employed. These results provide strong support for the notion that policy prescriptions emanating from the empirical bank production and cost function literature are in fact robust.

On the other hand, these findings do not imply that the two cost specifications will never produce significantly different public policy prescriptions. Instead, they make it clear that as banks and banking markets continue to evolve, policy-oriented studies of bank production and cost functions should establish the robustness of policy prescriptions to specification changes if the prescriptions are to be seriously considered in policy debates.

Notes

1. Comprehensive reviews of this literature can be found in Clark (1988) and Humphrey (1990).
2. See Hunter and Timme (1991) for an examination of the relationship between concentration and innovation in banking markets.
3. For a more detailed and technical discussion of the research reported in this article see Hunter and Timme (1990).
4. The one exception in the published literature is the paper by Noulas, Ray, and Miller (1990). However, the authors fail to compare the estimates of bank cost characteristics they derive from a quasi-fixed specification with those derivable from a traditional specification assuming instantaneous adjustment. In addition, their study examines only one quasi-fixed input (core deposits), and therefore the importance of quasi-fixed physical inputs cannot be ascertained. Finally, because Noulas, Ray, and Miller have examined bank cost data for only one year, their study provides no insight into the dynamic aspects of quasi-fixed inputs in bank production.
5. The review article by Clark (1988) contains an excellent technical discussion and overview of the properties of the translog cost function.
6. Empirical evidence on technology-induced shifts in bank production and cost functions is reported in Hunter and Timme (1991).
7. Neither does consistency with economic theory make one specification preferable over the other. It should be noted that both the variable-cost and the total-cost specifications were found to produce results consistent with most of the dictates of economic theory.

References

Becker, Gary S. "Investment in Human Capital: A Theoretical Analysis." *Journal of Political Economy* 70 (October 1962, Supplement): 9-49.

Bell, Fredrick, and Neil Murphy. *Costs in Commercial Banking: A Quantitative Analysis of Bank Behavior and Its Relationship to Bank Regulation.* Federal Reserve Bank of Boston, Research Report No. 41, 1968.

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): 435-56.

Berger, Allen N., Gerald A. Hanweck, and David B. Humphrey. "Competitive Viability in Banking: Scale, Scope and Product Mix Economies." *Journal of Monetary Economics* 20 (December 1987): 501-20.

Clark, Jeffrey A. "Estimation of Economies of Scale in Banking Using a Generalized Functional Form." *Journal of Money, Credit and Banking* 16 (February 1984): 53-68.

_____. "Economies of Scale and Scope at Depository Financial Institutions: A Review of the Literature." Federal Reserve Bank of Kansas City *Economic Review* 73 (September/October 1988): 16-33.

Evanoff, Douglas. "Branch Banking and Service Accessibility." *Journal of Money, Credit and Banking* 20 (May 1988): 191-202.

Flannery, Mark J. "Retail Deposits as Quasi-Fixed Factors of Production." *American Economic Review* 72 (June 1982): 527-36.

Gilligan, Thomas, and Michael Smirlock. "An Empirical Study of the Joint Production and Scale Economies in Commercial Banking." *Journal of Banking and Finance* 8 (March 1984): 67-76.

Greenbaum, Stuart I. "A Study of Banking Costs." *National Banking Journal* 4 (June 1967): 415-34.

Humphrey, David B. "Cost and Scale Economies in Bank Intermediation." *In Handbook for Bank Strategy,* edited by R. Aspinwall and R. Eisenbeis. New York: Wiley and Sons, 1985.

_____. "Why Do Estimates of Bank Scale Economies Differ?" Federal Reserve Bank of Richmond *Economic Review* 76 (September/October 1990): 38-50.

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): 152-66.

_____. "Quasi-Fixed Inputs in the Estimation of Bank Scale Economies." Federal Reserve Bank of Atlanta Working Paper 90-8, October 1990.

_____. "Technological Change in Large U.S. Commercial Banks." *Journal of Business* 64 (July 1991): 206-45.

Hunter, William C., Stephen G. Timme, and Won Keun Yang. "An Examination of Cost Subadditivity and Multiproduct Production in Large U.S. Commercial Banks." *Journal of Money, Credit and Banking* 22 (November 1990): 504-25.

Lawrence, Colin. "Banking Costs, Generalized Functional Forms, and Estimation of Economies of Scale and Scope." *Journal of Money, Credit and Banking* 21 (August 1989): 368-79.

Noulas, Athanasios, Subhash C. Ray, and Stephen M. Miller. "Returns to Scale and Input Substitution for Large U.S. Banks." *Journal of Money, Credit and Banking* 22 (February 1990): 94-108.

Oi, Walter Y. "Labor as a Quasi-Fixed Factor." *Journal of Political Economy* 70 (December 1962): 538-55.

Parsons, Donald O. "Specific Human Capital: An Application to Quit Rates and Layoff Rates." *Journal of Political Economy* 80 (December 1972): 1120-43.